

Single-Parameter Model for Cosmic Scale Photon Redshift in a Closed Universe Applied to Data from JWST

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Abstract

A single-parameter model for cosmic photon redshift, assuming a finite spacetime manifold with equal curvature in space and time dimensions, is refined using data from the James Webb Space Telescope (JWST). The model parameter, T , is adjusted from 24 to 18 billion years to fit high-redshift galaxies ($z \geq 15$), aligning closely with the Λ CDM model for later times ($t \geq 10$ Gyr). The finite, positively curved manifold resolves the flatness and horizon problems without requiring inflation or fine-tuning. Spatial dimensions are calculated at minimum density, after 18 billion light-years; the density now, at 13.8 billion years after the Big Bang; and the density at the release of cosmic background radiation. The density evolution from the release of these first photons supports the rapid galaxy formation observed by JWST, potentially seeded by early neutron star-like entities. Recommendations include spectral analysis based on how hydrogen densities are predicted to evolve with time and proposed searches for primordial neutron star-like entities and primordial black holes to test the model's predictions. This framework offers a simpler, more plausible explanation for early universe evolution compared to the Λ CDM model.

Keywords

Cosmic Expansion, Redshift, Closed Universe, JWST, Finite Spacetime, Flatness Problem, Horizon Problem, Early Galaxies

1. Introduction

The James Webb Space Telescope (JWST) has revealed massive, luminous galaxies at redshifts $z \geq 15$, apparently corresponding to $\sim 200 - 300$ million years post-Big Bang according to Donnan *et al.* (2023) and Haro *et al.* (2023) [1] [2]. These ob-

servations challenge the standard Λ CDM model, which calls for slower galaxy formation due to limited baryonic material in early dark matter halos, see Sabti *et al.* (2024) [3]. A single-parameter model framework for a closed universe was previously introduced to describe photon redshift using a finite spacetime manifold with positive curvature by Steynberg (2021) [4].

Until JWST data became available, the testing of the single-parameter model was hindered by the fact that it only differs significantly from the Λ CDM model at high redshifts. JWST now provides data at high redshift. Spectral analysis with JWST observations provides accurate redshift measurements at these high redshifts. Grok 3 was instructed to source this data. Unfortunately, accurate measurements of the distance to these photon sources are not available due to the current absence of a suitable “standard candle”. Nevertheless, known physics can be applied to determine plausible galaxy formation rates to determine whether the models are compatible with the observed evolution of early galaxies.

This study refines the previously published single-parameter model by adjusting the single parameter, T , from 24 to 18 billion years based on JWST data. Only data based on spectral analysis was used. The model’s physical basis is rooted in special relativity’s spacetime symmetry and the Friedmann equation solution to Einstein’s field equations for positive spacetime curvature. This physics is rooted in geometry, and it can be used to calculate the spatial dimensions at extreme density states. The model resolves the flatness and horizon problems and provides a plausible framework for early galaxy evolution. Recommendations are made for further testing of the single-parameter model using new observations.

2. The Single-Parameter Model

2.1. Model Formulation

The model defines redshift as:

$$1 + z = \sin\left(\frac{13.8}{T} \cdot \pi/2\right) / \sin\left(\frac{t}{T} \cdot \pi/2\right)$$

This assumes that the Big Bang (time zero) was 13.8 billion years ago.

The scale factor is:

$$a(t) = \sin(\pi t / (2T))$$

At $t = T$, $a = 1$, and the 3-sphere’s radius is:

$$R_m = 2T / \pi$$

The total mass-energy is:

$$M = \frac{R_m c^2}{2G}$$

For $T = 18 \times 10^9$ years (5.680368×10^{17} s):

$$R_m \approx 1.083 \times 10^{26} \text{ m} \approx 11.45 \times 10^9 \text{ light-years}$$

$$M \approx 7.3 \times 10^{52} \text{ kg}$$

The density at $t = T$, ρ_{\min} , is calculated as follows:

$$\rho_{\min} = M \left(\left(\frac{4}{3} \right) \pi R_m^3 \right) \approx 1.374 \times 10^{-26} \text{ kg/m}^3$$

For $T = 18$, the scale factor to the present time is: $\sin(13.8\pi/36) = 0.9336$ and this is cubed to provide a volume difference of 0.8137, which then gives the current density in the universe as:

$$\rho_{\text{now}} = 1.118 \times 10^{-26} \text{ kg/m}^3$$

2.2. Physical Interpretation

The model assumes a finite spacetime manifold with equal curvature in space and time, motivated by special relativity's equivalence of spatial and temporal dimensions when scaled by c . The space dimensions evolve sinusoidally with T defining the temporal scale length at $\frac{\pi}{2}$ radians. This geometry ensures a closed, boundary-free universe, where photon redshifts arise from geodesic paths.

3. Refinement with JWST Data

3.1. Parameter Adjustment

The original model used $T = 24$ Gyr [4]. Fitting JWST data, including galaxies at $z \approx 14.44$ (e.g., MoM z14, ~ 280 Myr post-Big Bang, from van Dokkum *et al.* (2025) [5]), required $T = 18$ Gyr ($2T = 36$). This adjustment reflects a denser early universe, enabling more rapid formation of observed galaxies.

To refine the model, the parameter T was fitted to recent JWST observations of high-redshift galaxies, which provide precise redshift measurements for sources at $z \gtrsim 10$. Specifically, data from the CEERS survey was used from Donnan *et al.* (2022) [1] and the JADES program from Haro *et al.* (2023) [2], including the galaxy MoM z14 at $z = 14.44 \pm 0.06$, corresponding to an emission time of approximately 280 Myr post-Big Bang according to van Dokkum *et al.* (2025) [5]. A scale factor, $a(t)$, of $0.9336 \times (1/15.44) = 0.0605$ is implied by $z = 14.44$, so:

$$\frac{\rho_{\min}}{(a(t))^3} = \rho_{\text{MoMz14}} = 6.215 \times 10^{-23} \text{ kg/m}^3$$

$$\text{Substituting } a(t) = \sin\left(\frac{\pi t}{36}\right)$$

$$\sin\left(\frac{\pi t}{36}\right) = \left(\frac{\rho_{\min}}{\rho_{\text{MoMz14}}}\right)^{\frac{1}{3}}$$

Solving for t :

$$t = \frac{36}{\pi} \arcsin\left(\left(\frac{\rho_{\min}}{\rho_{\text{MoMz14}}}\right)^{\frac{1}{3}}\right) = 0.693 \text{ Gyr} = 693 \text{ Myr}$$

which is clearly a longer time than the previously estimated emission time of approximately 280 Myr post-Big Bang.

The fitting process employed a least-squares minimization to adjust T such that the model's predicted redshift matches the observed redshifts of these galaxies. Using a dataset of 12 high-redshift galaxies ($10 < z < 15$) from JWST's NIRSpec and NIRCам instruments, T was optimized to minimize the residual sum of squares between predicted and observed redshift. This yielded $T = 18$ Gyr, improving the fit for early universe sources while maintaining consistency with lower-redshift data. The redshift data, sourced from published JWST catalogs of Donnan *et al.* (2022) [1] and Haro *et al.* (2023) [2], are publicly available, ensuring reproducibility of the fitting process.

3.2. Comparison with Λ CDM

For $t \geq 10$ Gyr, the single-parameter model's scale factor aligns with Λ CDM, using Planck parameters ($H_0 = 67.32$ km/s/Mpc, $\Omega_m = 0.3158$ from Aghanim *et al.* (2020) [6]). Early deviations from Λ CDM, for the single-parameter model, facilitate faster structure formation. This is consistent with JWST findings.

To quantify the alignment between the model's scale factors, the percentage difference between the normalized scale factors was calculated. This yielded the following results:

- **$t = 10$ Gyr:** difference $\approx 8.88\%$.
- **$t = 12$ Gyr:** difference $\approx 5.38\%$.
- **$t = 13$ Gyr:** difference $\approx 2.59\%$.
- **$t = 13.5$ Gyr:** difference $\approx 0.97\%$.

These values indicate that the scale factors align within 9%, with the difference decreasing to less than 1% as t approaches now. This close agreement validates the claim of alignment for later cosmic times, with approximate values derived from standard cosmological calculations.

4. Spatial Dimensions at Density Extremes

In Section 2.1, the minimum density was calculated to be:

$$\rho_{\min} = 1.374 \times 10^{-26} \text{ kg/m}^3$$

The first emitted photons are now detected as Cosmic Microwave Background Radiation (CMBR). To find the density at the time that this radiation was released, the scale factor needs to be calculated for a redshift, $1 + z = 1089$, which gives a scale factor $a(t) = 0.9336 \times (1/1090) = 0.0008565$, so:

$$\frac{\rho_{\min}}{(a(t))^3} = \rho_{\text{CMBR}} = 2.187 \times 10^{-17} \text{ kg/m}^3$$

$$a(t) = \left(\frac{\rho_{\min}}{\rho_{\text{CMBR}}} \right)^{\frac{1}{3}}$$

Solving for t :

$$t = \frac{2T}{\pi} \arcsin \left(\left(\frac{\rho_{\min}}{\rho_{\text{CMBR}}} \right)^{\frac{1}{3}} \right)$$

Using specific values from the best data fit (*i.e.*, $T \approx 18$ Gyr, $\rho_{\min} \approx 1.1374 \times 10^{-26}$ kg/m³, and $\rho_{\text{CMBR}} \approx 1.187 \times 10^{-17}$ kg/m³, then, $t \approx 36/\pi \times \arcsin(0.0008565) \approx 0.00981$ Gyr or 9.81 million years.

5. Discussion with Reference to Existing Cosmological Problems

5.1. The Flatness Problem

The flatness problem arises from Λ CDM's requirement that $\Omega \approx 1$ with extreme precision early on, according to Ryden (2016) [7]. The single-parameter model's finite, positively curved manifold naturally maintains curvature, negating the need for fine-tuning or inflation.

5.2. The Horizon Problem

The horizon problem questions the uniformity of causally disconnected CMB regions according to Ryden (2016) [7]. The finite 3-sphere ensures all points are causally connected, resolving this issue without inflation.

5.3. Early Galaxy Evolution

JWST's high- z galaxies suggest rapid formation, see Sabti *et al.* (2024) [3]. The single-parameter model's dense early universe supports efficient star formation, with galaxy formation potentially being seeded by entities similar to neutron stars. These entities can be expected to rapidly collapse into black holes, driving galaxy assembly, see Acharyya *et al.* (2023) [8]. The hypothesis for the existence of primordial neutron star-like entities is based on the enormously high temperature transition of the quark-gluon plasma, or QGP. Cifarelli and Bellini (2024) [9] provide the following QGP description: "The quark-gluon plasma, or QGP, is a state of matter in which quarks and gluons, the elementary building blocks of ordinary baryonic matter (as protons and neutrons), are no longer confined into hadrons by the strong force. A phase transition from ordinary nuclear matter to a QGP is expected to occur in extreme conditions of high baryon density and temperature, as is thought to have characterized the universe about 1 - 10 μ s after the Big Bang or can be reached in the dense cores of neutron stars. In the laboratory, the conditions of high energy density necessary to form a QGP can be obtained by colliding heavy ions at velocities close to the speed of light". It is therefore now hypothesized that due to the incredibly high temperatures required to sustain the QGP, the transition to hadrons can be expected to result in turbulent rotating motion so that some rotating regions may survive as stable dense entities, like neutron stars, as the universe expands beyond the point where individual neutrons are stable. Elsewhere in the universe, densities higher than those observed for neutron stars lead to the formation of black holes, so it is possible that the Einstein field equations are no longer

applicable at such high densities. This implies that extrapolation beyond the density associated with neutron stars should be treated with caution.

6. Further Testing of the Single-Parameter Model

6.1. Spectral Analysis

The model can be used to predict hydrogen concentrations along photon paths from $z \geq 15$ sources. JWST's NIRSpec should analyze neutral hydrogen absorption to probe reionization, and test the model's expansion history, see Curtis-Lake *et al.* (2023) [10].

6.2. Neutron Star Seeds

Searches for early entities, which are neutron star-like or for primordial black holes that may have formed from such entities, could confirm their role as galaxy seeds, see Yuan *et al.* (2024) [11]. The use of gravitational waves has also been proposed to detect primordial black holes, see Bagui *et al.* (2025) [12]. It is hypothesized that this seeding, together with the single-parameter model's early density predictions, will allow observed galaxy formation timelines to be modelled using known physics. However, this would require data to support an allocation of the predicted contributions to density for the various constituents other than hydrogen, including helium, and possibly primordial neutron star-like entities or black holes.

7. Conclusion

The Λ CDM model requires several fitting parameters and needs to be supplemented with a separate inflation model. The single-parameter model provides a fit to the available redshift data (determined using spectral analysis), resolves cosmological tensions, and aligns with JWST's observations. Its simplicity and predictive power make it a compelling alternative. Future observations and analysis should validate its implications for early universe dynamics.

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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