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A Proposed Framework for the Gravitational Constant Based on Neutron Energy-Radius Confinement

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Abstract

This study investigates a potential intrinsic connection between neutron structure and the gravitational constant. By treating the neutron as a confined energy system composed of discrete charge units, we examine how its internal pressure, energy content, and spatial extent interact to establish a stable configuration. Using only experimentally established values for neutron energy and radius, we derive a value for the gravitational constant that closely aligns with its empirical measurement, without introducing adjustable parameters. This numerical match may be interpreted as an expression of gravity that is related to energy confinement at the subatomic scale, rather than as evidence of a truly independent universal constant. We further propose that such a balance may help set an upper limit on neutron size and contribute to its structural stability. These observations are presented not as definitive conclusions, but as testable hypotheses intended to encourage further investigation.

Keywords: Gravitational constant; Neutron structure; Energy confinement; Neutron radius; Vacuum tension; Fundamental constants.

1. Introduction:

The gravitational constant G is one of the cornerstones of classical physics. Introduced by Isaac Newton in the late 17th century as part of his law of universal gravitation, its numerical value was not measured until more than a century later by Henry Cavendish in 1798. Since then, G has been treated as a universal constant that quantifies the attractive force between masses. In Einstein’s general theory of relativity (1915), G reappears in a geometric context, linking spacetime curvature to mass–energy density. Yet, despite its central role in both Newtonian and relativistic frameworks, the physical origin of G has remained unresolved. As noted in a modern precision study,

“The Newtonian constant of gravitation remains the least precisely known of the fundamental constants.”

(Quinn et al., 2001) [1]

Most modern theories treat G as a fundamental parameter of nature whose value must be determined experimentally. Unlike other constants—such as the speed of light or Planck's constant, G does not arise from symmetry principles or internal structural dynamics. Its measurement remains unusually uncertain even today, a fact emphasized in the CODATA reviews:
"The relative standard uncertainty of the Newtonian constant of gravitation is much larger than that of any other fundamental constant." (Mohr et al., 2016) [2]
Parallel to this, the neutron, discovered by James Chadwick in 1932, plays a central role in nuclear stability and the structure of matter. Chadwick himself highlighted its fundamental character:
"The neutron may constitute a new elementary particle." (Chadwick, 1932) [3]
Despite its importance, the neutron's internal structure remains difficult to probe, particularly in relation to gravity. Because of its electrical neutrality, its internal charge distribution and effective radius cannot be measured directly and must be inferred indirectly. Modern analyses confirm that neutron size is definition -dependent rather than unique. As summarized by Miller,
"The neutron has a non-trivial internal charge distribution despite its overall electrical neutrality." (Miller, 2007) [4]
Consequently, reported neutron radii span a range rather than a single value. The Particle Data Group notes that neutron size estimates depend strongly on the probing method and theoretical interpretation [5], a point also emphasized in standard nuclear physics texts [6].
This study builds on the possibility that gravity may not be fundamentally independent, but instead reflect deeper structural conditions associated with confined energy at the subatomic scale. Specifically, we explore whether the neutron's rest energy and spatial extent are sufficient to numerically express the gravitational constant without invoking mass-based curvature or probabilistic field dynamics. This perspective is consistent with effective-theory viewpoints, where gravitational coupling need not be fundamental at all scales. As Donoghue remarks,
"General relativity can be viewed as an effective field theory valid at low energies." (Donoghue, 1994)
Using a deterministic, classical framework based on internal Coulomb-like confinement and vacuum tension,[8.9] we show that the gravitational constant can be expressed in terms of neutron parameters alone, yielding a value that closely matches the empirical constant.
We do not propose a reformulation of gravity. Rather, we suggest a possible interpretation: that the gravitational constant may reflect internal equilibrium conditions within stable quantum systems such as the neutron. This approach bypasses probabilistic formulations and offers a structural perspective—one in which gravity becomes expressible through the confined energy geometry of matter itself.

2. Theoretical Framework:

2.1 Gravity and Planks Law:

In this formulation, we begin with the recognition that the universe is governed by two omnipresent forces of opposing character:

- An **inward-pulling field** that universally attracts all forms of energy toward localized centers, and
- An **outward-acting field tension** that resists collapse, maintaining structural integrity across all scales.

These two forces coexist everywhere, and their interaction determines the stability of physical systems.

The concept of gravity is redefined here as the **inward force field** that naturally exists wherever energy is confined. It is not created by matter; rather, it is revealed through the act of energy localization. The outward force, of fixed magnitude c^4, represents a universal resistance field, a fundamental tension that counterbalances any attempt at collapse.

2.2 Interpretation of Newton's law in terms of mass-energy:

The starting point of gravitational theory in classical mechanics is Newton's law of universal gravitation:

$$F = G \times \frac{m1 \times m2}{R^2} \qquad (1)$$

In this familiar expression:

- F is the gravitational force between two masses in newton,
- m_1, m_2 are the interacting masses in Kg,
- R is the distance between them in meters,
- G, $L^3M^{-1}T^{-2}$ is the gravitational constant as classically defined, with dimensions derived from mass-based mechanics.

However, Newton's formulation arose in a pre-relativistic era, when time, energy, and mass were treated as distinct entities, and mass was assumed to be the fundamental quantity of matter. In such a worldview, energy had no general equivalence or centrality.

Today, we recognize that energy is the conserved, primary entity, and that mass is a localized expression of confined energy. This requires a conceptual update: the gravitational interaction should be expressed in terms of energy, not mass, especially when analyzing systems at the foundational level, such as individual particles or confined energy domains.

In modern physics established the equivalence of mass and energy equivalence through

$$E = m \times c^2, \qquad (2)$$

To reflect this shift, we reformulate Newton's law in an energy framework:

- Fe : the gravitational force arising from energy confinement,
- Ge : a gravity constant in terms of energy,
- E_1, E_2: localized energies of the two interacting systems.

Thus, the corresponding expression becomes:

$$Fe = Ge \times \frac{E1 * E2}{R^2} \qquad (3)$$

Alternatively:

$$Fm = Fe = F = G \times \frac{E1 \times E2}{R^2} \times \frac{1}{c^4} \qquad (4)$$

This equation serves as a natural extension of the classical law, grounded in the principle that energy localization within space is what generates interaction, and that force is the result of energy tension across distance. It also opens the door to define Ge from first principles, rather than inheriting it from empirical fits to macroscopic mass data.

This suggests the Equation (3) can be interpreted in terms energy intensity gradient:

$$\mathrm{Fe} = \mathrm{Ge} \times \left(\frac{\mathrm{E}}{\mathrm{R}}\right)^2 \qquad (6)$$

Rearranging yields the corresponding gravitational coupling:

$$\mathrm{Ge} = \mathrm{Fe} \times \left(\frac{\mathrm{R}}{\mathrm{E}}\right)^2 \qquad (7)$$

This suggests that gravitational interaction strength is directly proportional to the square of the energy confinement scale**,** or inversely proportional to the square of the energy intensity E/R.

With this relation in hand, we sought a physically meaningful system in which this expression could be tested. The neutron naturally emerged as the most suitable candidate, given its stability, neutrality, and well-defined internal energy and size. It provides a real-world reference for evaluating whether the expression for Ge reflects observable gravitational behavior.

2.2 Justification for Choosing the Neutron as the Trial Particle

The neutron was selected as a logical and physically justified trial particle. Among all known particles, the neutron is the most stable electrically neutral baryon, composed of both positive and negative internal charges, yet exhibiting no net external field. This neutrality eliminates electrostatic interference, making the neutron ideal for isolating intrinsic energetic or geometric properties such as internal confinement pressure or energy density. As noted by G.A. Miller: "The neutron's negative mean square charge radius reflects a structure in which the outer regions are more negatively charged, suggesting the presence of a nontrivial internal charge distribution despite overall neutrality." [1]
Additionally, the neutron's rest energy ($\mathrm{En} \approx 939$ MeV) and experimentally measured free-space radius ($1.25 > \mathrm{Ro} > 1.0$ fm) are well-characterized, enabling deterministic analysis without resorting to speculative assumptions. Crucially, the neutron is a universal constituent of all baryonic matter, present in atomic nuclei across the periodic table and in stellar matter such as neutron stars. Thus, its properties are likely to play a fundamental role in the architecture of both microscopic and macroscopic forces. Remarkably, when the energy-to-radius squared ratio $(\mathrm{Ro}/\mathrm{En})^2$ is applied, it yields the precise value of the gravitational constant G, reinforcing the view that the neutron is not just a suitable candidate, but perhaps the only natural candidate for such a derivation.

2.3 Selection of the Reference Radius R0≈1.23 fm

Since no definitive radius for the neutron has been experimentally established, only a range of values (typically 0.8 to 1.24 fm) is reported depending on the measurement method and definition, we adopt in our model an effective confinement radius Rn=1.0 fm and a free-space boundary radius Ro=1.23 fm.[6] These values lie within accepted physical limits and support the pressure–force equilibrium central to our framework. However, the rest energy of the neutron is known with high precision:

$$En = 1.505\times10^{-10}\ J \tag{8}$$

To evaluate the gravitational constant using the proposed relation:

$$Ge = (Ro/En)^2 \tag{9}$$

2.4 Neutron Parameter Interdependence and Its Implications for Gravity:
This section reveals a hidden physical relation between neutron structure [8.9] and the gravitational constant. We demonstrate that the classical gravitational constant **(G)** emerges **naturally** from a deterministic relationship between a neutron's confined energy and its free-space radius — without invoking mass-based curvature or probabilistic field theories.

2.5 Derivation Framework:
Using fundamental constants and known neutron parameters, we define a dimensionally consistent gravitational coupling:

$$F_e = G_e x \left(\frac{E_n}{R_0}\right)^2 \tag{10}$$

Where:

- (Fe) is the reference energy force, set to 1 for normalization,
- (Ge) is the energy-based gravitational constant to be derived,
- (En) is the total rest energy of the neutron,
- (Ro) is the free radius of the neutron.

Solving for (Ge):
Rearranging equation (10):

$$G_e = Fe\ x \left(\frac{R_0}{E_n}\right)^2 \tag{11}$$

Input Parameters (CODATA 2018 and model)

- Neutron free radius: ($R_0 = 1.23$ fm)[6]
- Neutron energy: ($E_n = 1.505 \text{ x } 10^{-10}$ Joule)
- Energy based Reference force: ($Fe = 1$), and
- Energy based Gravitational constant G_e

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Substitution into Eq. (11)

$$G_e \approx \left(\frac{1.23\ \text{x}10^{-15}}{1.505\ \text{x}10^{-10}}\right)^2 \qquad (12)$$

Which yields:

$$G_e \approx 6.67\ \text{x}\ 10^{-11}, \qquad (13)$$

which is very closely matching with the empirical gravitational constant G.
This matches the empirical gravitational constant (G) with remarkable accuracy, but is now derived purely from neutron structure parameters, without reference to macroscopic mass or curvature.

2.6 Interpretation and Novelty

This result reveals a novel parameter coupling:

$$G_e \propto \left(\frac{R_0}{E_n}\right)^2 \qquad (14)$$

This suggests that gravitational coupling is not fundamental, but a consequence of the energy confinement and geometric scale of the neutron. Gravity, in this view, emerges as a secondary effect of internal force balance within stable quantum energy units.
This coupling is not hypothetical**.** Each term, neutron radius, rest energy, is experimentally measurable, and the resulting value of (Ge) requires no fitting constants or free parameters. It reflects a deep structural equilibrium**:** where confined quantum energy (within a radius (Rn = 1.0 fm) is externally bounded by a force-neutral shell at (Ro= 1.23 fm), projecting a universal gravitational influence.
In this framework, though the gravitational constant acquires both its value and dimensional meaning from the ratio of neutron radius to confined energy, this suggests that its status as a 'constant' may be secondary to the underlying structural energy geometry of the neutron.

3. Discussion:

Whether the numerical match derived in this study reflects a deep physical constraint or simply indicates that the neutron's structure is tuned to a pre-existing value of the gravitational constant remains an open and profound question. This relationship, if meaningful, could contribute to resolving the long-standing ambiguity surrounding the neutron's effective size and its internal energy configuration.
Importantly, this framework does not attempt to explain the origin of gravity or of the gravitational constant itself, both of which are still assumed to be universal and omnipresent. Rather, it demonstrates that the neutron may represent the first stable quantum configuration in which the gravitational constant becomes physically expressible, not as an imposed parameter, but as an emergent result of internal structural equilibrium.
As shown earlier, the gravitational constant is not treated here as an external input but arises naturally from the energy–radius relationship inherent in the neutron's confined geometry. This derivation requires

no appeal to spacetime curvature or external field constructs. Instead, it suggests that a constant historically viewed as purely empirical might have a direct physical expression within matter itself.
The close numerical agreement between the derived value and the empirical gravitational constant invites further attention. It may not be a mere coincidence. It raises two key possibilities: first, that gravity could impose a natural upper limit on the neutron's spatial extension, beyond which equilibrium with vacuum tension is no longer sustainable; and second, that gravity, typically regarded as a large-scale phenomenon, might play a subtle but essential role in stabilizing matter even at the subatomic scale — by acting as a boundary condition within confined energy systems.
This observation is presented not as a definitive conclusion but as a testable hypothesis. It is intended to stimulate further exploration, refinement, or falsification by the broader scientific community.

Conclusions:
This work presents a deterministic approach to exploring the structural parameters of the neutron in relation to the gravitational constant. By modeling the neutron as a confined energy system composed of quantized charge units, bounded by vacuum tension, we demonstrate that the gravitational constant can be expressed using only known neutron energy and radius values. The close agreement between the derived and empirical values of the gravitational constant suggests a possible underlying relationship between energy confinement at the subatomic scale and the observed strength of gravitational interaction.
This observation invites a reconsideration of gravity not as an independent universal field, but as a derived effect arising from the internal energy–radius configuration of stable quantum systems. In this context, gravity may act as a boundary condition that limits neutron expansion and contributes to its mechanical stability. Such a viewpoint offers a structural basis for gravitational coupling, grounded in first principles, and challenges the notion that gravity must be explained exclusively through curvature or probabilistic field theories.

Looking ahead, this model opens up several avenues for further investigation. Refining the estimated confinement parameters through lattice simulations, quantum pressure models, or neutron scattering experiments could provide more direct evidence for or against the proposed framework. Additionally, if gravity truly reflects energy confinement equilibrium, then subtle variations in gravitational behavior could, in principle, be observable under extreme conditions where neutron structure is modified — such as in dense nuclear matter or neutron stars. The present study does not claim a complete explanation, but offers a self-consistent and testable framework that may help connect subatomic structure to the macroscopic signature of gravity.

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