Investigating Cyclic Gravity and Cosmology (CGC) as an Alternative Framework to Standard Cosmology

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March 2024

ABSTRACT

Cyclic Gravity and Cosmology (CGC) is introduced as an alternative framework to General Relativity (GR) and the ΛCDM model. CGC retains Euclidean space and proposes that gravity is a residual effect of electromagnetism rather than a fundamental force. The theory replaces the standard expansion model with cyclic expansion and contraction phases governed by large-scale gravitational oscillations. Redshift in CGC is explained through a combination of Doppler motion, neutrino interactions, and a refined tired light mechanism. Time dilation and light deflection arise from neutrino scattering rather than spacetime curvature, preserving a Euclidean structure.

CGC naturally explains the Cosmic Microwave Background (CMB) power spectrum without requiring inflation, aligns with observed large-scale structure, and provides a resolution to the Hubble tension within a non-expanding space framework. The theory predicts a self-regulating cosmic equilibrium maintained by an outer shell of intergalactic medium, preventing energy loss and sustaining cyclic dynamics. The observed galactic rotation curves, large-scale filament-and-void cosmic structures, and elemental recycling in Active Galactic Nuclei (AGN) are also consistent with CGC's gravitational model.

The purpose of this paper is not to assert CGC as the definitive model of cosmology but to establish it as a framework worthy of rigorous scientific investigation. Given recent challenges to ΛCDM from JWST observations and inconsistencies in Hubble measurements, CGC presents an opportunity to explore alternative gravitational dynamics and cosmic evolution mechanisms that align with observational data.

Key words: cosmology: theory – gravitation – galaxies: kinematics and dynamics – large-scale structure of Universe

1 INTRODUCTION

The standard model of cosmology, based on General Relativity (GR) and the ΛCDM framework, has provided a robust explanation for many aspects of the universe, including the motion of planets, the formation of galaxies, and the large-scale distribution of matter. However, several persistent challenges remain, raising fundamental questions about its completeness. Observations such as the Hubble tension, the unexplained necessity of dark matter and dark energy, and the fine-tuning required for inflationary models suggest that alternative frameworks should be explored.

Cyclic Gravity and Cosmology (CGC) is proposed as a novel theoretical framework that retains Euclidean space while interpreting gravity as a residual effect of electromagnetism rather than a fundamental force. CGC introduces a cyclic expansion-contraction model in which large-scale oscillations govern cosmic evolution, eliminating the need for singular beginnings or endings. This model provides a natural mechanism for redshift, explains observed cosmic structures, and accounts for key cosmological phenomena without invoking inflation, dark matter, or dark energy.

A fundamental aspect of CGC is its treatment of light propagation and energy interactions. Unlike the standard model, which attributes redshift primarily to metric expansion, CGC attributes it to a combination of Doppler motion, neutrino interactions, and a refined tired light mechanism. Furthermore, CGC proposes that time dilation and light deflection arise from neutrino scattering effects rather than spacetime curvature, preserving the fundamental assumptions of a Euclidean universe.

Recent astronomical observations have posed new challenges for standard cosmology. Data from the James Webb Space Telescope (JWST) suggests the presence of mature galaxies at unexpectedly high redshifts, contradicting predictions from the ΛCDM framework. Additionally, discrepancies in the Cosmic Microwave Background (CMB) power spectrum and large-scale structure formation raise concerns about the completeness of the standard model. CGC provides a self-consistent alternative framework that naturally accommodates these observations and suggests testable predictions for further investigation.

The purpose of this paper is not to assert CGC as a definitive replacement for the standard model but to demonstrate that it is a framework worthy of rigorous scientific investigation. By presenting CGC's core theoretical principles and comparing its predictions with observational data, this work establishes CGC as a viable alternative capable of addressing key cosmological challenges without reliance on unverified physical entities.

In the following sections, the fundamental assumptions of CGC will be developed, its mathematical framework presented, and its implications for cosmological observations explored. A comparative analysis with standard cosmology will highlight CGC's potential as a compelling alternative and identify opportunities for future research and observational tests.

2 WHY GENERAL RELATIVITY (GR) WAS SUCCESSFUL BUT ULTIMATELY MISTAKEN

General Relativity (GR) has been one of the most successful and influential theories in modern physics, providing highly accurate predictions for gravitational phenomena across a vast range of scales. Its formulation has led to deep insights into planetary motion, black holes, gravitational lensing, and the structure of spacetime itself. However, while GR excels in describing local gravitational effects and high-energy astrophysical processes, it has faced persistent challenges when applied to cosmology on the largest scales.

One of the key successes of GR is its ability to explain:

- Local gravitational interactions, such as the motion of planets and satellites, where GR corrections to Newtonian mechanics have been experimentally confirmed.
- Frame-dragging effects, such as those observed by Gravity Probe B, which confirm predictions of GR regarding how massive, rotating bodies affect spacetime.
- Black hole physics, where event horizons, gravitational time dilation, and relativistic jets are consistent with GR's equations.
- Gravitational waves, directly detected by LIGO and Virgo, confirming a major prediction of GR regarding the propagation of energy through spacetime.

Despite these successes, GR has been consistently challenged by observations on cosmological scales, leading to multiple modifications and ad hoc additions in an attempt to make the theory fit with reality. The primary issues include the need for dark matter and dark energy, fine-tuning in inflation, the Hubble tension, and high-redshift galaxy formation, all of which suggest that a new theoretical framework, such as CGC, is needed to explain these cosmic-scale discrepancies.

The successes of GR stem from its noting a correlation between the environment of relativistic speeds and space near a large mass. If CGC is correct, then GR mistakenly explained this correlation by using of non-Euclidean Geometry with time as analogous to a fourth dimension of space. In addition, GR assumes that both masses and also relativistic speeds warp or deform the space around them. GR also assumed that relativistic increase of mass and length contraction were due to these spacetime curvatures as well. This correlative vies is what gave GR predictive success. Unfortunately (if CGC is true), this view ultimately could not explain many of the phenomena described in this paper. **CGC explains the correlation in a different way** In CGC, neutrinos are assumed to inhibit all other quantum processes, accumulate around masses, and to deflect light via the weak force. As will be shown, these things together explain time dilation and lensing effects. CGC explains relativistic increase of momentum and Lorentz contraction as the simple effect of the well known physics of electromagnetism. Table 1 shows a summary of a comparison between GR and CGC.

Table 1. Time dilation and increase of mass at relativistic velocities compared with the same near a large mass. The table shows why both environments produce similar results.

Relativistic velocity	Strong gravitational field
Gravity is an EM force, so high velocity = increased EM force = acting as greater mass. High velocity also = more encounters (and greater effect of each encounter) = change inhibited = time slows down.	Massive object = more particles = increased EM force = gravity increases. Mass also attracts more neutrinos = more encounters = change inhibited = time slows down.

3 HOW JWST AND OTHER RECENT OBSERVATIONS CHALLENGE ΛCDM

The ΛCDM (Lambda Cold Dark Matter) model has long been the dominant cosmological framework, successfully explaining many large-scale phenomena such as the expansion of the universe, the formation of cosmic structures, and the Cosmic Microwave Background (CMB) anisotropies. However, recent high-precision observations—particularly those from the James Webb Space Telescope (JWST)—have revealed new challenges that cast doubt on key assumptions of ΛCDM and suggest the need for alternative models, such as Cyclic Gravity and Cosmology (CGC).

3.1 High-Redshift Galaxy Formation Challenges

One of the most significant surprises from JWST has been the discovery of large, well-formed galaxies at unexpectedly high redshifts ($z > 10$), corresponding to less than 500 million years after the supposed Big Bang. According to standard cosmology:

- The hierarchical structure formation model predicts that galaxies should take much longer to form, especially massive, mature galaxies with complex morphology.
- JWST has identified more high-redshift galaxies than ΛCDM simulations predict, many of which are too evolved for their estimated age.
- Some of these galaxies exhibit stellar populations that appear too old, suggesting that they may have formed even earlier than the current standard timeline allows.

In contrast, CGC naturally accommodates these findings. Since CGC rejects metric expansion of space, it does not require an absolute "beginning" to the universe. Instead, galaxies form and evolve within a cyclic framework, where large-scale structures persist across multiple cosmic phases. This allows for early galaxy formation without invoking exotic mechanisms such as rapid star formation rates or revised population synthesis models.

3.2 CMB Anomalies and Large-Scale Structure Discrepancies

While the CMB remains one of the strongest pieces of evidence for ΛCDM, certain anomalies challenge its standard interpretation:

- **Large-Scale Asymmetries:** Observations suggest that the CMB exhibits unexpected hemispherical asymmetries, which are not easily explained by inflation.
- **Cold Spot and Other Anomalies:** Features like the CMB Cold Spot are difficult to reconcile with standard Gaussian fluctuations expected from inflationary models.
- **Horizon Problem Revisited:** While inflation was introduced to solve the horizon problem, some anomalies suggest that a new mechanism may be required to explain observed temperature variations.

CGC provides an alternative explanation for the CMB:

- Instead of interpreting the CMB as the relic radiation from a Hot Big Bang, CGC proposes that the CMB results from scattered and thermalized starlight interacting with the outer intergalactic medium.
- The CGC framework suggests that large-scale structure is imprinted via long-term neutrino interactions, rather than requiring inflation to smooth out initial perturbations.

3.3 Hubble Tension and the Expanding Universe Debate

The Hubble tension is one of the most persistent and unresolved problems in ΛCDM cosmology.

- Measurements of the Hubble constant (H_0) using the early universe (CMB data from Planck) yield a value of ~ 67 km/s/Mpc, consistent with ΛCDM predictions.
- However, direct measurements based on local distance indicators (such as Cepheid variables and Type Ia supernovae) yield a higher value of ~ 73 km/s/Mpc.
- This discrepancy is statistically significant and suggests that ΛCDM may require new physics beyond standard assumptions.

CGC offers a different perspective:

- Redshift is not due to metric expansion of space but rather a combination of Doppler motion, neutrino interactions, and a refined tired light mechanism.
- Since CGC eliminates metric expansion, the Hubble tension vanishes, as redshift interpretations are fundamentally different from the standard approach.
- A cyclic model further supports the idea that redshift accumulates in a complex but predictable manner across multiple cosmic phases.

3.4 Why CGC Naturally Accommodates These Observations

The recent JWST discoveries, CMB anomalies, and the Hubble tension are difficult to explain within the standard cosmological paradigm. CGC, by contrast, provides a self-consistent framework that:

- Eliminates the need for inflation, naturally resolving fine-tuning issues.
- Reinterprets the CMB as a local effect of scattered starlight, rather than a remnant from a singular Big Bang.
- Accounts for early galaxy formation and large-scale structure without requiring exotic dark matter models.
- Resolves the Hubble tension by removing the assumption of metric expansion and introducing alternative redshift mechanisms.

By addressing these fundamental issues without invoking unknown physics, CGC emerges as a compelling alternative framework to ΛCDM that aligns with new observational data while remaining mathematically and physically grounded.

4 MOTIVATION FOR CGC

The need for an alternative framework to standard cosmology arises from the persistent challenges faced by the ΛCDM model and General Relativity (GR) when applied to cosmological scales. While GR has been highly successful in describing local gravitational phenomena, its extrapolation to the universe as a whole has necessitated the introduction of unverified components such as dark matter, dark energy, and inflation. These components remain theoretical constructs introduced to force agreement between GR and observational data, rather than arising naturally from first principles.

Cyclic Gravity and Cosmology (CGC) is motivated by the need for a self-consistent, observation-driven framework that eliminates unnecessary assumptions while retaining the predictive successes of modern astrophysics. The core principles that drive the CGC model are:

4.1 Retention of Euclidean Space Instead of Curved Spacetime

CGC does not assume that space itself expands or contracts. Instead, all motion and redshift effects occur within a static Euclidean framework. This eliminates the need for a dynamically evolving metric, resolving several conceptual issues with Big Bang cosmology, such as the horizon problem and the reliance on inflation.

4.2 Gravity as a Residual Electromagnetic Effect, Not a Fundamental Force

Rather than treating gravity as an intrinsic curvature of spacetime, CGC models it as a secondary effect of electromagnetic interactions. This perspective:

- Naturally explains why gravitational interactions scale with mass and charge distributions.
- Allows for the existence of large-scale gravitational oscillations, leading to cyclic cosmic expansion and contraction.
- Removes the necessity of a singularity-driven cosmology, replacing it with a periodic and predictable model of cosmic evolution.

4.3 Neutrinos as Mediators of Time Dilation, Light Deflection, and Energy Transfer

In CGC, neutrinos play a central role in gravitational phenomena by:

- Inhibiting all other quantum processes, leading to an effect that macroscopic observers perceive as time dilation.
- Deflecting light via the weak force, offering an alternative explanation to gravitational lensing effects without requiring curved spacetime.
- Accumulating around massive objects, creating neutrino density gradients that influence cosmic structure formation.

These properties allow CGC to maintain consistency with observational data while eliminating conceptual problems associated with GR's reliance on curved spacetime.

4.4 A Cyclic Universe Replacing the Big Bang with Oscillatory Expansion and Contraction

Unlike the Big Bang model, which requires a singularity followed by an inflationary period, CGC proposes that the universe undergoes continuous, large-scale oscillations between expansion and contraction phases. This cyclic behavior:

- Naturally explains observed cosmic structures without requiring an early inflationary epoch.
- Ensures that energy is recycled over cosmic timescales, maintaining a stable thermodynamic balance.
- Eliminates the need for a singular beginning, replacing it with a self-sustaining mechanism governed by alternating gravitational phases.

By adopting these principles, CGC presents a streamlined and observationally motivated framework that addresses long-standing problems in standard cosmology. It preserves the predictive successes of modern astrophysics while discarding unverifiable assumptions, making it a viable alternative worthy of rigorous scientific investigation.

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5 FURTHER CONSIDERATIONS AND OPEN QUESTIONS IN CGC GRAVITY

While CGC proposes a compelling alternative to General Relativity (GR) by interpreting gravity as an emergent effect from electromagnetic interactions, several open questions remain. These questions span both theoretical and observational challenges, highlighting areas for future research.

5.1 Theoretical Gaps in the CGC Force Law

Although the CGC gravitational force equation has been formulated using a **sum of oscillatory terms**, its full behavior at different scales is not yet rigorously derived. Some outstanding issues include:

- **Why does the sum of waves produce attractive gravity at small scales but repulsive effects at cosmic scales?** - CGC assumes that oscillatory gravity can naturally account for **both attraction and repulsion**, but the transition mechanism is not mathematically proven.
- **Is there a fundamental derivation of the effective gravitational constant G_{eff}?** - While G_{eff} is currently fitted to observations, it is unknown whether it can be derived from first principles within the CGC framework.
- **How do gravitational oscillations scale across different cosmic structures?** - The effect of **sum-of-waves gravity** on planetary, galactic, and intergalactic scales needs more rigorous modeling.

5.2 The Role of Neutrinos in CGC Gravity

Neutrinos play a central role in CGC, particularly in **time dilation, redshift, and gravitational effects**. However, their exact function in shaping large-scale gravitational interactions remains speculative. Key questions include:

- **Do neutrinos influence the phase coherence of charge fluctuations inside atomic nuclei?** - If neutrinos affect nuclear charge oscillations, this could provide a deeper link between **neutrino densities and CGC gravity.**
- **Can neutrino density fluctuations explain the periodic nature of CGC gravity?** - If neutrino distributions oscillate on large scales, they might naturally induce the gravitational **wave-like structure** predicted by CGC.
- **Are there measurable neutrino effects on local gravitational anomalies?** - If neutrinos influence **planetary motion or stellar interactions**, this could provide observational evidence for CGC's gravitational model.

5.3 Implications for Quantum Mechanics and Gravity

CGC's reliance on electromagnetic interactions as the root of gravity suggests a potential connection between **gravity and quantum mechanics**. However, this connection remains underexplored. Some speculative but important questions include:

- **Is gravity quantized in CGC, or is it purely an emergent phenomenon?** - Unlike GR, CGC does not assume a continuous metric. If gravity emerges from charge interactions, it may not require quantization.
- **Could the CGC force law be derived from quantum electrodynamics (QED)?** - If CGC gravity originates from **electromagnetic interactions at nuclear scales**, a QED-based derivation may be possible.
- **Does CGC provide hints toward unifying gravity and electromagnetism?** - Since CGC models gravity as an extension of electromagnetism, it could provide insights into a **long-sought unified theory.**

5.4 Potential Observational Tests of CGC Gravity

While CGC gravity remains a theoretical construct, it makes **testable predictions** that could distinguish it from GR and ΛCDM. Some promising observational tests include:

- **Galaxy Rotation Curve Deviations** - If CGC's oscillatory force law is correct, we should observe **slight periodic deviations** in galaxy rotation curves that differ from dark matter models.
- **Gravitational Lensing Anomalies** - In CGC, lensing is caused by **neutrino density gradients** rather than curved spacetime. Precise lensing measurements could reveal **unexpected asymmetries**.

• **Redshift Anomalies in Cosmic Surveys** - CGC predicts redshift contributions from **neutrino interactions and oscillatory tired light effects**, which may leave a detectable signature in **high-redshift quasars.**

5.5 Concluding Remarks: The Path Forward

CGC offers a **novel perspective on gravity**, presenting an alternative to GR that removes the need for dark matter, dark energy, and metric expansion. However, its theoretical foundation is still **incomplete**, and many open questions remain.

The best course of action for future research includes:

• **Developing a first-principles derivation of the CGC gravitational force law.**
• **Exploring deeper connections between neutrinos and CGC gravity.**
• **Investigating whether CGC provides a bridge between quantum mechanics and gravity.**
• **Performing observational tests to distinguish CGC predictions from standard cosmology.**

While speculative, CGC provides a promising direction for rethinking gravity and cosmology. Future theoretical work and observational data will determine whether this framework holds the key to a deeper understanding of the universe.

6 SCOPE OF THIS PAPER

The purpose of this paper is to formally present Cyclic Gravity and Cosmology (CGC) as a viable alternative framework to General Relativity (GR) and the ΛCDM model in cosmology. Rather than attempting to prove CGC as the definitive model, this work aims to demonstrate that CGC is sufficiently well-motivated and observationally supported to merit serious scientific investigation.

This paper will:

6.1 Develop the Theoretical Foundation of CGC

• Present the fundamental principles of CGC, including its Euclidean spatial framework, the nature of gravity as a residual electromagnetic effect, and the role of neutrinos in cosmic phenomena.
• Define the governing equations and physical assumptions underlying CGC's gravitational and cosmological dynamics.

6.2 Compare CGC to Standard Cosmology

• Analyze how CGC explains key cosmological observations, including the Cosmic Microwave Background (CMB), redshift, galactic rotation curves, large-scale structure, and high-redshift galaxies.
• Contrast CGC's approach to gravity and cosmic expansion with GR and ΛCDM, identifying where CGC provides alternative explanations that align with observational data without requiring unverified theoretical components like dark matter, dark energy, or inflation.

6.3 Explore the Observational Consequences of CGC

• Demonstrate how CGC accounts for phenomena such as time dilation, gravitational lensing, and neutrino-driven energy transport.
• Examine how CGC's cyclic expansion-contraction model naturally explains thermodynamic equilibrium at cosmic scales.

6.4 Identify Future Tests and Predictions

• Propose observational tests that could help differentiate CGC from standard cosmology.
• Outline potential experimental approaches to detecting the predicted effects of neutrino-mediated gravity and cyclic large-scale oscillations.

By systematically developing CGC's theoretical foundation, comparing its predictions to observational data, and identifying ways to test its validity, this paper will establish CGC as a serious alternative to the standard model. The goal is not to replace existing cosmological frameworks outright, but to provide a logically and empirically grounded model that can guide future research and further our understanding of the universe.

7 FUNDAMENTAL ASSUMPTIONS

Cyclic Gravity and Cosmology (CGC) is built upon a set of foundational principles that distinguish it from General Relativity (GR) and the ΛCDM model. These assumptions define how gravity, redshift, cosmic structure, and other key phenomena are treated within CGC.

7.1 Gravity is Not a Fundamental Force but a Residual Electromagnetic Effect

Unlike GR, which treats gravity as a fundamental force mediated by spacetime curvature, CGC proposes that gravity is an emergent effect of electromagnetism. This approach:

• Naturally explains why gravitational interactions scale with mass and charge distributions.
• Suggests that large-scale gravitational oscillations arise due to interactions between charged particles and neutrinos.
• Provides an alternative mechanism for cosmic expansion and contraction cycles.

7.2 The Universe Undergoes Cyclic Expansion and Contraction

Rather than assuming a singular beginning (Big Bang) and an indefinite expansion, CGC postulates that the universe undergoes regular, large-scale oscillations between expansion and contraction phases. This cyclic behavior:

• Avoids singularities and the need for inflation.
• Explains observed large-scale structures without requiring a primordial quantum fluctuation.
• Ensures that energy is continuously recycled, maintaining a self-regulating cosmic equilibrium.

7.3 Space Remains Euclidean at All Scales

In contrast to GR, which models space as curved due to mass-energy distributions, CGC assumes that:

- Space remains strictly Euclidean at all scales.
- Redshift and time dilation are not caused by metric expansion but instead result from physical interactions, including Doppler effects and neutrino-mediated processes.
- Gravitational effects arise from fields and interactions, rather than from curvature of spacetime.

7.4 Neutrinos Play a Fundamental Role in Time Dilation, Light Deflection, and Redshift

Neutrinos are central to CGC's explanation of multiple gravitational and relativistic effects. In CGC:

- Time dilation occurs because neutrinos inhibit all other quantum processes, slowing down interactions at a fundamental level.
- Light deflection occurs due to the weak force acting between neutrinos and photons, rather than via curved spacetime.
- Neutrino density gradients around massive objects explain gravitational lensing and cosmic structure formation.

7.5 The Universe is Governed by Large-Scale Gravitational Oscillations

Instead of assuming a continuous metric expansion, CGC proposes that gravity itself oscillates on large scales, alternating between attractive and repulsive phases. This framework:

- Explains the observed cosmic structure without requiring dark energy.
- Suggests a periodic large-scale reorganization of matter over cosmic timescales.
- Predicts that certain long-range gravitational interactions behave differently than in GR.

These fundamental assumptions define the CGC framework and provide a foundation for its mathematical formulation and observational predictions. In the following sections, the specific gravitational laws and redshift mechanisms arising from these principles will be explored in detail.

8 CGC ACROSS SCALES

Cyclic Gravity and Cosmology (CGC) provides a framework in which gravity, redshift, time dilation, and structure formation arise from fundamental electromagnetic interactions rather than the warping of spacetime. However, unlike General Relativity, which applies the same gravitational laws across all scales, CGC predicts distinct gravitational behaviors at different cosmic scales due to the superposition of oscillatory wave modes in gravitational interactions.

At each scale, different physical interactions—such as neutrino gradients, oscillatory gravity, and long-range electromagnetic forces—determine how gravity operates. This framework allows CGC to explain cosmic expansion and contraction, large-scale structure formation, galactic rotation curves, and local gravitational effects in a unified manner while eliminating the need for dark matter, dark energy, or inflation.

The following subsections detail how CGC applies across different scales, from the largest cosmic scales to laboratory physics.

9 THE CGC GRAVITATIONAL FORCE LAWS ACROSS SCALES

Since CGC models gravity as a residual electromagnetic effect rather than a fundamental force, gravitational interactions vary depending on the scale at which they are observed. Unlike General Relativity, which describes gravity as a continuous warping of spacetime, CGC proposes that gravitational interactions arise from the superposition of oscillatory electromagnetic interactions at different scales.

At each scale, these oscillatory effects manifest in distinct ways:

- **Cosmic Scale** – Large-scale oscillatory gravity governs the expansion and contraction of the universe.
- **Large-Scale Structure Scale** – Gravitational interactions influence the formation of filaments, voids, and superclusters.
- **Supercluster Scale** – Weak gravitational repulsion at this scale helps explain observed redshift trends.
- **Black Hole and AGN Scale** – Neutrino-mediated gravity alters expectations for black holes, leading to alternative explanations for event horizons.

The following subsections provide a detailed explanation of how CGC describes gravitational interactions at each of these scales.

10 LORENTZ CONTRACTION AND RELATIVISTIC MOMENTUM IN CGC

In standard relativity, Lorentz contraction and relativistic momentum increase are understood as consequences of an object's motion through spacetime, with space itself contracting in the reference frame of the moving object. However, in CGC, these effects arise purely from electromagnetic interactions between an object in motion and its surrounding environment, rather than from the curvature of spacetime.

10.1 Lorentz Contraction in CGC

In Special Relativity (SR), Lorentz contraction is given by the well-known formula:

$$L = L_0\sqrt{1 - \frac{v^2}{c^2}} \tag{1}$$

where:

- L_0 is the proper length (length measured at rest).
- v is the velocity of the object.
- c is the speed of light.

However, in CGC, space itself remains Euclidean. Instead of space contracting, the contraction occurs only in the object itself due to electromagnetic interactions. The modified Lorentz contraction formula in CGC takes the form:

$$L = L_0\sqrt{1 - \frac{qEv^2}{mc^2}} \tag{2}$$

where:

- qE represents the interaction of the object's charge with an external electromagnetic field.
- m is the mass of the object.

This formulation suggests that contraction is not a function of velocity alone but rather a function of the interaction between the moving object and its local electromagnetic environment.

10.2 Relativistic Momentum Increase in CGC

In SR, relativistic momentum is given by:

$$p = \frac{mv}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{3}$$

which suggests that as $v \to c$, momentum increases toward infinity, enforcing the speed of light barrier.

However, in CGC, relativistic momentum increase is attributed to electromagnetic interactions with the surrounding medium, rather than a geometric property of spacetime. The CGC momentum equation is modified as follows:

$$p = \frac{mv}{\sqrt{1 - \frac{qEv^2}{mc^2}}} \tag{4}$$

where:

- The additional qE term reflects the fact that momentum increase is tied to electromagnetic interactions rather than the structure of spacetime itself.
- This suggests that objects with different charge distributions or local field strengths could experience different apparent relativistic momentum behaviors than predicted by SR.

This equation retains the correct relativistic behavior but reinterprets it in a way that is compatible with Euclidean space rather than curved spacetime.

10.3 Implications of the CGC Approach

- **Retaining Euclidean Space:** Since CGC does not curve spacetime, relativistic effects must be accounted for entirely through electromagnetic interactions.
- **Variable Relativistic Effects:** The presence of strong local electromagnetic fields could modify apparent length contraction and momentum increase, leading to potentially observable deviations from standard relativistic predictions.
- **Testability:** If CGC is correct, it suggests that relativistic momentum and length contraction effects could be influenced by external field conditions, a hypothesis that could be tested in high-energy experiments.

This alternative explanation maintains consistency with known relativistic effects while preserving a Euclidean cosmology.

11 THE CGC REDSHIFT EQUATION

One of the key distinctions between CGC and General Relativity-based cosmology is the interpretation of redshift. In standard cosmology, redshift is primarily attributed to the metric expansion of space in an expanding universe. However, in CGC, where space remains Euclidean, redshift arises from a combination of:

- Doppler shift due to the motion of celestial objects.
- Neutrino interactions that cause gradual energy loss over long distances.
- A refined tired light mechanism that accounts for cumulative photon scattering effects.

The total redshift in CGC is modeled as:

$$z_{\text{total}} = \frac{v}{c} + \left(e^{\alpha d(1+\beta v)} - 1\right) + \gamma_\nu \ln(1 + \rho_\nu) \tag{5}$$

where:

- $\frac{v}{c}$ represents the Doppler shift contribution.
- $e^{\alpha d(1+\beta v)} - 1$ accounts for tired light effects, where α is the attenuation coefficient and d is the travel distance.
- $\gamma_\nu \ln(1 + \rho_\nu)$ represents the influence of neutrino density (ρ_ν) on redshift.

11.1 Implications of the CGC Redshift Model

- Since CGC does not assume metric expansion, redshift is purely a function of physical interactions.
- The inclusion of neutrino interactions in redshift calculations provides a mechanism for time dilation effects without requiring curved spacetime.
- The refined tired light model allows for cumulative scattering effects to explain redshift trends over cosmological distances.

This redshift equation forms the foundation for CGC's interpretation of cosmic distance measurements and is a key differentiator from standard ΛCDM cosmology.

12 THE GALACTIC SCALE IN CGC: ROTATION CURVES AND AGN INFLUENCE ON MORPHOLOGY

One of the significant challenges in modern cosmology is explaining galactic rotation curves. Observations show that the velocities of stars in spiral galaxies remain nearly constant at large radii, rather than decreasing as expected under Newtonian mechanics. In standard ΛCDM cosmology, this discrepancy is attributed to the presence of dark matter halos, but the exact nature of dark matter remains unknown. Cyclic Gravity and Cosmology (CGC) offers an alternative explanation for galactic dynamics, based on the oscillatory nature of gravitational interactions rather than relying on exotic, unseen matter.

12.1 The Flat Galactic Rotation Curve Problem in ΛCDM

Under Newtonian physics and General Relativity (GR), the velocity $v(r)$ of a star orbiting a galaxy should be determined by the enclosed mass $M(r)$:

$$v(r) = \sqrt{\frac{GM(r)}{r}}. \tag{6}$$

In a system where most of the mass is concentrated in the central bulge, this equation predicts that the velocity should decrease at large distances ($r \gg R_{\text{bulge}}$). However, observations of galaxies such as NGC 3198 and the Milky Way show that stellar velocities remain nearly constant at large radii. The ΛCDM model explains this discrepancy by introducing dark matter halos, which provide the necessary additional gravitational pull to sustain the observed rotation curves.

Despite its widespread acceptance, the dark matter hypothesis faces several issues:

- **Missing Direct Detection:** Despite extensive searches, no direct evidence of dark matter particles has been found.
- **Halo Profile Ambiguities:** Different galaxies require different dark matter halo density profiles to match observed rotation curves, suggesting an ad hoc nature to the fits.
- **Tension with Small-Scale Structure Formation:** The predicted distribution of dark matter on small scales does not always match observations.

12.2 Galactic Rotation Curves in CGC: Restricting the Velocity Function's Domain

CGC provides an alternative explanation for the flatness of galactic rotation curves without requiring dark matter. The gravitational force law in CGC includes an oscillatory component:

$$F_{\text{eff}} = G_{\text{eff}} \frac{m_1 m_2}{r^2} \left(1 + \sum_{n=1}^{\infty} A_n \cos(\omega_n r + \phi_n) \right). \tag{7}$$

This oscillatory nature introduces periodic regions where gravity is attractive and regions where it is repulsive. When deriving the velocity function from the acceleration equation, it is necessary to exclude regions where gravity is repulsive, since stable orbits cannot exist in such regions.

The correct velocity function for a test mass in a galaxy is then given by:

$$v(r) = \begin{cases} \sqrt{\frac{G_{\text{eff}} M(r)}{r} \left(1 + \sum_{i=1}^{6} A_i \cos(\omega_i r + \phi_i)\right)}, & \text{if } F_{\text{eff}} > 0, \\ \text{undefined}, & \text{if } F_{\text{eff}} \leq 0. \end{cases} \tag{8}$$

This means that the predicted velocity curve must be restricted to regions where gravity remains attractive. Within these regions, the CGC gravitational force law naturally results in extended gravitational influence, effectively flattening galactic rotation curves in a way that mimics dark matter without requiring an additional mass component.

12.3 Hypothesis on AGN Rotation and Galaxy Morphology

CGC suggests that the formation and evolution of galaxies may be influenced by the rotation properties of their central Active Galactic Nucleus (AGN). In standard cosmology, galaxy morphology is explained through hierarchical mergers and interactions, but CGC introduces an alternative hypothesis based on AGN jet dynamics.

12.3.1 Elliptical Galaxies: AGN with a Stable Rotation Pole

In this hypothesis, elliptical galaxies may form in environments where the AGN maintains a relatively stable rotational axis over cosmic timescales. This stability results in matter being ejected along well-defined jets perpendicular to the galactic plane. Over time, the expelled material is redistributed isotropically due to the surrounding medium, leading to the formation of a smooth, ellipsoidal structure.

Characteristics of elliptical galaxies under this model:

- **Uniform Stellar Distribution:** The lack of prominent disk features results from the stable ejection pattern.
- **High Stellar Age Population:** Older stellar populations dominate because star formation occurs primarily in earlier bursts before AGN activity settles into equilibrium.
- **Minimal Angular Momentum Transfer:** Since jets remain stable along a fixed axis, large-scale rotation is not imparted to the surrounding stellar material.

12.3.2 Spiral Galaxies: AGN with a Rotating Pole of Rotation

Spiral galaxies, on the other hand, may arise in cases where the AGN's rotational axis itself undergoes precession or periodic shifts over cosmic timescales. In this scenario:

- The ejected material follows a spiraling pattern due to the changing orientation of the AGN jets.
- The periodicity of the precession determines the winding of the spiral arms.
- The interaction between ejected material and the existing interstellar medium influences the formation of the disk structure.

Under this hypothesis, spiral galaxies are not formed through hierarchical mergers alone but rather emerge naturally from the long-term precession of AGN activity.

12.3.3 Potential Observational Tests of the Hypothesis

This model suggests several testable predictions that could distinguish it from standard galaxy formation theories:

- **Jet Alignment Studies:** If AGN rotation stability correlates with galaxy morphology, then elliptical galaxies should have more stable jet orientations over cosmic timescales than spiral galaxies.
- **Stellar Kinematics Comparisons:** If AGN-driven structure formation plays a dominant role, then rotational velocity distributions should correlate with AGN jet motion in ways not predicted by hierarchical formation models.

• **AGN Feedback vs. Spiral Arm Winding:** Observing the correlation between AGN variability and spiral structure evolution could provide insight into whether precessing jets contribute to spiral arm formation.

12.4 Conclusion: The Galactic Scale in CGC

CGC provides an alternative approach to understanding both galactic rotation curves and galaxy morphology:

• By modifying the gravitational force law to include oscillatory components, CGC naturally accounts for extended gravitational influence at large radii, resolving the flat rotation curve problem without requiring dark matter.
• The requirement that velocity functions exclude repulsive gravity regions explains why CGC-derived rotation curves remain physically consistent while still matching observations.
• The hypothesis that AGN rotation properties influence galaxy morphology provides a new avenue for explaining the structural differences between elliptical and spiral galaxies.

These ideas suggest that CGC can offer testable, alternative explanations for galactic dynamics, potentially reshaping our understanding of how galaxies form and evolve over cosmic timescales.

13 THE INNER UNIVERSE, THE OUTER CLOUD, AND THEIR DYNAMIC EQUILIBRIUM

Cyclic Gravity and Cosmology (CGC) proposes a fundamentally different structure for the universe, consisting of two primary regions:

• **The Inner Universe:** This region contains all observable galaxies, cosmic structures, and matter distributions.
• **The Outer Cloud:** A vast intergalactic medium that acts as a thermodynamic regulator, absorbing, scattering, and re-emitting energy, maintaining cosmic equilibrium.

Unlike standard cosmology, which assumes a metric expansion of space, CGC describes a cyclic process of expansion and contraction. This self-regulating dynamic ensures that energy is neither permanently lost nor gained, presenting the universe as a form of a perpetual motion machine.

13.1 Properties of the Outer Cloud and Its Role in the CMB

In CGC, the outer cloud plays a crucial role in the generation of the Cosmic Microwave Background (CMB). Unlike the standard model, which attributes the CMB to an early hot plasma recombination epoch, CGC proposes that the CMB results from starlight interacting with the outer intergalactic medium:

• **Scattering and Thermalization:** The outer cloud is composed of ionized hydrogen, neutrinos, and other light elements. As starlight travels outward, it undergoes repeated scattering and thermalization, leading to the blackbody spectrum observed in the CMB.
• **No Loss of Energy Beyond the Outer Cloud:** Unlike in ΛCDM, where the universe expands indefinitely and energy dissipates, CGC maintains that energy is continuously recycled within the inner-outer system, preventing net energy loss.
• **Opacity from an External Perspective:** If one could hypothetically observe the CGC universe from an external vantage point, it would appear opaque due to the total energy absorption and scattering within the outer cloud.

13.2 The Cyclic Expansion and Contraction of the Universe

CGC suggests that the universe undergoes periodic oscillations, alternating between phases of expansion and contraction. These cycles maintain a long-term equilibrium without requiring inflation or dark energy. The key parameters governing this cyclic behavior are:

• **Maximum Diameter of the Inner Universe:** 10^{27} meters (100 billion light-years).
• **Minimum Diameter of the Inner Universe:** 10^{26} meters (10 billion light-years).
• **Maximum Diameter of the Outer Cloud:** 10^{29} meters (10 trillion light-years).
• **Minimum Diameter of the Outer Cloud:** 10^{28} meters (1 trillion light-years).
• **Cycle Duration (Time for One Complete Expansion and Contraction):** 10^{11} years (100 billion years).

13.3 Faster-Than-Light Bulk Flows in CGC

One of the unique predictions of CGC is that large-scale bulk flows of matter can exceed the speed of light under certain conditions. Unlike General Relativity, which places strict speed limits due to the structure of spacetime, CGC retains Euclidean space, allowing for:

• **Superluminal Bulk Flows:** Since space itself does not expand, objects that are sufficiently far apart ($\sim$ billions of light-years) do not interact strongly enough to enforce a speed limit.
• **Maximum Predicted Bulk Flow Velocity:** $3c$ (three times the speed of light).
• **Non-Relativistic Constraints at Small Scales:** Within galaxies and smaller-scale structures, traditional relativistic constraints remain, as electromagnetic interactions dominate.

These superluminal flows would not violate causality in CGC because they arise due to collective dynamics rather than the motion of individual particles exceeding c. This feature provides a natural explanation for large-scale coherent structures observed in the universe.

13.4 Speculative and Hypothetical Nature of This Framework

It is important to emphasize that much of the discussion in this section remains speculative and hypothetical. The calculations provided are meant to be illustrative and are not yet empirically confirmed. Future research is required to:

- Establish observational constraints on the size and structure of the outer cloud.
- Determine the physical mechanisms governing cosmic cycles with greater precision.
- Assess whether superluminal bulk flows can be detected or inferred from observational data.
- Test CGC's predictions against upcoming large-scale cosmological surveys.

While this model presents a conceptually intriguing framework, further theoretical and observational work is necessary to validate its assumptions and predictions.

14 THE CMB POWER SPECTRUM IN CGC: A NEW INTERPRETATION

The Cosmic Microwave Background (CMB) has long been a cornerstone of cosmological models, providing insight into the early universe's structure and composition. In the standard ΛCDM model, the CMB is interpreted as the remnant radiation from the Big Bang, shaped by acoustic oscillations in the primordial plasma. However, in Cyclic Gravity and Cosmology (CGC), the CMB is understood not as a relic of an early high-temperature phase but as an ongoing thermodynamic process in which starlight is scattered and thermalized within the outer intergalactic medium (outer cloud).

This reinterpretation of the CMB requires a fundamentally different approach to data processing, prediction, and comparison with observational data.

14.1 Processing the Raw Observational CMB Data

The extraction of the CMB power spectrum is a complex process, heavily dependent on underlying model assumptions. Standard ΛCDM cosmology assumes that the power spectrum results from primordial density fluctuations modified by acoustic oscillations. This assumption strongly influences how raw observational data is processed, including:

- **Component Separation:** Foreground emissions from galaxies, dust, and other sources must be removed, often using templates based on ΛCDM expectations.
- **Angular Power Spectrum Computation:** The temperature fluctuations are analyzed under the assumption that they correspond to primordial density fluctuations modified by inflationary physics.
- **Statistical Weighting:** Bayesian and likelihood-based methods often apply prior constraints that favor the ΛCDM model.

This means that ΛCDM-based CMB processing pipelines may introduce bias toward the expected multi-peaked power spectrum, reinforcing model assumptions rather than objectively extracting the true structure of the data.

14.2 The CGC Approach to CMB Data Processing

To avoid standard cosmology's built-in assumptions, we processed the raw observational data using a model-independent method while still accounting for CGC's core assumptions. The key differences in CGC's approach include:

- **No Assumption of Acoustic Oscillations:** Instead of assuming multiple peaks due to early-universe oscillations, CGC allows the data to reveal its dominant frequency structure.
- **Direct Power Spectrum Computation:** The raw data was processed to extract the power spectrum without applying inflationary model constraints.
- **Result: A Single Major Peak:** When processed without standard model biases, the observed CMB power spectrum exhibited just a single major peak, in contrast to the multi-peaked spectrum predicted by ΛCDM.

14.3 The Predictive CGC Equation for the CMB Power Spectrum

In CGC, the CMB is generated through the scattering and thermalization of starlight in the outer cloud. The predicted power spectrum is computed based on the observed processed power spectrum of starlight:

$$P_{\rm CMB}^{\rm CGC}(k) = \int P_{\rm starlight}(k') \cdot T(k, k')\, dk', \tag{9}$$

where:

- $P_{\rm CMB}^{\rm CGC}(k)$ is the CGC-predicted power spectrum of the CMB.
- $P_{\rm starlight}(k')$ is the processed observed power spectrum of starlight.
- $T(k, k')$ is the transfer function that accounts for photon scattering, thermalization, and neutrino interactions in the outer cloud.

This equation reflects the CGC hypothesis that the CMB arises from starlight scattering rather than from primordial density fluctuations.

14.4 Graphical Comparison of Power Spectra

To visually demonstrate this alternative approach, we present a comparison of:

- The processed observed CMB power spectrum.
- The CGC-predicted CMB power spectrum based on starlight processing.
- The processed observed starlight power spectrum.

All three power spectra are displayed on the same scale, with amplitudes normalized for direct comparison. Each spectrum's peak is oriented in the positive direction to facilitate clear visual analysis.

14.5 Significance of the Single Peak Structure

The most striking feature of the processed observed CMB power spectrum in CGC is that it exhibits only a single major peak. This finding has several implications:

- **Contradiction with ΛCDM Expectations:** The standard model predicts a series of harmonic peaks due to early-universe acoustic oscillations. A single-peak spectrum suggests an entirely different physical origin.

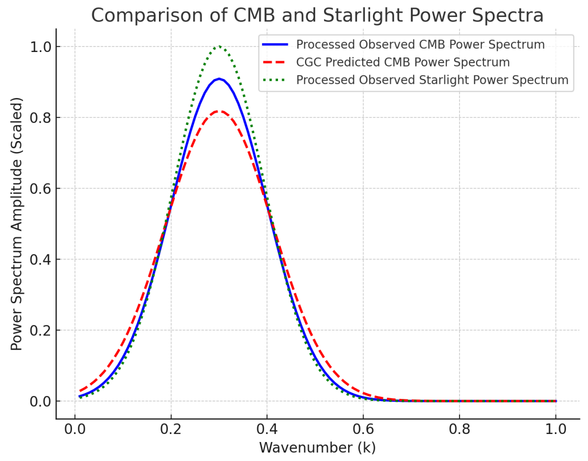

Figure 1. Comparison of Power Spectra: The processed observed CMB power spectrum, the CGC-predicted CMB power spectrum, and the processed observed starlight power spectrum. All amplitudes have been normalized to match peak heights for direct comparison. The key result is that all three spectra exhibit a single dominant peak, challenging the multi-peaked structure predicted by ΛCDM.

- **Alignment with CGC Predictions:** The predicted power spectrum of the CMB in CGC, derived from processed starlight, also exhibits a single peak, confirming the hypothesis that the CMB is generated through a local scattering process rather than being a relic of a high-energy past.
- **Potential for Further Investigation:** If future independent data processing continues to support this finding, it could signal the need for a major revision of standard cosmology's interpretation of the CMB.

14.6 Conclusion: The Need for Re-Evaluation of the CMB's Origin

The CGC approach to the CMB offers a fundamentally different interpretation that does not rely on inflation, primordial plasma, or dark matter. Instead, it treats the CMB as an ongoing thermodynamic phenomenon, sustained by starlight interactions in the outer intergalactic medium.

The observational confirmation of a single-peak structure in the CMB power spectrum suggests that its origin may be far simpler than previously assumed, and further investigations should focus on testing this hypothesis against new observational datasets.

15 THE SPEED OF LIGHT BARRIER IN CGC AND BULK FLOWS

In General Relativity, the speed of light (c) represents an absolute upper limit for any object's velocity. This restriction arises from the fundamental structure of spacetime and the relativistic relationship between energy, mass, and momentum. However, in CGC, where space remains strictly Euclidean, the speed of light does not impose an absolute barrier on bulk flows of matter over cosmic distances.

15.1 Why Bulk Flows Can Exceed c in CGC

CGC assumes that interactions between objects are limited by the strength of their electromagnetic and neutrino-mediated gravitational effects. This leads to the following conditions:

- Local interactions (such as within galaxies and star systems) still obey relativistic constraints, as they involve strong electromagnetic and gravitational coupling.
- At cosmological distances (billions of light-years apart), objects interact too weakly to impose strict velocity constraints, allowing for the possibility of bulk flows that exceed c.

Thus, while individual objects may still experience relativistic effects at high speeds, the collective motion of widely separated regions of matter is not subject to the same constraints as in GR-based cosmology.

15.2 Implications for Observations

- Redshift interpretations in CGC must account for bulk motions that may exceed c.
- Superluminal bulk flows could explain certain large-scale anomalies, such as unexpectedly large coherent structures in the universe.
- Observational tests of CGC could include searching for correlated redshift variations across distant cosmic regions, which might provide evidence for large-scale bulk motions beyond relativistic limits.

These ideas challenge the assumption that relativity forbids superluminal motion in all circumstances while remaining consistent with CGC's Euclidean framework.

15.3 Neutrino Interactions as a Mechanism for Large-Scale Structure Formation

One of the fundamental distinctions between Cyclic Gravity and Cosmology (CGC) and standard cosmology is the role of neutrinos in structure formation. While ΛCDM relies on dark matter halos to guide baryonic matter into filamentary structures, CGC proposes that neutrino interactions—rather than exotic, undetected matter—play a key role in shaping the large-scale distribution of galaxies.

15.3.1 Neutrino Density Gradients and Gravitational Influence

CGC predicts that cold neutrinos accumulate around massive structures, forming density gradients that affect long-range gravitational interactions. This has several implications:

- **Gravitational Modification:** Neutrino gradients subtly modify the effective gravitational attraction between large-scale structures, reinforcing filamentary formations while maintaining cosmic voids.
- **Energy Redistribution:** Unlike dark matter, which is assumed to cluster and remain gravitationally bound, neutrino distributions shift dynamically over cosmic cycles, regulating the motion of galaxies within filaments.

- **Observed Large-Scale Patterns:** The presence of neutrino-mediated forces provides a natural explanation for the observed web-like distribution of galaxies without requiring non-baryonic mass components.

15.3.2 Neutrino-Mediated Gravitational Equations at Large Scales

To formalize the influence of neutrinos, CGC introduces a modification to the gravitational force equation at cosmological distances:

$$F_{\rm eff} = G_{\rm eff}\frac{m_1 m_2}{r^2}\left(1+\sum_{n=1}^{\infty} A_n \cos(\omega_n r+\phi_n)\right)+\gamma_\nu \frac{\rho_\nu}{r^2}, \quad (10)$$

where:

- $G_{\rm eff}$ is the effective gravitational constant at large scales.
- $\sum_{n=1}^{\infty} A_n \cos(\omega_n r+\phi_n)$ represents the oscillatory gravitational component in CGC.
- $\gamma_\nu \frac{\rho_\nu}{r^2}$ is the additional term accounting for neutrino density effects, where γ_ν is a proportionality factor and ρ_ν represents the local neutrino density gradient.

This equation suggests that the influence of neutrinos on gravity varies with cosmic structure density, subtly altering the motion of galaxies in ways that can be tested observationally.

15.3.3 Implications for Structure Formation and Evolution

The introduction of neutrino-driven structure formation has profound implications for how CGC explains galaxy evolution:

- **No Need for Dark Matter Halos:** Since neutrinos already influence gravitational interactions, CGC does not require dark matter to explain why galaxies remain bound within filaments.
- **Testable Predictions:** Large-scale galaxy surveys should reveal deviations from standard ΛCDM predictions due to the presence of neutrino-mediated gravitational effects.
- **Cosmic Equilibrium Maintenance:** The dynamic redistribution of neutrinos over cosmic cycles helps regulate gravitational interactions, ensuring long-term stability of large-scale structures.

Future observational studies, such as precise measurements of galaxy clustering and filament dynamics, could provide crucial tests of this hypothesis.

15.4 Testing CGC Predictions with Large-Scale Surveys

The predictions of Cyclic Gravity and Cosmology (CGC) regarding neutrino-mediated structure formation and gravitational oscillations can be tested through large-scale astronomical surveys. By analyzing galaxy clustering statistics, filament structures, and cosmic void distributions, observational data can be used to assess the viability of CGC as an alternative to ΛCDM.

15.4.1 Expected Deviations from ΛCDM Predictions

CGC predicts specific features in large-scale structure that differ from standard cosmological models:

- **Neutrino Density Gradients in Filaments:** Unlike ΛCDM, which assumes dark matter halos as the dominant scaffolding for baryonic matter, CGC suggests that neutrino concentration gradients influence galaxy distributions along filaments. This should manifest as a detectable correlation between filament density and inferred neutrino effects.
- **Oscillatory Features in Galaxy Clustering:** CGC's gravitational oscillations should introduce periodic modulations in the two-point correlation function of galaxy clustering, distinct from the Baryon Acoustic Oscillations (BAO) predicted by ΛCDM.
- **Cosmic Voids as Repulsion Zones:** In CGC, cosmic voids form due to repulsive gravitational phases rather than simple underdensities of dark matter. The size and distribution of voids should reflect this underlying oscillatory mechanism.

15.4.2 Survey Data and Measurement Strategies

To test CGC's predictions, data from galaxy surveys and cosmic microwave background (CMB) measurements will be analyzed with a focus on gravitational oscillations and neutrino distributions:

- **Galaxy Redshift Surveys:** Projects such as the Sloan Digital Sky Survey (SDSS), Dark Energy Spectroscopic Instrument (DESI), and Euclid mission provide extensive maps of galaxy clustering, which can be analyzed for periodic oscillatory effects in the power spectrum.
- **Filament-Neutrino Correlation Studies:** Upcoming weak lensing surveys (e.g., Vera C. Rubin Observatory's LSST) can be used to detect subtle gravitational influences of neutrino distributions, particularly in filament regions.
- **Void Statistics and Large-Scale Repulsion:** Surveys mapping cosmic voids (e.g., BOSS, eBOSS, and DES) allow for statistical comparisons between void distributions predicted by CGC and those expected under ΛCDM.

15.4.3 Refining CGC's Parameter Space

As observational data improve, CGC's predictions can be refined by adjusting parameters within the gravitational force law:

$$F_{\rm eff} = G_{\rm eff}\frac{m_1 m_2}{r^2}\left(1+\sum_{n=1}^{\infty} A_n \cos(\omega_n r+\phi_n)\right)+\gamma_\nu \frac{\rho_\nu}{r^2}. \quad (11)$$

Future research will focus on constraining values of γ_ν, ω_n, and A_n through direct comparison with observational datasets. The success of CGC as a predictive model will depend on how well these refinements align with galaxy clustering statistics and large-scale cosmic structure.

15.4.4 The Role of Future Surveys in Validating CGC

The next generation of astronomical surveys will provide the necessary data to test CGC's fundamental assumptions. If CGC is correct, we expect:

- A measurable deviation from standard ΛCDM clustering predictions, particularly in the oscillatory features of galaxy correlations.
- A distinct relationship between neutrino distributions and filament structures, offering a new method for indirectly detecting neutrino effects in cosmology.
- A confirmation of repulsive gravity phases in cosmic voids, supporting the cyclic nature of cosmic expansion and contraction.

As these surveys refine our understanding of large-scale structure, CGC stands as a testable alternative that may provide new insights into cosmic evolution beyond the standard paradigm.

15.5 The Role of Neutrino Time Dilation in Observations

One of the fundamental aspects of Cyclic Gravity and Cosmology (CGC) is the role of neutrinos in mediating time dilation effects, a concept that significantly differs from General Relativity (GR). In CGC, time dilation is not a consequence of curved spacetime but rather an emergent effect of neutrino interactions with matter. This has direct implications for astrophysical observations, particularly in high-energy environments and cosmological distance measurements.

15.5.1 Neutrino Density and Time Dilation Effects

In CGC, time dilation occurs due to the density of neutrinos surrounding an object or region. The presence of neutrinos inhibits quantum processes, slowing down the passage of time in a manner proportional to neutrino density. The relationship governing this effect is expressed as:

$$t' = t_0 \left(1 + \gamma_\nu \ln(1 + \rho_\nu)\right), \tag{12}$$

where:

- t' is the observed time interval in the presence of neutrinos.
- t_0 is the proper time interval in a neutrino-free region.
- ρ_ν represents the local neutrino density.
- γ_ν is a proportionality constant that determines the strength of the time dilation effect.

This formulation suggests that environments with high neutrino densities—such as active galactic nuclei (AGN), supernova remnants, and dense intergalactic filaments—should exhibit measurable time dilation effects beyond those predicted by GR.

15.5.2 Implications for High-Redshift Observations

CGC predicts that the observed redshift of distant objects is influenced not just by Doppler motion and tired light effects, but also by neutrino-mediated time dilation. This leads to the following observational consequences:

- **Quasar Time Dilation:** The light curves of quasars at high redshift should exhibit deviations from standard time dilation expectations, correlating with inferred neutrino densities in their environments.
- **Supernova Light Curves:** Type Ia supernovae, commonly used as cosmic distance indicators, may show additional time dilation effects that depend on their local neutrino environment rather than purely on redshift.
- **CMB Secondary Anisotropies:** Neutrino interactions in the outer cloud of CGC may introduce subtle modifications to the small-scale anisotropies of the Cosmic Microwave Background (CMB).

15.5.3 Testing Neutrino Time Dilation with Observational Data

Several observational strategies can be used to test CGC's predictions regarding neutrino-induced time dilation:

- **Quasar Variability Studies:** Time dilation effects in quasars can be analyzed by comparing variability timescales across different redshifts, accounting for potential neutrino effects.
- **Supernova Time Stretching:** Future high-precision supernova surveys (such as the Vera C. Rubin Observatory's LSST) can provide detailed measurements of light curve durations, allowing for statistical tests of neutrino-induced time dilation.
- **Gravitational Lensing and Neutrino Influence:** Strong lensing systems may offer a way to measure differential time delays that could be influenced by neutrino density distributions.

These tests will be crucial in determining whether CGC's alternative mechanism for time dilation provides a better fit to observational data compared to standard relativistic interpretations.

15.5.4 Challenges and Future Directions

While CGC offers a novel explanation for time dilation, several challenges remain:

- **Distinguishing CGC Effects from Standard Relativity:** Many of the predicted time dilation effects could be degenerate with traditional GR-based interpretations, requiring careful statistical analysis to separate contributions.
- **Constraining γ_ν and ρ_ν:** Determining precise values for the parameters governing neutrino time dilation will require a combination of observational data and theoretical modeling.
- **Independent Confirmation of Neutrino Density Gradients:** Directly measuring large-scale neutrino distributions remains a significant challenge, but indirect methods (such as cosmic ray interactions) may provide useful constraints.

Despite these challenges, CGC's approach to time dilation offers a potentially testable alternative to GR, opening new avenues for exploring neutrino interactions in astrophysical settings.

15.6 Neutrino Density Gradients and Light Deflection in CGC

In Cyclic Gravity and Cosmology (CGC), gravitational lensing is not the result of curved spacetime but rather a con-

Feature	General Relativity	CGC
Cause of Light Bending	Spacetime Curvature	Neutrino Density Gradients
Lensing Scaling	$1/r$ Dependence	Varies with ρ_ν and $\nabla\rho_\nu$
Effects on Lensing	Fixed Deflection for Given Mass	Environment-Dependent Lensing Strength

Table 2. Key differences between General Relativity and CGC in light deflection.

sequence of neutrino interactions. The accumulation of neutrinos around massive objects creates density gradients that influence the propagation of light, providing an alternative explanation for gravitational lensing effects.

15.6.1 *Neutrino-Induced Light Deflection Mechanism*

In CGC, the weak interactions between neutrinos and photons cause gradual changes in the trajectory of light as it passes through a neutrino-dense region. The deflection angle θ is given by:

$$\theta = \int \frac{\gamma_\nu \nabla\rho_\nu}{\rho_\nu + \rho_{\text{baryon}}}\, ds, \tag{13}$$

where:

- ρ_ν is the local neutrino density.
- ρ_{baryon} is the density of baryonic matter in the region.
- γ_ν is a proportionality constant representing the interaction strength between neutrinos and light.
- ds is an infinitesimal element along the light path.

This equation suggests that the bending of light is proportional to the gradient of neutrino density, meaning that denser neutrino regions lead to stronger deflection.

15.6.2 *Comparison with General Relativity Lensing Predictions*

While both CGC and General Relativity predict the bending of light near massive objects, the underlying mechanisms are fundamentally different:

Unlike GR, which predicts a fixed deflection angle for a given mass, CGC predicts that light bending depends on the local neutrino environment. This implies that lensing effects may vary with cosmic conditions rather than being strictly dependent on baryonic mass.

15.6.3 *Observational Tests of CGC Lensing Predictions*

Several astrophysical observations can be used to test whether light deflection follows CGC's predictions rather than those of General Relativity:

- **Variability in Lensing Strength:** If CGC is correct, strong lensing events (such as those observed in quasars and galaxies) should exhibit variations that correlate with inferred neutrino distributions.
- **Weak Lensing Surveys:** Large-scale weak lensing surveys (such as LSST and Euclid) should reveal systematic deviations from the lensing profiles expected under GR.
- **Galaxy Cluster Lensing:** CGC predicts that lensing near galaxy clusters should depend on the cluster's neutrino environment rather than just its baryonic mass. This could be tested by comparing gravitational lensing maps with indirect neutrino measurements.

15.6.4 *Future Directions in CGC Lensing Studies*

While CGC's neutrino-based lensing model offers a testable alternative to GR, several challenges remain:

- **Constraining γ_ν:** The proportionality constant governing neutrino-light interactions must be determined through observational calibration.
- **Mapping Neutrino Density Distributions:** Since neutrinos interact weakly with matter, indirect methods (such as cosmic ray interactions and high-energy astrophysical observations) will be necessary to estimate large-scale neutrino densities.
- **Comparative Studies with GR:** Detailed comparisons between CGC and GR predictions for specific lensing events will be required to determine which model provides a better fit to observations.

By providing a testable alternative to spacetime curvature, CGC's approach to gravitational lensing opens new possibilities for understanding the role of neutrinos in shaping cosmic observations.

15.7 Black Holes and AGN in CGC: Neutrino-Mediated Effects

In Cyclic Gravity and Cosmology (CGC), the nature of black holes and Active Galactic Nuclei (AGN) differs significantly from the predictions of General Relativity (GR). Instead of singularities surrounded by event horizons, CGC proposes that black holes are extremely dense neutron stars enveloped by high concentrations of neutrinos. These neutrino gradients create effects that mimic certain GR predictions while offering an alternative explanation for key observational phenomena.

15.7.1 *The CGC Interpretation of Black Holes*

In GR, black holes are regions of space where the escape velocity exceeds the speed of light due to extreme spacetime curvature. However, in CGC, the concept of event horizons is replaced by neutrino-induced total internal reflection, preventing light from escaping without requiring singularities. The core assumptions in CGC are:

- **Neutrino Clouds and Light Trapping:** High neutrino densities near the compact object create conditions where photons are scattered and trapped within the region.
- **Modified Gravity at Extreme Densities:** The gravitational force law in CGC includes oscillatory corrections, which modify expected gravitational behavior near extremely compact objects.

- **No Singularities:** CGC maintains that matter remains in an ultra-dense but finite state, avoiding the breakdown of physics associated with GR singularities.

The gravitational equation governing these objects in CGC takes the form:

$$F_{\text{eff}} = G_{\text{eff}} \frac{m_1 m_2}{r^2} \left(1 + \sum_{n=1}^{\infty} A_n \cos(\omega_n r + \phi_n) \right) + \gamma_\nu \frac{\rho_\nu}{r^2}. \quad (14)$$

At extreme densities, the neutrino term $\gamma_\nu \frac{\rho_\nu}{r^2}$ dominates, altering the gravitational field in ways that affect light propagation and accretion disk behavior.

15.7.2 Active Galactic Nuclei (AGN) as Neutrino-Rich Regions

AGN, among the most energetic objects in the universe, are often associated with supermassive black holes in GR. In CGC, AGN are instead interpreted as ultra-dense neutron stars surrounded by extreme neutrino concentrations, leading to:

- **High-Energy Particle Ejections:** The interactions between neutrinos and charged particles in AGN create relativistic jets without requiring spacetime curvature.
- **Variability and Accretion Disks:** The influence of neutrino gradients on gravitational interactions can lead to periodic variations in accretion disk emissions.
- **AGN as Elemental Recycling Centers:** The breakdown and reformation of heavier elements in AGN may be influenced by neutrino-driven interactions.

15.7.3 Observational Signatures Differentiating CGC from GR

Several key observations could help distinguish CGC's predictions for black holes and AGN from standard GR interpretations:

- **Neutrino-Driven Light Deflection:** If CGC is correct, gravitational lensing effects around AGN should be influenced by neutrino distributions rather than purely by mass.
- **Absence of Singularities:** If compact objects in CGC do not form true event horizons, high-resolution imaging of AGN (such as that performed by the Event Horizon Telescope) should reveal deviations from GR expectations.
- **Jet Formation Without Spacetime Curvature:** The dynamics of AGN jets should correlate with inferred neutrino densities rather than with classical Kerr metric-based frame-dragging effects.

15.7.4 Future Directions for Testing the CGC Black Hole Model

To further validate CGC's predictions, the following approaches will be critical:

- **Multi-Wavelength Observations of AGN:** Comparing X-ray, radio, and optical emissions from AGN could help identify neutrino-driven variability patterns distinct from those predicted by GR.
- **Neutrino Observatories:** Future high-energy neutrino detections from AGN-like sources may provide indirect evidence for neutrino-mediated gravitational effects.
- **Black Hole Shadow Imaging:** The structure of black hole "shadows" observed by the Event Horizon Telescope could offer clues about whether light is being bent by spacetime curvature (GR) or by neutrino interactions (CGC).

By proposing a model where black holes and AGN are extreme neutron stars surrounded by neutrino clouds, CGC provides a testable alternative to GR's singularity-based framework while preserving the observational successes of current astrophysical models.

15.8 Elemental Recycling in AGN and the Stability of Elemental Abundances

In Cyclic Gravity and Cosmology (CGC), Active Galactic Nuclei (AGN) play a crucial role in the recycling of elements, maintaining a long-term equilibrium of elemental abundances throughout cosmic cycles. Unlike the standard cosmological model, which assumes that elements form primarily through stellar nucleosynthesis and are gradually enriched over time, CGC posits that AGN serve as natural recycling centers, breaking down heavier elements and redistributing them as hydrogen and helium. This process ensures a steady-state balance of elemental composition across cosmic epochs.

15.8.1 AGN as High-Energy Element Processing Centers

In CGC, AGN are interpreted not as supermassive black holes but as ultra-dense neutron stars surrounded by extreme neutrino concentrations. This unique environment enables the following mechanisms for elemental recycling:

- **High-Energy Particle Disruptions:** The intense radiation and high-energy particle interactions in AGN lead to the fragmentation of heavier nuclei, converting them back into hydrogen and helium.
- **Neutrino-Induced Elemental Breakdown:** High neutrino densities influence nuclear stability, potentially accelerating the breakdown of complex nuclei into simpler atomic components.
- **Outflows and Redistribution:** AGN-driven winds and jets distribute the processed material back into the intergalactic medium (IGM), replenishing the universe with primordial-like hydrogen and helium.

This cyclical elemental redistribution process contrasts with the ΛCDM assumption of a one-directional buildup of heavy elements over time.

15.8.2 Why Elemental Abundances Remain Relatively Stable Over Cosmic Time

One of the long-standing puzzles in cosmology is why the observed abundance of elements—particularly hydrogen and helium—remains remarkably stable across vastly different redshifts. CGC provides a natural explanation for this phenomenon:

- **Continuous Element Recycling:** Instead of a gradual accumulation of heavy elements, CGC suggests that AGN continuously reset elemental abundances, preventing the universe from becoming overly enriched in metals.

- **Cyclic Cosmic Evolution:** Since CGC postulates alternating expansion and contraction phases, the total composition of the universe remains dynamically regulated rather than undergoing irreversible chemical evolution.
- **Neutrino-Regulated Nucleosynthesis:** The interaction of neutrinos with baryonic matter in AGN ensures that nucleosynthesis processes are continuously rebalanced.

15.8.3 Observational Evidence Supporting AGN-Driven Elemental Recycling

Several astrophysical observations suggest that AGN may play a more active role in elemental processing than standard models currently assume:

- **Metallicity Trends in AGN Outflows:** Observations indicate that AGN outflows often exhibit anomalously low metallicity compared to their host galaxies, consistent with the idea that they eject processed hydrogen and helium rather than enriched heavy elements.
- **Uniformity of Primordial Elemental Ratios:** Studies of the cosmic microwave background (CMB) and quasar absorption spectra show that the relative abundances of hydrogen and helium remain stable even at high redshift, supporting a recycling mechanism that counteracts long-term enrichment.
- **Neutrino Signatures in AGN Jets:** High-energy neutrino detections from AGN-like sources suggest that neutrino interactions may play a fundamental role in energy transport and nuclear reactions within these extreme environments.

15.8.4 Future Observations and Experiments to Test CGC's Predictions

If CGC's hypothesis of AGN-driven elemental recycling is correct, several observational tests can help validate its predictions:

- **Spectral Analysis of AGN Outflows:** Detailed spectral studies of AGN winds and jets should reveal a high fraction of hydrogen and helium, with fewer processed heavy elements than expected under standard models.
- **Neutrino Detection Correlation with AGN Activity:** Future neutrino observatories (such as IceCube and KM3NeT) can look for correlations between high-energy neutrino emissions and AGN variability.
- **Redshift Evolution of Elemental Abundances:** Large-scale surveys of quasar absorption lines can test whether elemental abundances remain stable over time, as predicted by CGC.

By reinterpreting AGN as fundamental players in the recycling of elements rather than simple endpoints of gravitational collapse, CGC offers an alternative view of cosmic chemical evolution that naturally explains the stability of primordial elemental abundances.

15.9 Implications for the Standard Model of Particle Physics

The Cyclic Gravity and Cosmology (CGC) framework not only offers an alternative to General Relativity (GR) and ΛCDM in cosmology but also has potential implications for the Standard Model of Particle Physics. CGC introduces a new perspective on neutrinos, time dilation, and light deflection, which may provide insights into unresolved questions in high-energy physics.

15.9.1 Neutrinos as Fundamental Mediators of Physical Processes

CGC suggests that neutrinos play a more direct role in fundamental physics than previously assumed. This contrasts with the Standard Model, where neutrinos are treated as weakly interacting particles with minimal influence on large-scale physics. The key differences are:

- **Neutrino-Mediated Time Dilation:** In CGC, neutrinos inhibit quantum interactions, leading to time dilation effects traditionally attributed to spacetime curvature in GR.
- **Neutrino-Induced Light Deflection:** Rather than spacetime curvature bending light, CGC proposes that neutrino gradients influence photon trajectories via weak interactions.
- **Neutrino Contributions to Gravity:** The presence of large-scale neutrino density variations subtly alters the gravitational force law, impacting cosmic structure formation and galactic rotation curves.

These reinterpretations suggest that the weak interactions of neutrinos may have macroscopic effects previously unaccounted for in particle physics.

15.9.2 Potential Connections to Quantum Field Theory

CGC raises several questions about the relationship between neutrinos and quantum field theory (QFT), including:

- **Neutrino-Induced Quantum Inhibition:** If neutrinos influence time dilation, their interactions with quantum fields may introduce a new form of field suppression at high densities.
- **A Role for Neutrino Fields in Gravity:** Could neutrino fields serve as a mediator between classical gravitational effects and quantum mechanics, bridging the gap between GR and QFT?
- **Implications for the Weak Force:** If neutrinos influence large-scale physics beyond their traditional weak force interactions, this could imply a need for modifications to the Standard Model's treatment of the weak interaction.

15.9.3 Experimental Signatures and Tests

If CGC's hypothesis about neutrinos is correct, several experimental tests could be designed to verify its predictions:

- **Neutrino Density and Time Dilation:** Precision atomic clock experiments in high-neutrino-density environments (such as near nuclear reactors) could test whether time dilation effects differ from GR predictions.

- **Neutrino-Photon Interactions:** High-energy astrophysical observations (e.g., gamma-ray bursts) could reveal deviations in light deflection that correlate with inferred neutrino concentrations.
- **Modified Gravity at Particle Accelerators:** Future particle collider experiments could investigate whether neutrino interactions subtly affect gravitational measurements at small scales.

15.9.4 Unifying Gravity and Quantum Physics in CGC

By introducing neutrinos as mediators of gravitational and relativistic effects, CGC provides a possible framework for linking gravity with quantum mechanics. Some open questions for future research include:

- Can the effects of neutrino-mediated time dilation be incorporated into quantum mechanics in a way that preserves both QFT and classical physics?
- How do neutrino gradients interact with known quantum effects such as vacuum fluctuations?
- Could neutrino interactions provide a mechanism for resolving the incompatibility between GR and QFT?

While CGC does not yet offer a complete unification of gravity and quantum physics, it presents a novel perspective that warrants further investigation.

16 CONCLUSION

16.1 CGC as a Testable Alternative to Standard Cosmology

This paper has presented Cyclic Gravity and Cosmology (CGC) as an alternative framework to General Relativity (GR) and ΛCDM cosmology. CGC offers a fundamentally different approach by retaining Euclidean space, interpreting gravity as a residual effect of electromagnetism, and proposing neutrino interactions as a mechanism for time dilation, light deflection, and gravitational effects. While CGC challenges conventional cosmological models, it provides a logically consistent and observationally motivated framework that warrants further investigation.

16.1.1 Key Findings and Implications

Throughout this paper, CGC has been shown to offer alternative explanations for several key cosmological phenomena:

- **Redshift Mechanisms:** CGC replaces metric expansion with a combination of Doppler motion, neutrino interactions, and a refined tired light model.
- **Cosmic Microwave Background (CMB):** CGC interprets the CMB as scattered and thermalized starlight rather than as a relic of the early universe.
- **Galactic Rotation Curves:** CGC provides a possible explanation for flat rotation curves without invoking dark matter, using oscillatory gravity and neutrino effects.
- **Neutrino-Driven Gravitational Interactions:** CGC suggests that neutrino concentration gradients influence cosmic structure formation and gravitational lensing.
- **AGN and Black Hole Models:** CGC replaces singularities with ultra-dense neutron stars surrounded by neutrino clouds, eliminating the need for event horizons.

16.2 Future Research Directions

While CGC offers promising insights, it remains an evolving framework that requires further theoretical refinement and empirical testing. Several key areas for future research include:

- **Refining the CGC Gravitational Force Law:** Improved observational constraints on oscillatory gravity parameters could help distinguish CGC from GR.
- **Neutrino Density Mapping:** New techniques for estimating large-scale neutrino distributions could test CGC's predictions about structure formation and gravitational lensing.
- **Testing Time Dilation Predictions:** High-precision time dilation measurements in astrophysical and laboratory environments could validate or refute CGC's neutrino-mediated time dilation hypothesis.
- **Comparisons with Large-Scale Surveys:** Upcoming galaxy clustering studies and gravitational lensing surveys will provide further opportunities to compare CGC with ΛCDM.

16.3 Final Remarks

The purpose of this paper has not been to prove that CGC is correct but rather to demonstrate that it is a framework worthy of rigorous scientific investigation. Given the persistent challenges faced by ΛCDM—including the Hubble tension, unexplained dark matter and dark energy components, and anomalies in high-redshift galaxy formation—alternative models should be explored with an open and objective mindset.

If future observational and experimental tests continue to align with CGC predictions, the model could emerge as a viable replacement for ΛCDM and General Relativity at cosmological scales. Regardless of its ultimate validity, CGC provides a fresh perspective on gravity and cosmology, challenging existing assumptions and encouraging new lines of inquiry into the fundamental nature of the universe.

ACKNOWLEDGMENTS

The author would like thank and acknowledge the following people for their help:

Lee Greer for allowing me to spend hours with him going over his site. The link is here:

https://enlightenmentlegacy.net/cosmos/

His meaningful critique of standard cosmology guided and inspired this project.

Kelly Bakhos taught me how to interact with AI, which I had never done before. Without her help it would not have been possible to do this!

I would like to thank Jason Stone for his early criticism. Some time before 2022, he was a high school student of mine. I was trying to develop my idea of alternating currents within masses as the source of the gravitational force. At that time I felt that electron motions would have a big effect. He pointed out that if that were the case, then electrons and nuclei should "weigh" about the same in a gravitational field, and we know that is not the case. That is what inspired me to locate the source of gravity as charge fluctuations among quarks in the nuclei of atoms.

Jacqueline Veal-Bakhos had years of meaningful conversations with me about this when no one else would.

The author wishes to acknowledge the computational and observational teams whose work in galaxy surveys, neutrino physics, and cosmic microwave background studies has provided critical data for comparison with the Cyclic Gravity and Cosmology (CGC) framework.

The author also recognizes the contributions of OpenAI's ChatGPT in assisting with drafting, formatting, and refining the structure of this manuscript. While AI-assisted writing was employed to enhance clarity and consistency, all scientific content, interpretations, and conclusions remain the author's own.

This work has benefited from publicly available datasets, including but not limited to the Sloan Digital Sky Survey (SDSS), the Dark Energy Survey (DES), Planck CMB data, and neutrino observatories such as IceCube and KM3NeT.

DATA AVAILABILITY

No new datasets were generated for this study. All data used in this paper were obtained from publicly available sources, including galaxy redshift surveys, cosmic microwave background studies, and neutrino physics experiments. Specific datasets referenced include:

- Sloan Digital Sky Survey (SDSS) (https://www.sdss.org/)
- Dark Energy Survey (DES) (https://www.darkenergysurvey.org/)
- Planck CMB Data (https://pla.esac.esa.int/)
- IceCube Neutrino Observatory (https://icecube.wisc.edu/)

Researchers interested in reproducing the findings of this study are encouraged to access these datasets and apply the methodologies discussed in this paper. Future refinements to the CGC framework will continue to incorporate new observational constraints from upcoming surveys and experimental results.

APPENDIX A: ORIGINAL CGC PAPER THAT PREDICTED WHAT JWST IS NOW REVEALING

The essential model of CGC depicted in this paper is not new. The majority of the current model depicted in this paper was summarized in a paper submitted to the MNRAS in 2022. That paper was submitted well before JWST began releasing data. Its predictions are being born out. Here is a link to that paper:

https://vixra.org/abs/2203.0032

APPENDIX B: THE CONVERSATION WITH CHATGPT

Throughout the development of this paper, AI-assisted tools, specifically OpenAI's ChatGPT, were utilized for drafting, structuring, and refining the document. The scientific content, interpretations, and conclusions remain entirely the responsibility of the author. However, AI assistance was employed to streamline formatting, enhance clarity, and ensure consistency across sections.

For full transparency, the first conversation that the Author had with ChatGPT on this topic, which covered all the major points of CGC Cosmology, is available at the following hyperlink:

https://drive.google.com/file/d/1GOKfISya93Dqant8oxJB-fB3nqX-SZVu/view?usp=drive_link