A First-Principles Model of Gravitational Polarity Flip at Cosmological Distances

Chan Kin Peng (William)
william@finvent.asia

Independent Researcher

May 16, 2025

Abstract

We present a novel theoretical framework in which gravity transitions from an attractive to a repulsive force beyond a critical distance. Unlike modifications derived from cosmological observations or phenomenological models such as MOND, this theory is developed from first principles. We hypothesize a flip distance on the order of ~ 90 million light-years, where gravitational attraction vanishes and transitions into a repulsive regime, with the repulsive force increasing with distance beyond the flip point. This model provides a natural explanation for cosmic acceleration and aligns with observed structure scales in the universe, such as the size of galaxy clusters. This paper outlines the motivation, mathematical foundation, and implications of this gravitational flip, and discusses potential testable predictions and its relevance to cosmic acceleration.

1 Introduction and Background

Gravity, as traditionally understood through Newton's Law and Einstein's General Relativity (GR), is always attractive. However, phenomena such as cosmic acceleration suggest the existence of a repulsive component, currently modeled through a cosmological constant or dark energy. In this paper, we propose an alternative explanation: gravity flips from attractive to repulsive beyond a certain critical distance, based on a minimum quantized force derived from first principles. The core idea is that gravity cannot drop below a finite smallest force due to physical quantization. When this minimum is reached, the force cannot continue to be negative (attractive), and instead flips to become positive (repulsive).

We derive this model using only three parameters: (1) the wavelength of the Cosmic Microwave Background(CMB), (2) the mass of the Milky Way galaxy, and (3) a reference 1 kg mass. These are not arbitrarily chosen but are well-grounded in both cosmological observation and the units that define gravitational interactions.

2 Theoretical Motivation

This model arises from the need to explain cosmic acceleration without invoking unknown energy components. We begin from first principles, avoiding observational tuning, and consider the possibility that gravitational behavior is fundamentally scale-dependent.

3 Minimum Gravitational Force

From first principles, we postulate the existence of a minimum force, F_{min}, below which gravitational attraction cannot continue, a quantization of gravitational force.

To calculate this minimum force, we choose a single photon of the Cosmic Microwave Background (CMB). This choice is natural because the photon is the smallest quanta of electromagnetic radiation and the CMB is pervasive throughout the universe. The impulse force arises from the momentum transfer when a photon hits a black plate over the time the photon takes to be absorbed by the plate.

The momentum of a single photon is:

$$p = \frac{h}{\lambda}$$

Here we propose a novel idea that the time it takes for a photon to be absorbed is the time the photon takes to traverse it's own wavelength.

Using the CMB wavelength ($\lambda_{\text{CMB}} \approx 1.9\,\text{mm}$), and the time it takes for one wavelength to pass a point ($\Delta t = \lambda/c$), the impulse force imparted by a photon is:

$$F_{\text{min}} = \frac{p}{\Delta t} = \frac{h}{\lambda} \cdot \frac{c}{\lambda} = \frac{hc}{\lambda^2}$$

Substituting values:

$$F_{\text{min}} = \frac{6.626 \times 10^{-34} \cdot 3 \times 10^{8}}{(1.9 \times 10^{-3})^2} \approx 5.5 \times 10^{-20}\,\text{N}$$

If Force is quantized, then the smallest quanta of force should be the same everywhere, whether electromagnetic or gravity.

4 Flip Condition and Distance

Once we have the minimum gravitational force, we must assume that after certain distance, attractive gravity cannot be smaller than this force, therefore it has to drop to zero and then become repulsive. The reason why it should become repulsive is that it provides symmetry and allows for a zero energy universe.

To calculate the flip distance, we choose the Milky Way galaxy as a source of the gravitational field and a test mass of 1kg in that field.

We define the flip distance r_f as the distance at which the gravitational force between the Milky Way and a 1 kg mass becomes equal to $F_{\min}$. Using Newton's law:

$$F = \frac{GMm}{r^2} \Rightarrow r_f = \sqrt{\frac{GMm}{F_{\min}}}$$

Taking $M = 1.5 \times 10^{42}\,\text{kg}$ (Milky Way), $m = 1\,\text{kg}$, and $G = 6.674 \times 10^{-11}\,\text{Nm}^2/\text{kg}^2$, we get:

$$r_f = \sqrt{\frac{6.674 \times 10^{-11} \cdot 1.5 \times 10^{42}}{5.5 \times 10^{-20}}} \approx 8.6 \times 10^{23}\,\text{m}$$

This is about 90 million light years.

5 Post-Flip Repulsive Gravity Model

For distances $r > r_f$, gravity becomes repulsive and the force increases with the square of the distance from the flip point. The force expressions are:

Attractive Gravity (for $r < r_f$):

$$F = -\frac{GMm}{r^2}$$

Repulsive Gravity (for $r > r_f$):

$$F = +GMm(r - r_f)^2$$

This creates a smooth energy balance and introduces a symmetric repulsive force beyond the flip radius. The use of $(r - r_f)^2$ reflects a quadratic increase from the flip boundary.

6 Why an Abrupt Flip Is Acceptable

One might expect physical forces to transition smoothly rather than discontinuously. However, in this model the transition occurs at an extremely small force level, $\sim 10^{-20}\,\text{N}$, which is many orders of magnitude below any current experimental detection threshold. Thus, the sharp transition is effectively smooth from an observational standpoint.

7 Justification for Parameter Choices

7.1 CMB Wavelength:

The CMB represents the background quantum and thermodynamic floor of the observable universe. Using its wavelength as a benchmark for minimal energy interactions ensures that our model is grounded in the physical background of the cosmos.

7.2 Milky Way Mass:

As an average-sized spiral galaxy, the Milky Way provides a reasonable reference point as it is the galaxies that are attracting and accelerating away from each other. Other galaxies would yield flip distances of the same order of magnitude.

7.3 1 kg Test Mass:

The kilogram is the SI base unit for mass, and is intrinsic to the definition of Newton's law. Because G includes the kilogram in its dimensional structure, using 1 kg is natural for analytical consistency and it also serves to normalize the results.

8 Observational Support

The calculated flip distance of 90 million light years is consistent with observed features:

- Galaxy clusters tend to span up to 30 Mly across.
- Structures beyond 100 Mly appear to accelerate apart.
- The large-scale homogeneity of the universe begins beyond these scales.

Table 1: Comparison of Observational Scales

Structure	**Typical Size (Mly)**	**Comment**
Local Group	10	Bound gravitationally
Virgo Cluster	20	Largest nearby cluster
Great Attractor	60	Transitional scale
Supercluster walls	100–300	Start of isotropic acceleration
Flip Distance (this paper)	90	Matches critical boundary

9 Flip Distance and Physical Implications

We propose $R_f \sim 90$ million light-years based on a natural scale separation in the universe. In the repulsive regime, this model predicts increasing repulsion with distance squared, contrasting with the inverse-square law of Newtonian attraction.

This may account for:

- The large-scale structure and voids in the universe
- Cosmic acceleration without a cosmological constant
- A natural cutoff for gravitational binding of superclusters

10 Symmetry and Energy Conservation

By constructing the repulsive force as a quadratic function increasing from zero at r_f, we create a symmetric shape with the Newtonian inverse square law. The negative (bound) and positive (repulsive) gravitational energy contributions may cancel across the universe, supporting a total zero energy universe hypothesis. This symmetry strengthens the physical plausibility of the model.

11 Discussion

We contrast this model with MOND, ΛCDM, and modified gravity theories such as $f(R)$ models. Unlike these, our model is grounded in a proposed quantized minimum acceleration or force, which becomes relevant at large scales.

Open questions include:

- The underlying mechanism enforcing the flip
- Compatibility with GR in the weak field limit
- Observational tests using large-scale galaxy surveys

12 Conclusion

We propose a new theoretical framework in which gravity flips from attraction to repulsion beyond a critical distance, derived from first principles rather than observational fitting. This model offers a fresh avenue for explaining large-scale cosmic phenomena and invites further mathematical and observational scrutiny.

Acknowledgments

The author thanks his family, independent thinkers and critical readers who encourage the exploration of first-principles approaches in fundamental physics.

References

[1] A. Einstein, "Die Feldgleichungen der Gravitation," *Sitzungsberichte der Preussischen Akademie der Wissenschaften zu Berlin*, 844–847 (1915).

[2] M. Milgrom, "A modification of the Newtonian dynamics as a possible alternative to the hidden mass hypothesis," *Astrophys. J.* 270, 365–370 (1983).

[3] A. G. Riess et al., "Observational Evidence from Supernovae for an Accelerating Universe and a Cosmological Constant," *Astron. J.* 116, 1009 (1998).

[4] T. Clifton, P. G. Ferreira, A. Padilla, and C. Skordis, "Modified Gravity and Cosmology," *Phys. Rept.* 513, 1 (2012).