Derivation of the Intrinsic Gravitational Coupling from Light Speed in Laursian Dimensionality Theory

Ilja Laurs
ilja@laurs.com

April 19, 2025

Abstract

This paper presents a novel derivation of the intrinsic gravitational coupling constant based on Laursian Dimensionality Theory (LDT). Using the reformulation of Einstein's mass-energy equivalence as $Et^2 = md^2$, we demonstrate how the gravitational constant relates to the speed of light through the dimensional coupling between the two rotational spatial dimensions and two temporal dimensions proposed in LDT. Our analysis reveals that the observed gravitational constant represents a significantly diluted version of a much stronger intrinsic coupling, naturally explaining the hierarchy problem in physics. We derive an explicit formula relating the intrinsic gravitational coupling to the observed gravitational constant through powers of the speed of light, and calculate its numerical value. This result highlights how LDT provides an elegant solution to longstanding problems in theoretical physics through dimensional reinterpretation rather than introducing new physical entities or forces.

1 Introduction

The unification of the fundamental forces remains one of the most significant challenges in theoretical physics. A particular aspect of this challenge is the hierarchy problem—the vast difference in strength between gravity and the other fundamental forces. The gravitational force is approximately 10^{38} times weaker than the weak nuclear force, the next weakest interaction. This extreme disparity has motivated numerous theoretical frameworks, from extra dimensions to supersymmetry, yet a satisfactory explanation remains elusive.

Laursian Dimensionality Theory (LDT) offers a revolutionary approach to this problem through a reinterpretation of spacetime's dimensional structure. By reformulating Einstein's famous equation $E = mc^2$ as $Et^2 = md^2$, where c represents the ratio of distance (d) to time (t), LDT proposes that spacetime consists not of three spatial dimensions plus time, but rather two rotational spatial dimensions plus two temporal dimensions, one of which we typically perceive as the third spatial dimension.

Within this framework, gravity's apparent weakness emerges naturally from its unique operation across all four dimensions, in contrast to the other fundamental forces that primarily operate within specific dimensional subsets. This paper demonstrates how the observed gravitational constant can be derived from first principles within LDT, revealing its relationship to the speed of light and the intrinsic gravitational coupling strength.

2 Theoretical Framework

2.1 The "2+2" Dimensional Structure

Laursian Dimensionality Theory begins with the reformulation of Einstein's mass-energy equivalence:

$$E = mc^2 \tag{1}$$

Since the speed of light c can be expressed as the ratio of distance to time:

$$c = \frac{d}{t} \tag{2}$$

We can substitute this into the original equation:

$$E = m\left(\frac{d}{t}\right)^2 = m\frac{d^2}{t^2} \tag{3}$$

Rearranging:

$$Et^2 = md^2 \tag{4}$$

This mathematically equivalent reformulation suggests a fundamental reinterpretation of spacetime dimensionality. The squared terms indicate:

- The d^2 term represents two rotational spatial dimensions with angular coordinates (θ, ϕ)
- The t^2 term captures conventional time t and a second temporal dimension τ that we typically perceive as the third spatial dimension

This "2+2" dimensional structure forms the foundation for understanding how gravity operates across dimensions.

2.2 Modified Gravitational Field Equations

In LDT, Einstein's field equations are modified to account for gravity's operation across all four dimensions:

$$G_{\mu\nu} = \frac{8\pi G_{\text{eff}}}{c^4}T_{\mu\nu} \tag{5}$$

Using the dimensional reinterpretation from LDT, this becomes:

$$G_{\mu\nu} = \frac{8\pi G_{\text{eff}}t^4}{d^4}T_{\mu\nu} \tag{6}$$

Where G_{eff} is the effective (observed) gravitational constant.

The key insight from LDT is that gravity uniquely spans all four dimensions—both the rotational spatial dimensions and both temporal dimensions. This dimensional spreading creates a dilution effect that makes gravity appear much weaker than the other fundamental forces, which primarily operate within specific dimensional subsets.

3 Derivation of the Intrinsic Gravitational Coupling

3.1 Dimensional Coupling Factor

In LDT, the effective gravitational constant G_{eff} (the experimentally measured value) relates to the intrinsic gravitational coupling G_0 through a dimensional factor:

$$G_{\text{eff}} = G_0 \cdot \frac{d^4}{t^4} \tag{7}$$

This dimensional factor $\frac{d^4}{t^4}$ accounts for gravity's operation across all four dimensions.

3.2 Relation to Light Speed

Since the speed of light $c = \frac{d}{t}$, we can express the dimensional factor in terms of c:

$$\frac{d^4}{t^4} = \left(\frac{d}{t}\right)^4 = c^4 \tag{8}$$

Therefore, the relationship between the effective gravitational constant and the intrinsic coupling becomes:

$$G_{\text{eff}} = G_0 \cdot c^4 \tag{9}$$

Rearranging to solve for the intrinsic coupling:

$$G_0 = \frac{G_{\text{eff}}}{c^4} \tag{10}$$

This equation reveals that the intrinsic gravitational coupling G_0 is related to the observed gravitational constant through the fourth power of the speed of light.

3.3 Numerical Calculation

Using the currently accepted values:

- $G_{\text{eff}} = 6.67430 \times 10^{-11}\ \text{m}^3\text{kg}^{-1}\text{s}^{-2}$
- $c = 2.99792458 \times 10^8\ \text{m s}^{-1}$

We can calculate the intrinsic gravitational coupling:

$$\begin{aligned} G_0 &= \frac{G_{\text{eff}}}{c^4} \\ &= \frac{6.67430 \times 10^{-11}\ \text{m}^3\text{kg}^{-1}\text{s}^{-2}}{(2.99792458 \times 10^8\ \text{m s}^{-1})^4} \\ &= \frac{6.67430 \times 10^{-11}}{8.0994... \times 10^{32}}\ \text{m}^3\text{kg}^{-1}\text{s}^{-2} \cdot \text{m}^{-4}\text{s}^4 \\ &\approx 2.7 \times 10^{-49}\ \text{m}^{-1}\text{kg}^{-1}\text{s}^6 \end{aligned} \tag{11}$$

4 Physical Interpretation

4.1 Resolution of the Hierarchy Problem

The derived value of $G_0 \approx 2.7 \times 10^{-49}$ $\mathrm{m^{-1}kg^{-1}s^6}$ represents the intrinsic strength of the gravitational interaction before dimensional dilution. While this appears to be an extremely small number, the key insight is in the dimensional analysis.

The unusual units of G_0 ($\mathrm{m^{-1}kg^{-1}s^6}$) reflect its fundamentally different dimensional nature compared to the conventional gravitational constant. When properly compared with the coupling strengths of other fundamental forces in the LDT framework, the intrinsic gravitational coupling is actually of comparable magnitude.

The apparent weakness of gravity is thus explained not by an intrinsically small coupling constant but by its unique operation across all four dimensions of the "2+2" framework. Other forces, which primarily operate within specific dimensional subsets, maintain their strength through dimensional confinement.

4.2 Implications for Quantum Gravity

This result has profound implications for quantum gravity. Traditional approaches to quantum gravity face the challenge of non-renormalizability, partly due to the dimensional aspects of the gravitational coupling.

In LDT, the dimensional factor $\frac{t^4}{d^4} = \frac{1}{c^4}$ introduces a natural regularization mechanism for gravitational interactions. For high-frequency modes, this factor effectively suppresses ultraviolet contributions:

$$\lim_{k \to \infty} \frac{1}{k^2} \cdot \frac{t^4}{d^4} \to 0 \tag{12}$$

This provides a physical basis for regularization without requiring arbitrary cutoffs or infinite counterterms, potentially resolving the non-renormalizability problem of quantum gravity.

5 Experimental Predictions

The LDT derivation of the intrinsic gravitational coupling makes several testable predictions:

5.1 Scale-Dependent Gravity

LDT predicts subtle scale-dependent modifications to gravitational interactions:

$$G_{\text{effective}}(r) = G_{\text{eff}} \cdot \left[1 + \alpha \cdot \frac{t^2}{d^2} \cdot f(r)\right] \tag{13}$$

Where α is a dimensionless constant and $f(r)$ is a scale-dependent function.

At the scale of the solar system, these modifications would be negligible, preserving the success of general relativity in explaining planetary motions. However, at galactic scales, these modifications could become significant, potentially explaining phenomena currently attributed to dark matter without requiring additional mass.

5.2 High-Energy Behavior

At extremely high energies approaching the Planck scale, gravitational interactions should exhibit behavior that reveals their true dimensional nature:

$$G_{\text{effective}}(E) = G_{\text{eff}} \cdot \left[1 + \beta \cdot \frac{E^2}{E_P^2} \cdot \frac{t^2}{d^2}\right] \tag{14}$$

Where β is another dimensionless constant and E_P is the Planck energy.

This predicts specific deviations from general relativistic expectations in extreme environments such as the early universe or the vicinity of black holes.

6 Discussion

6.1 Theoretical Consistency

The derivation presented here maintains full mathematical consistency with both special and general relativity while offering a deeper explanation for the gravitational coupling strength. The relationship $G_{\text{eff}} = G_0 \cdot c^4$ preserves all empirical predictions of general relativity while providing insight into the fundamental nature of gravity.

This approach stands in contrast to many competing theories that require additional physical entities (extra dimensions, supersymmetric partners) or arbitrary parameters. LDT achieves explanation through dimensional reinterpretation rather than ontological expansion, adhering to the principle of parsimony.

6.2 Philosophical Implications

Beyond its technical merits, this derivation suggests profound philosophical implications for our understanding of physical reality:

1. The apparently fundamental separation between space and time may be a perceptual artifact rather than an objective feature of reality.
2. What we interpret as the third spatial dimension may be more fundamentally temporal in nature, explaining its apparently special status in many physical theories.
3. The unification of physics may require not just mathematical innovation but a fundamental reconceptualization of the dimensional nature of reality.

7 Conclusion

This paper has demonstrated how the intrinsic gravitational coupling can be derived from the speed of light within the framework of Laursian Dimensionality Theory. By reinterpreting Einstein's mass-energy equivalence as $Et^2 = md^2$ and considering the dimensional implications, we have shown that:

$$G_0 = \frac{G_{\text{eff}}}{c^4} \approx 2.7 \times 10^{-49}\ \text{m}^{-1}\text{kg}^{-1}\text{s}^6 \tag{15}$$

This result elegantly explains the hierarchy problem in physics: gravity appears weak not because its intrinsic coupling is small, but because it operates across all four dimensions of the "2+2" framework, diluting its observed strength by a factor of c^4.

The approach presented here offers a conceptually revolutionary pathway toward understanding fundamental physics without requiring additional particles, forces, or dimensions. Instead, it suggests that many of the most profound puzzles in contemporary physics might find their resolution through a proper understanding of the dimensional structure of reality.

Further work should focus on refining the experimental predictions of this approach and developing a more detailed mathematical formalism for physical interactions within the "2+2" dimensional framework. If confirmed by observation, this approach could represent a significant paradigm shift in our understanding of spacetime and the fundamental forces.