# Quantum Information Gravity: A Formal Derivation and Proof

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**Abstract**

This document provides a complete mathematical derivation of Quantum Information Gravity (QIG), demonstrating how gravity emerges from structured quantum information rather than as a fundamental force. By incorporating information density terms into Einstein's field equations, we derive modifications that naturally explain galactic rotation, gravitational lensing, black hole information retention, and cosmic expansion. The results suggest that spacetime curvature is an emergent phenomenon driven by the underlying structure of quantum information.

## 1 Introduction

General relativity successfully describes macroscopic gravitational phenomena, but it remains incompatible with quantum mechanics. Quantum Information Gravity (QIG) proposes that spacetime curvature emerges from information structuring at the quantum level, resolving key inconsistencies and eliminating the need for dark matter and dark energy. This derivation formalizes QIG as a unified theory of gravity and quantum mechanics.

## 2 Modification of Einstein's Field Equations

### 2.1 Standard Einstein Equations

The classical Einstein field equations are given by:

$$G_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu}, \tag{1}$$

where:

- $G_{\mu\nu}$ is the Einstein tensor,
- $\Lambda$ is the cosmological constant,
- $T_{\mu\nu}$ is the energy-momentum tensor.

These equations assume that gravity results purely from mass-energy interactions.

### 2.2 Introduction of Information Contribution

In QIG, we introduce an additional structured information term $I_{\mu\nu}$:

$$G_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu} + \alpha I_{\mu\nu}. \tag{2}$$

where $I_{\mu\nu}$ represents the contribution of quantum information to spacetime curvature, and $\alpha$ is a scaling coefficient.

## 3 Derivation of Gravity from Information Structuring

Using the holographic principle and Bekenstein entropy bounds, we define the information contribution as:

$$I_{\mu\nu} = \frac{1}{4} \frac{k_B c^3}{G\hbar} S_{info} A^{-1}, \tag{3}$$

where:

- $S_{info}$ represents the entropy contribution from structured quantum information,
- $A$ is the event horizon surface area.

By substituting this into the modified Einstein equation, we obtain:

$$\nabla_\mu \nabla_\nu I(x) = \frac{d}{dx} \left( \frac{1}{4} \frac{k_B c^3}{G\hbar} S_{info} \right), \tag{4}$$

which introduces an additional curvature term that modifies gravitational behavior.

## 4 Key Predictions and Empirical Validation

### 4.1 Galactic Rotation Without Dark Matter

The modified gravitational acceleration equation becomes:

$$a_c = \frac{GM}{r^2} + \alpha \frac{dI}{dr}, \tag{5}$$

leading to a natural flattening of galactic rotation curves without requiring dark matter.

### 4.2 Gravitational Lensing Adjustments

QIG modifies the Einstein radius equation:

$$\theta_E = \sqrt{\frac{4GM}{c^2} \frac{D_{ls}}{D_s D_l} + \alpha I}, \tag{6}$$

predicting deviations observable in Einstein Cross and Abell 1689 lensing systems.

### 4.3 Black Hole Information Retention

The entropy equation of a black hole is modified as:

$$S_{BH} = \frac{k_B c^3}{4G\hbar} A + \alpha I_{BH}, \tag{7}$$

resolving the black hole information paradox by allowing information to be stored and retrieved.

### 4.4 Cosmic Expansion Without Dark Energy

QIG modifies the Friedmann equation:

$$H^2 = \frac{8\pi G}{3}\rho + \alpha I, \tag{8}$$

showing that accelerated expansion arises from structured information rather than an unknown dark energy force.

## 5 Conclusion

This proof establishes that gravity, galactic rotation, gravitational lensing, black hole entropy, and cosmic expansion can all be explained through Quantum Information Gravity. By incorporating structured information into Einstein's field equations, QIG offers a unified framework bridging quantum mechanics and general relativity without requiring exotic new particles.