From Locked Energy to Newtonian Gravity: A Minimal Story of Conceptual Necessity

Dr. S. M. H. Emamifar

Independent Research Collaboration on Black Hole & Cosmology Concepts (IRCBHC)
Corresponding author: Koodakemanclinic@gmail.com

March 10, 2026

Abstract

Why must gravity, in its macroscopic manifestation, take the precise form of Newton's universal law? We answer this long-standing *descriptive*—not dynamical—question by constructing a minimal chain of operational reasoning. Starting from the relativistic definition of mass as timelike locked energy, we demonstrate that statistical coarse-graining erases all directional details, leaving only a scalar density. In empty, flat space, linearity and symmetry then enforce the Poisson equation as the unique consistent long-range closure. This structure is shown to be identical to the Newtonian-limit constraint of General Relativity. The contribution is interpretive: it reduces the apparent arbitrariness of Newtonian gravity by revealing it as the inevitable macroscopic imprint of three simple and well-established principles. This work exemplifies how theoretical physics advances not only by discovering new laws, but also by deepening our understanding of why established laws cannot be otherwise.

Keywords: Newtonian gravity, conceptual derivation, coarse-graining, operational physics, teaching general relativity

1 Introduction: The Quest for Conceptual Clarity

Physics progresses in two complementary ways: by discovering new phenomena, and by deepening our understanding of why established phenomena must take the form they do. Newton's law of universal gravitation marked a triumph of the first kind, unifying celestial and terrestrial motion. General Relativity (GR) later subsumed it within a profound geometric framework. Yet a *phenomenological* gap remains: Why, in the macroscopic limit, does GR's complex geometry *necessarily* simplify to Newton's inverse-square law? Is this a mere contingent approximation, or a sign of deeper structural necessity?

> **Intuitive Understanding**
>
> **The Core Question in Simple Terms:**
> Imagine you already know all the advanced rules of gravity (Einstein's equations). A student asks: "Okay, but why does it *have* to look like Newton's simple $1/r^2$ pull when things are slow and far apart? Couldn't it have been something else?"
> This paper provides a clear, step-by-step answer to that "why." It shows that Newton's law is not an arbitrary choice, but the only possible outcome of combining a few basic, uncontroversial ideas.

This paper addresses that question through an operational, minimal-necessity approach. It does not propose new physics or modify GR. Instead, it constructs a logical narrative from the relativistic nature of mass to the macroscopic gravitational potential, demonstrating that Newtonian gravity emerges as the *only consistent description* once a handful of bedrock principles

are accepted. The value of such a derivation is analogous to that of Newton's original synthesis: it replaces a collection of seemingly separate facts with a single, compelling story of *why things must be so.*

The argument is structured as a chain of five lemmas, each employing standard relativistic kinematics, statistical reasoning, and symmetry principles. The scope is strictly the weak-field, slow-motion, static regime. Our aim is **conceptual clarification**—a reduction of perceived arbitrariness through operational and structural reasoning, firmly in the tradition of Bridgman, Feynman, and the pedagogical spirit of this Journal.

2 Historical and Conceptual Context: Beyond "So What?"

A potential objection to conceptual work is the dismissive "So what?" Newton faced the same: apples fell before his theory. Gravity still works. What, then, is the value of retracing its logical origins?

The answer lies in the very nature of scientific understanding. Each major advance—from Newton's synthesis to Maxwell's unification to Einstein's relativity—has been a **descriptive revolution**. It did not change the phenomena, but it fundamentally changed our *story* about them, transforming a list of observed rules into a coherent, often inevitable, narrative. This work continues that tradition. By showing that the macroscopic form of gravity is *structurally necessitated* by more fundamental concepts (timelike energy, statistics, symmetry), we achieve a higher level of understanding: we see not just *how* it works, but *why it could not have worked any other way.*

This shifts the status of Newton's law from an empirical coincidence to a logical milestone, enriching our comprehension of the physical world.

3 The Logical Narrative: Five Lemmas

The following lemmas form a continuous chain of reasoning. Each step introduces a necessary concept, culminating in the unique form of the Newtonian potential.

Lemma 0 — Operational Decoupling: Energy Existence $\neq$ Direct Detectability

Statement. The existence of an energy configuration is an invariant fact, independent of whether it produces a net detectable signal (e.g., flux) in a particular measurement. Bound or internally circulating energy can be present while yielding zero net detection in a coarse-grained measurement.

> **Intuitive Understanding**
>
> **Why This Matters First:**
> A battery that is "off" emits no detectable signals, yet it undeniably contains stored energy. Separating the concept of *existence* from *immediate detectability* is crucial for talking about sources (like mass) that are not always actively radiating.

Role. This prepares the ground for defining mass as a form of "locked" energy that may not manifest as a propagating flux.

Lemma 1 — Mass as Timelike Locked Energy

Statement. For any isolated system with a finite total four-momentum p^μ, the invariant rest mass m, defined by $m^2c^2 = p^\mu p_\mu$, exists and is non-zero if and only if p^μ is timelike ($p^\mu p_\mu > 0$).

This mass represents energy that cannot be transformed away by any Lorentz boost; it is *locked* within the system.

> **Intuitive Understanding**
>
> **The Central Image:**
> A stationary rock has energy. If you run past it, its kinetic energy from your perspective changes, but a core part of its energy—its mass-energy—*remains*. This "un-removable" core is what we call rest mass. It is a direct consequence of the energy-momentum four-vector pointing more in the time direction than in any space direction (it is **timelike**).

Role. This provides a purely relativistic-kinematic definition of mass, devoid of microscopic ontology, as the necessary starting point for a gravitational source.

Lemma 2 — The Emergence of Scalarity from Coarse-Graining

Statement. Consider a large collection of independent, timelike energy carriers (e.g., particles with mass). When coarse-grained over a macroscopic volume much larger than the inter-carrier separation and in a local rest frame where bulk momentum vanishes, the averaged energy-momentum tensor $\langle T^{\mu\nu} \rangle$ becomes diagonal. The spatial components (pressure) become isotropic and, in the non-relativistic limit, negligible compared to the time-time component, which is a scalar energy density ρ.

Assumptions. Statistical isotropy of random motions in the local rest frame; no coherent large-scale drift at the averaging scale.

> **Intuitive Understanding**
>
> **The Key Conceptual Leap:**
> Imagine a sealed box filled with buzzing flies. Up close, each fly has a velocity vector. But from outside the box, you don't see individual vectors; you just see a **box full of flies**. The detailed motions average out to zero net flow.
> Similarly, for matter: Microscopically, particles have individual momenta (vectors). Macroscopically, after averaging, only one number remains: **how much stuff per volume**. The "vector-ness" and "tensor-ness" cancel out. Gravity, at large scales, sees only this **scalar density**.

Role. This lemma explains the critical transition: why the complex microscopic source (a full tensor $T^{\mu\nu}$) appears to gravity as a simple scalar density ρ in the Newtonian limit. It is the heart of our narrative.

Lemma 3 — The Unique Long-Range Scalar Closure in Flat Space

Statement. In static, empty, flat spacetime (Minkowski background), a linear, local influence sourced by a scalar density $\rho(\vec{x})$ must be described by a potential Φ satisfying the simplest second-order linear equation consistent with rotational invariance and the absence of intrinsic scales: $\nabla^2 \Phi = \kappa\rho$, where κ is a coupling constant. The solution is the familiar Poisson potential, $\Phi(\vec{x}) \propto \int d^3x' \, \rho(\vec{x}')/|\vec{x} - \vec{x}'|$, implying an inverse-square law force $\vec{F} \propto -\nabla\Phi$.

Interpretation. Φ is a bookkeeping device for the cumulative scalar influence; the sign of κ (positive for attractive gravity) is fixed by the positive definiteness of mass-energy (Lemma 1).

Role. This lemma closes the system, showing that the macroscopic interaction law is fixed by symmetry and linearity, given the scalar source from Lemma 2.

Lemma 4 — Identification with the Newtonian Limit of General Relativity

Statement. The Poisson equation derived in Lemma 3 is mathematically identical to the time-time component of the linearized Einstein field equations in the slow-motion, weak-field limit (the Newtonian gauge). Specifically, the Hamiltonian constraint of GR reduces precisely to $\nabla^2 \Phi = 4\pi G \rho$, where Φ is identified with the perturbation in the temporal metric component.

Clarification. This is not a derivation of GR from simpler principles, but a *conceptual identification*. It shows that the necessary structure we have arrived at is exactly the structure that GR mandates in its appropriate limit.

Role. This lemma grounds our conceptual narrative in the solid foundation of established physics, confirming its consistency and relevance.

4 Discussion: Nature of the Contribution and Addressing "So What?"

The contribution of this work is **clarificatory and unifying**, not dynamical. It weaves together three well-established strands of physics—relativistic kinematics, statistical mechanics, and classical field theory—into a single, compelling narrative that explains the *necessity* of Newtonian gravity's macroscopic form.

What is New Here?

The individual components (timelike four-momentum, coarse-graining, the Poisson equation, the Newtonian limit of GR) are standard. The novelty lies in:

1. **The specific logical sequence:** Starting from the operational definition of mass and *explicitly justifying* the scalar nature of the source via coarse-graining (Lemma 2) provides a causal link missing from purely geometric or axiomatic derivations.

2. **The minimalist, operational philosophy:** Each step is justified by what is minimally necessary, avoiding ontological commitments.

3. **The pedagogical synthesis:** The narrative is structured to answer the "why" question directly and intuitively, making the inevitability of Newton's law clear to students and experts alike.

This work stands in the tradition of Taylor's derivation of the inverse-square law from symmetry [1] but deepens it by grounding the scalar source assumption in relativistic statistics. It complements the geometric perspective of Misner, Thorne, and Wheeler [2] by providing a "bottom-up" operational story for the source term in their top-down geometric framework.

Scope and Intended Impact

This analysis is deliberately restricted to the static, weak-field, slow-motion regime where Newtonian gravity is an excellent approximation. It does not address gravitational waves, black holes, cosmology, or quantum gravity. Its goal is to improve *conceptual understanding* of a cornerstone of classical physics. By showing that Newton's law is not an arbitrary starting point but a logical endpoint of deeper principles, we aim to:

1. Enrich the teaching of gravity and the transition from special to general relativity.

2. Provide a satisfying answer to the perennial student question: "Why does gravity have this specific form?"

3. Exemplify how theoretical physics often advances by revealing the hidden necessity within known laws.

5 Conclusion

We have presented a minimal operational narrative demonstrating that the macroscopic, Newtonian form of gravity is a structural necessity. The chain is simple and compelling:

<div align="center">

Timelike Locked Energy (Mass)
$\Downarrow$ (Statistical Coarse-Graining)
Scalar Energy Density
$\Downarrow$ (Linearity + Symmetry in Empty Space)
Potential satisfying Poisson's Equation
$\Downarrow$ (Identification)
Newtonian Limit of General Relativity

</div>

This work does not change the equations of gravity. Instead, it changes our *story* about them. It shows that Newton's law, far from being an arbitrary empirical rule, is the inescapable macroscopic signature of three robust ideas: energy is frame-invariant when timelike, details vanish under averaging, and empty space treats all directions equally. In answering "why this form?", we achieve a deeper, more unified understanding—a goal at the very heart of the physics enterprise.

> **Intuitive Understanding**
>
> **The Take-Home Message:**
> If you believe in:
>
> 1. **Einstein's** $E = mc^2$ (mass is locked energy),
>
> 2. **The law of large numbers** (random motions average out),
>
> 3. **The simplicity and symmetry of empty space**,
>
> then you are logically committed to **Newton's law of universal gravitation** as the correct description of attraction at large scales. There is no other option. This is the power of logical necessity in physics.

Acknowledgments

References

[1] Taylor, E. F. (1963). *Newton's law of gravitation from a symmetry assumption*, Am. J. Phys. **31**, 626–627.

[2] Misner, C. W., Thorne, K. S., & Wheeler, J. A. (1973). *Gravitation*, W. H. Freeman.

[3] Wald, R. M. (1984). *General Relativity*, University of Chicago Press.

[4] Feynman, R. P., Morinigo, F. B., & Wagner, W. G. (1995). *Feynman Lectures on Gravitation*, Addison-Wesley.

[5] Carroll, S. M. (1997). *Lecture Notes on General Relativity*, arXiv:gr-qc/9712019.

[6] Padmanabhan, T. (2010). *Gravitation: Foundations and Frontiers*, Cambridge University Press.

[7] Sakstein, J. (2017). *Beyond the Cosmological Standard Model*, Physics Reports **733**, 1–93.