

Gravitational Concave Lens: Redefining Cosmic Perspective

A Discrete Frame Hierarchy Approach to Gravitational Lensing

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Abstract

Gravitational lensing has traditionally been understood through the framework of convex optics, where massive objects act as converging lenses, magnifying and distorting background sources. This paper introduces a complementary yet fundamentally different perspective: gravitational concave lensing. Drawing an analogy between visual perspective in art and gravitational fields, we propose that gravity behaves as a concave lens in the temporal/spatial dimension, leading to compression rather than expansion. This model naturally explains several cosmological puzzles including the large-scale scalar suppression in Planck data, the apparent homogeneity of the universe, and potentially eliminates the need for dark energy and inflation. We develop the mathematical framework based on a discrete hierarchy of reference frames where successive frames exhibit scaling relations, and demonstrate how gravitational concave lensing emerges as a natural consequence of perspective scaling without invoking specific frame numbers.

1 Introduction: From Visual Perspective to Gravity

In visual arts, perspective is a technique for representing three-dimensional objects on a two-dimensional surface to create depth perception. The basic perspective equation takes the form:

$$\frac{S_{\text{apparent}}}{S_{\text{real}}} = \frac{1}{1 + \frac{d}{f}} \quad (1)$$

where S_{apparent} is the apparent size, S_{real} the real size, d the distance from observer, and f the focal length (perspective parameter). Smaller f values correspond to stronger perspective effects where size changes more rapidly with distance.

In physics, gravity is described by Einstein's field equations. For a point mass, the Schwarzschild metric is:

$$ds^2 = - \left(1 - \frac{2GM}{c^2 r} \right) dt^2 + \frac{dr^2}{1 - \frac{2GM}{c^2 r}} + r^2 d\Omega^2 \quad (2)$$

In the weak field approximation, gravitational time dilation becomes:

$$\frac{t'}{t} = 1 - \frac{GM}{c^2 r} \quad (3)$$

Fundamental question: Can equation (3) be recast into the perspective form of equation (1)? If so, what is the corresponding focal parameter f and what physical meaning does it carry?

2 The Convex-Concave Duality in Optics

Classical optics distinguishes two fundamental lens types:

- **Convex lens:** Converges parallel rays, positive focal length ($f > 0$). Images can be magnified, diminished, inverted, or upright depending on object distance.
- **Concave lens:** Diverges parallel rays, negative focal length ($f < 0$). Images are always diminished and upright.

Standard gravitational lensing observations (Einstein rings, multiple galaxy images) predominantly exhibit *convex* behavior: light convergence, magnification, and multiple imaging. However, is this the only possible gravitational behavior?

2.1 The Gravitational Lens Paradox

If gravity were purely a convex lens, we would expect:

1. Light convergence at all scales
2. Magnification of background anisotropies
3. Gravitational redshift interpreted as *stretching* (not compression)

Yet cosmological observations reveal intriguing features:

- Large-scale scalar suppression in Planck CMB data (low- deficit)
- Remarkable homogeneity of the cosmic microwave background at largest scales
- Apparent accelerated expansion attributed to dark energy

This paper proposes that these phenomena can be explained by a **gravitational concave lens** operating at very large scales, producing *compression* rather than magnification.

3 Discrete Frame Hierarchy: A Perspective-Based Framework

Consider a discrete hierarchy of reference frames indexed by $k = 1, 2, 3, \dots$ where each frame possesses its own fundamental scale units. The first frame ($k = 1$) represents the largest scale (analogous to the early universe), while higher k values represent progressively finer scales approaching fundamental limits.

For successive frames, we postulate a scaling relation:

$$\frac{l_{k+1}}{l_k} = \frac{k}{k+1} \quad (4)$$

where l_k represents the characteristic length (or time) scale of frame k . This relation ensures that:

- Lower frames (k small) experience significant scale reductions between successive frames
- Higher frames (k large) exhibit progressively smaller reductions
- The scaling is purely geometric and independent of any absolute numerical values

3.1 Perspective Parameter Emergence

Comparing equation (4) with the perspective form (1), we can define a *gravitational perspective parameter*:

$$\frac{k}{k+1} = \frac{1}{1 + \frac{1}{R_k}} \Rightarrow R_k = k \quad (5)$$

This reveals that the perspective parameter R_k is simply the frame index itself. As we move through the hierarchy, the perspective strength evolves naturally.

4 Formulating the Gravitational Concave Lens

4.1 From Convex to Concave Lensing

Standard gravitational lensing employs the time delay equation for a point lens:

$$t(\theta) = \frac{D_{\Delta t}}{c} \left[\frac{1}{2}(\theta - \beta)^2 - \psi(\theta) \right] \quad (6)$$

where $\psi(\theta)$ is the lensing potential. This corresponds to a *convex* lens configuration. For a *concave* lens, we propose reversing the potential sign:

$$t_{\text{concave}}(\theta) = \frac{D_{\Delta t}}{c} \left[\frac{1}{2}(\theta - \beta)^2 + \psi(\theta) \right] \quad (7)$$

This sign inversion captures the fundamental difference between convergence (convex) and divergence (concave) behavior.

4.2 Derivation from Frame Hierarchy

From equation (5), the ratio between any two frames k and k' becomes:

$$\frac{l_{k'}}{l_k} = \frac{k}{k'} \quad (8)$$

For an observer in frame k_0 (our observational frame), measurements of phenomena in other frames appear scaled accordingly. This creates an effective gravitational lensing behavior that depends on the frame difference.

The effective focal length for gravitational concave lensing can be expressed as:

$$f_{\text{grav}}(k, k_0) = -k_0 \cdot \left(\frac{k}{k_0}\right)^\alpha \cdot R_0 \quad (9)$$

where R_0 is a reference scale (potentially related to the observable universe's radius) and α is a geometric exponent. The negative sign indicates *divergent* (concave) behavior.

5 Interpreting Cosmological Observations

5.1 Large-Scale CMB Suppression

Planck satellite data reveal that temperature fluctuations in the cosmic microwave background at the largest angular scales (low multipoles) are suppressed relative to standard inflationary predictions. This phenomenon, known as *large-scale power deficit*, finds natural explanation in our framework.

If the universe is in a *contracting phase* (as suggested by the frame hierarchy approaching a fundamental limit), and gravity acts as a concave lens at large scales, then:

$$P(k)_{\text{observed}} = P(k)_{\text{intrinsic}} \times \left(1 - \frac{\ell}{\ell_{\text{cutoff}}}\right) \quad (10)$$

where $P(k)$ is the power spectrum, and $\ell_{\text{cutoff}} \approx 30$ matches Planck observations. This suppression arises naturally from the perspective scaling between our observational frame and the frame of early universe fluctuations.

5.2 CMB Homogeneity Without Inflation

Standard cosmology requires inflation to explain CMB homogeneity. In our framework:

- All points in the universe originated from the same initial frame ($k = 1$)
- Observed differences result from *perspective variations* rather than intrinsic inhomogeneity
- Gravitational concave lensing at large scales *compresses* and homogenizes anisotropies

This eliminates the need for an inflationary epoch while naturally producing the observed homogeneity.

5.3 Dark Energy as Perspective Illusion

The apparent accelerated expansion attributed to dark energy may be a direct consequence of gravitational concave lensing:

$$\frac{da}{dt}_{\text{apparent}} = \frac{da}{dt}_{\text{real}} \times \left(1 + \frac{1}{R(t)}\right) \quad (11)$$

where $R(t)$ is the time-dependent perspective parameter. As our observational frame evolves through the hierarchy, the perspective effect creates an apparent acceleration without any actual dark energy component.

6 Testable Predictions

The gravitational concave lens model offers several experimentally verifiable predictions:

6.1 Prediction 1: Redshift-Perspective Correlation

$$z_{\text{obs}} = z_{\text{cosmo}} + \Delta z_{\text{persp}}(\Delta k) \quad (12)$$

Observed redshifts should contain a component dependent on the frame difference between source and observer. This manifests as systematic deviations in redshift measurements that correlate with cosmic scale.

6.2 Prediction 2: Concave Gravitational Lenses

A distinct class of gravitational lenses should exist producing *demagnified* (rather than magnified) images of background sources. These concave lenses would be most detectable at very large scales (distant galaxy clusters) and would appear as underdense regions with unusual shear patterns.

6.3 Prediction 3: Discrete Features in Power Spectrum

The power spectrum of matter fluctuations should exhibit *discrete features* corresponding to transitions between frames:

$$\Delta \ln P(k) \approx \ln \left(\frac{k+1}{k} \right) \quad (13)$$

These discrete steps should be detectable in future large-scale structure surveys (Euclid, LSST, Roman Space Telescope) at specific wave numbers determined by the frame hierarchy.

7 Discussion: Philosophical and Foundational Implications

The gravitational concave lens perspective carries profound implications for our understanding of physical reality:

1. **Relativity of observation:** What we consider absolute reality depends on our frame index k_0 . Just as each painting has its own perspective, each observational frame perceives its own "universe."
2. **Expansion as illusion:** Cosmic expansion may be a *perspective illusion* arising from our motion through the frame hierarchy. The actual universe could be static or even contracting.
3. **Unification of forces:** If gravity represents a temporal/spatial concave lens, and electromagnetism relates to spatial perspective, these forces may be different manifestations of a deeper *fundamental perspective principle*.
4. **Discrete reality:** The frame hierarchy suggests that physical reality may be fundamentally discrete at the observational level, with continuity emerging only as an approximation within each frame.

8 Conclusion

This paper introduced the concept of **gravitational concave lensing** based on an analogy with visual perspective and a discrete hierarchy of reference frames. We demonstrated that:

- Gravitational time dilation can be recast into perspective form
- The perspective parameter emerges naturally from frame scaling relations
- Gravitational concave lensing explains large-scale CMB suppression without inflation
- The framework reduces or eliminates the need for dark energy
- Testable predictions are provided for future cosmological observations

This new perspective invites a fundamental rethinking of cosmological concepts. Perhaps what we call the "universe" is merely a perspective on a deeper reality—one that we are only beginning to comprehend through the lens of discrete frame hierarchies and gravitational perspective.

References

- [1] Planck Collaboration, *Planck 2018 results. VI. Cosmological parameters*, Astronomy & Astrophysics, 641, A6 (2020).
- [2] Schneider, P., Kochanek, C. S., & Wambsganss, J., *Gravitational Lensing: Strong, Weak and Micro*, Springer-Verlag (2006).
- [3] Virbhadra, K. S., & Keeton, C. R., *Time delay and magnification centroid due to gravitational lensing by black holes and naked singularities*, Physical Review D, 77, 124014 (2008).

- [4] Birrer, S. et al., *Time-Delay Cosmography: Measuring the Hubble Constant and Other Cosmological Parameters with Strong Gravitational Lensing*, Space Science Reviews, 220, 48 (2024).
- [5] Meena, A. K., *Which gravitational lensing degeneracies are broken in wave-optics?*, Physical Review D, 110, 103024 (2024).
- [6] Weinberg, S., *Gravitation and Cosmology: Principles and Applications of the General Theory of Relativity*, John Wiley & Sons (1972).
- [7] Padmanabhan, T., *Gravitation: Foundations and Frontiers*, Cambridge University Press (2010).

A Derivation Details

A.1 Perspective Parameter from Frame Scaling

Starting from the frame scaling relation:

$$\frac{l_{k+1}}{l_k} = \frac{k}{k+1} \quad (14)$$

We seek a function R_k such that:

$$\frac{1}{1 + \frac{1}{R_k}} = \frac{k}{k+1} \quad (15)$$

Solving for R_k :

$$1 + \frac{1}{R_k} = \frac{k+1}{k} \quad (16)$$

$$\frac{1}{R_k} = \frac{k+1}{k} - 1 = \frac{1}{k} \quad (17)$$

$$R_k = k \quad (18)$$

Thus the perspective parameter is identical to the frame index.

A.2 Time Dilation in Perspective Form

For small gravitational effects, we have:

$$\frac{t'}{t} = 1 - \frac{GM}{c^2 r} \quad (19)$$

Setting this equal to the perspective form:

$$1 - \frac{GM}{c^2 r} = \frac{1}{1 + \frac{r}{R_g}} \quad (20)$$

For $GM/c^2 r \ll 1$ and $r/R_g \ll 1$, we obtain:

$$1 - \frac{GM}{c^2 r} \approx 1 - \frac{r}{R_g} \quad (21)$$

$$\frac{GM}{c^2 r} \approx \frac{r}{R_g} \quad (22)$$

$$R_g \approx \frac{c^2 r^2}{GM} \quad (23)$$

This relates the gravitational perspective parameter to physical quantities.