The Dark Energy Principle: A Falsifiable Reinterpretation of Relativity's Invariant

Luthfi Muslihat
Independent Researcher
luthfi.muslihat1@gmail.com
ORCID: 0009-0001-7428-3600

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Abstract

Einstein's relativity enshrined the speed of light, c, as the universal invariant. We propose instead that the invariant is the speed of dark energy, c_{DE}. Photons are contingent travelers whose effective speed depends on cosmic environment. This principle predicts achromatic travel-time delays Δt that scale with path length L and mean offset μ, producing millisecond to hour-scale lags across voids, filaments, and clusters. The framework preserves Lorentz symmetry while offering clean falsification via fast radio bursts (FRBs), gamma-ray bursts (GRBs), and strong lensing time delays.

1 Introduction

Einstein's 1905 postulate that the speed of light is invariant for all observers [1] has shaped modern physics. From the Michelson–Morley experiment to GPS synchronization, c has been treated as the ruler of spacetime. Yet photons are not isolated; they traverse cosmic structures. This raises a provocative question: what if photons are contingent messengers, not the universal invariant?

Dark energy, responsible for cosmic acceleration [2], permeates spacetime. We propose that its characteristic speed, c_{DE}, defines the true causal cone. Photons, slowed or sped by environment-dependent indices, fall inside this cone, producing achromatic delays.

2 The Principle

Let $n_\gamma(x)$ denote the environment-dependent index along a path of length L. The effective photon speed is

$$c_\gamma(x) = \frac{c_{DE}}{n_\gamma(x)} \tag{1}$$

The achromatic delay relative to the c_{DE} baseline is

$$\Delta t = \int_0^L \frac{dx}{c_\gamma(x)} - \frac{L}{c_{DE}} = \frac{L}{c_{DE}} \langle n_\gamma - 1 \rangle = \frac{L}{c_{DE}} \mu \tag{2}$$

3 Geometry of the Cone

The spacetime interval with c_{DE} defines the true causal cone via $ds^2 = 0$. In units where $c_{DE} = 1$, the cone is traced by $x = \pm t$. Photon trajectories satisfy

$$x = \pm c_\gamma t = \pm \frac{t}{n_\gamma} \tag{3}$$

placing them inside the true cone when $n_\gamma > 1$. The geometric separation encodes the achromatic delay.

4 Implications

Replacing c with c_{DE} in Lorentz transformations preserves symmetry:

$$t' = \gamma_{DE} \left(t - \frac{vx}{c_{DE}^2} \right), \quad x' = \gamma_{DE}(x - vt) \tag{4}$$

with

$$\gamma_{DE} = \frac{1}{\sqrt{1 - \frac{v^2}{c_{DE}^2}}} \tag{5}$$

5 Falsifiability

The principle is falsifiable via:

- **Void baseline:** $\Delta t \approx 0$ ms across void sightlines.
- **Shuffle collapse:** Randomizing structure abolishes delays.
- **Ablation:** DE-only + DM-only contributions approximate full delay.
- **Scaling:** $\Delta t \propto L$ and $\Delta t \propto \mu$.

Data Availability

All simulation notebooks and figures supporting this work are openly available at: `https://github.com/bynd-id/dark-energy-principle`

A Formalism

We formalize the principle by deriving the achromatic delay from first principles. Consider a photon traversing a structured environment with index $n_\gamma(x)$. The travel time is

$$t_\gamma = \int_0^L \frac{dx}{c_\gamma(x)} = \frac{1}{c_{DE}} \int_0^L n_\gamma(x)\, dx \tag{6}$$

Relative to the invariant baseline $t_{DE} = L/c_{DE}$, the delay is

$$\Delta t = t_\gamma - t_{DE} = \frac{1}{c_{DE}} \int_0^L \big(n_\gamma(x) - 1 \big)\, dx \tag{7}$$

Defining $\mu = \langle n_\gamma - 1 \rangle$, we recover

$$\Delta t = \frac{L}{c_{DE}} \mu \tag{8}$$

B Figures

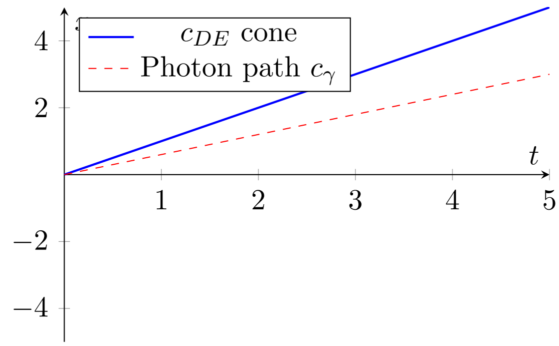

Figure 1: True causal cone defined by c_{DE} (blue) and contingent photon path c_γ (red).

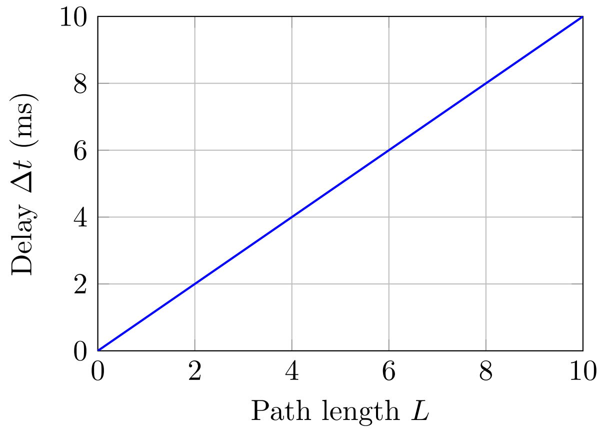

Figure 2: Linear scaling of achromatic delay Δt with path length L.

References

[1] A. Einstein, "On the Electrodynamics of Moving Bodies," Annalen der Physik, 1905. doi:10.1002/andp.19053221004

[2] J. Frieman, M. Turner, D. Huterer, "Dark Energy and the Accelerating Universe," Annual Review of Astronomy and Astrophysics, 2008. doi:10.1146/annurev.astro.46.060407.145243

[3] Z.-W. Zhao et al., "Probing dark energy with FRBs," arXiv:2210.07162

[4] T. Treu, S. Suyu, P. Marshall, "Strong lensing time-delay cosmography," A&A Review, 2022. doi:10.1007/s00159-022-00139-y