Structural Origin of Gravity

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Abstract

We present a structural formulation of gravity in which the gravitational constant and gravitational coupling strengths are derived from fixed ratios without introducing free parameters.

The framework is based on two constants,

$$R = \frac{13}{6}, \qquad S = \frac{31}{24},$$

together with structural indices Ψ_G and Ψ_G^* that encode the gravity-sector configuration.

Within this formulation, the gravitational constant is expressed as

$$\sqrt{G} = \frac{\alpha S}{\pi \Psi_G},$$

leading to

$$G \approx 6.674338186956 \times 10^{-11}.$$

In addition, gravitational couplings are derived as

$$\alpha_{Gp}, \qquad \alpha_{Ge},$$

using the same structural components that govern the particle mass hierarchy.

All quantities are obtained without parameter fitting and are expressed in dimensionless structural form.

A key result is that the structural expression, although dimensionless, reproduces the SI value of G, suggesting a possible correspondence between dimensional constants and underlying structural ratios.

Importantly, the residual gravitational suppression is not introduced as an independent parameter, but is uniquely determined from the global structure.

The results indicate that gravity can be interpreted as a residual structural coupling governed by the same architecture that determines electromagnetic and mass relations.

1 Introduction

In standard physical theory, the gravitational constant G is treated as a fundamental input parameter [1, 2]. Its numerical value is determined experimentally and reported by CODATA [3].

Similarly, the extremely small magnitude of gravitational coupling compared to other interactions remains unexplained within conventional frameworks.

In this work, we present a structural formulation in which gravitational quantities are derived from fixed ratios without introducing free parameters.

The approach follows the same framework used for electromagnetic coupling and mass hierarchy, extending it to the gravity sector through a set of structural indices.

We show that

- G,
- gravitational couplings α_{Gp} and α_{Ge},

can all be derived from a common structural basis.

No free parameters are introduced. No tuning is performed. All quantities arise from structure.

2 Structural Constants R and S

The present framework is constructed from two fixed structural constants,

$$R = \frac{13}{6}, \qquad S = \frac{31}{24},$$

which serve as common symbols across all derived relations.

These constants are not introduced as adjustable parameters, but are treated as fixed structural ratios. They appear universally in the formulation of coupling constants, mass hierarchies, and gravitational scales.

2.1 Structural Role of R

The constant R represents the fundamental structural propagation ratio. It encodes how the full underlying structure is reconstructed from the observable sector.

In the expressions derived in this work, R consistently appears in two characteristic forms:

$$3R^2, \qquad 4R,$$

which correspond to two distinct structural components:

- $3R^2$: secondary-binding structure (deeper, nested level),
- $4R$: primary-binding structure (direct interaction level).

These two components form the basis of the structural relations presented below.

2.2 Structural Role of S

The constant S acts as an internal/external conversion factor. It mediates the relation between the internal structural organization and the externally observed quantities.

In all expressions, S appears in the form of a projection or normalization factor, such as

$$\frac{3R^2}{S}, \qquad \frac{4R}{S},$$

which convert internal structural components into observable values.

In this interpretation,

- internal structure corresponds to the underlying binding configuration,
- external observation corresponds to quantities measured in the observational sector,
- S bridges these two descriptions.

2.3 Unified Structural Interpretation

Together, R and S provide a complete structural description of the system:

- R defines the internal organization of the structure,
- S connects the internal structure to observable quantities.

All physical relations in this work are expressed as combinations of these two constants, without introducing any additional free parameters.

3 Structural Indices in the Gravity Sector

In the gravity sector, the structural content is encoded by two indices, Ψ_G and Ψ_G^*.

3.1 Definition of Ψ_G and Ψ_G^*

The gravity-sector indices are defined as

$$\Psi_G = \frac{12(3R^2)(4R) + 2R}{4}, \tag{1}$$

$$\Psi_{G0} = RS^2(12 \cdot 24), \tag{2}$$

$$\Psi_G^* = 4\Psi_G - 3\left(1 + \frac{1}{\Psi_{G0}}\right). \tag{3}$$

For $R = 13/6$ and $S = 31/24$, these reduce to

$$\Psi_G = \frac{1469}{4} = 367.25, \tag{4}$$

$$\Psi_{G0} = \frac{12493}{12}, \tag{5}$$

$$\Psi_G^* = \frac{18314702}{12493} \approx 1465.997118386296. \tag{6}$$

3.2 Structural Interpretation

The index Ψ_G is interpreted as the global structural branching index of the gravity sector. It represents the full coupled pathway of secondary binding, primary binding, and residual transfer across the fourfold base.

The auxiliary bridge scale Ψ_{G0} represents the small residual bridge associated with the structural hierarchy,

$$\Psi_{G0} = RS^2(12 \cdot 24).$$

The quantity Ψ_G^* is interpreted as the residual suppression index governing gravitational coupling. It is not introduced as an independent parameter, but is derived from the fourfold gravity-sector propagation structure with a small bridge residual:

$$\Psi_G^* = 4\Psi_G - 3\left(1 + \frac{1}{\Psi_{G0}}\right).$$

Thus, the residual gravitational suppression is not an independent channel, but an emergent correction derived from the global structural configuration and its bridge residual.

4 Structural Gravity Relations

4.1 Gravitational Coupling Relations

$$\alpha_{Gp} = \alpha^{24}\left(\frac{m_p}{m_e}\right)^4\left(1 + \frac{1}{\Psi_G^*}\right)^{-1}. \tag{7}$$

$$\alpha_{Ge} = \alpha^{24}\left(\frac{m_p}{m_e}\right)^2\left(1 + \frac{1}{\Psi_G^*}\right)^{-1}. \tag{8}$$

4.2 Structural Expression for $\sqrt{G}$ and G

The gravitational constant is expressed as

$$\sqrt{G} = \frac{\alpha S}{\pi \Psi_G}. \tag{9}$$

Consequently,

$$G = \left(\frac{\alpha S}{\pi \Psi_G} \right)^2. \tag{10}$$

In this expression,

- α provides the observed coupling normalization,
- S acts as the internal/external bridge,
- π plays the role of observational projection,
- Ψ_G encodes the total structural branching of the gravity sector.

Thus, G is interpreted as the projected residual coupling of the full structural architecture.

4.3 Comparison with Observations

Using the structural values inherited from the electroweak sector, the updated theoretical results are:

$$\alpha_{Gp} \approx 5.906183221787 \times 10^{-39}, \tag{11}$$
$$\alpha_{Ge} \approx 1.751819421756 \times 10^{-45}, \tag{12}$$
$$\sqrt{G} \approx 8.169662286139 \times 10^{-6}, \tag{13}$$
$$G \approx 6.674338186956 \times 10^{-11}. \tag{14}$$

The same structural bridge also yields the following SI mass scales:

$$M_{\mathrm{Pl}} \approx 2.176428116519 \times 10^{-8} \text{ kg}, \tag{15}$$
$$M_P \approx 1.672621925955 \times 10^{-27} \text{ kg}, \tag{16}$$
$$M_E \approx 9.109383713904 \times 10^{-31} \text{ kg}. \tag{17}$$

These values show high agreement with observed reference values. In particular, the comparison for G yields a deviation of approximately 0.25σ, and the Planck mass is also reproduced within approximately 0.25σ.

This agreement is obtained without parameter fitting, indicating that both gravitational coupling and SI mass scales can be reconstructed from structural relations alone.

5 Interpretation of the Gravity Indices

5.1 Ψ_G

The quantity

$$\Psi_G = \frac{1469}{4} = 367.25$$

acts as the global branching index of the gravity sector.

It represents the total coupled pathway across the residual gravitational architecture. In this sense, Ψ_G plays the same role for gravity that Ψ_e or Ψ_p plays in the particle sector: it identifies the structural complexity of the configuration.

The product

$$(3R^2)(4R)$$

is interpreted not merely as an algebraic combination of two structural components, but as a maximally connected configuration in which the secondary-binding sector $(3R^2)$ and the primary-binding sector $(4R)$ are fully coupled.

In this sense, the expression does not represent an ordinary spatial density of particles. Rather, it represents a *structural density*, namely the saturation of available binding pathways across the coupled network. The gravity-sector index Ψ_G therefore reflects a state in which the relevant structural channels are densely occupied in the sense of connectivity, not in the sense of geometrical packing.

This interpretation is consistent with the role of gravity in the present framework. Unlike localized interaction sectors, gravity is described here as a residual coupling of the full structural architecture. Accordingly, the term $(3R^2)(4R)$ is understood as the dense structural background from which the gravitational sector emerges.

5.2 Ψ_G^*

The quantity

$$\Psi_G^* = \frac{18314702}{12493} \approx 1465.997118386296$$

acts as the residual suppression index.

It represents the small bridge residual remaining after hierarchical reduction of the dominant gravity pathway. The expression

$$\Psi_G^* = 4\Psi_G - 3\left(1 + \frac{1}{\Psi_{G0}}\right)$$

has three components:

- $4\Psi_G$: the full fourfold propagation structure of the gravity sector,
- 3: the dominant reduction of the primary propagation layer,
- $1/\Psi_{G0}$: the small bridge residual contribution.

This demonstrates that the suppression of gravitational coupling is not an external adjustment, but an intrinsic consequence of the global structural configuration and its residual bridge.

5.3 Summary

- Ψ_G: global structural scale of the gravity sector,
- Ψ_G^*: residual suppression derived from Ψ_G and the bridge scale Ψ_{G0}.

Thus, gravity is interpreted as a residual structural sector emerging from a single unified structure.

6 SI Representation and Dimensional Interpretation

A notable feature of the present formulation is that the numerical value associated with the SI representation of the gravitational constant is reproduced from a purely structural expression,

$$\sqrt{G} = \frac{\alpha S}{\pi \Psi_G}. \tag{18}$$

The quantities appearing in this relation are dimensionless structural parameters:

- the fine-structure constant α,
- the structural bridge factor S,
- the structural index Ψ_G,
- the projection factor π.

Nevertheless, the resulting numerical value closely matches the experimentally adopted SI value of G.

This observation does not by itself establish a derivation of physical dimensions. Rather, it suggests that part of the numerical content conventionally associated with the SI representation of G may be expressible through underlying dimensionless structure.

6.1 Role of π, S, and Ψ_G

Within this interpretation:

- π represents the projection factor associated with observational representation,
- S connects the internal structural scale to the external observational form,
- Ψ_G sets the global branching scale of the gravity sector.

From this perspective, the role of the structural relation is not to replace the SI framework, but to provide a possible organizational principle linking the observed numerical value of G to a hierarchy of fixed dimensionless quantities.

6.2 Implication

The interpretation proposed here is intentionally conservative. The agreement indicates the existence of a nontrivial structural correspondence, while the deeper origin of dimensional units remains outside the scope of the present work.

Thus, the SI expression of G is treated as an observational representation compatible with an underlying dimensionless structural formulation.

7 Planck Bridge and SI Mass Scales

The updated implementation also evaluates the Planck mass and the proton and electron SI mass scales. Using the exact SI definitions

$$c = 299792458, \qquad h = 6.62607015 \times 10^{-34},$$

and

$$\hbar = \frac{h}{2\pi},$$

the Planck mass is computed as

$$M_{\mathrm{Pl}} = \sqrt{\frac{\hbar c}{G}}. \tag{19}$$

In the present framework, M_{Pl} acts as a bridge between the dimensionless structural hierarchy and observed SI mass scales. The proton and electron SI masses are then written as

$$M_P = M_{\mathrm{Pl}}\,\alpha^{12}\left(\frac{m_p}{m_e}\right)^2\left(1+\frac{1}{\Psi_G^*}\right)^{-1/2}, \tag{20}$$

$$M_E = M_{\mathrm{Pl}}\,\alpha^{12}\left(\frac{m_p}{m_e}\right)\left(1+\frac{1}{\Psi_G^*}\right)^{-1/2}. \tag{21}$$

These expressions show that the same residual suppression factor entering the gravitational couplings also appears in the SI mass bridge. Thus, the gravity sector connects not only to the gravitational constant and gravitational couplings, but also to the observed proton and electron mass scales.

8 Conclusion

In this work, we have presented a structural formulation of gravity in which the gravitational constant and gravitational couplings are derived from fixed ratios rather than introduced as independent parameters.

The formulation is based on the same structural constants

$$R = \frac{13}{6}, \qquad S = \frac{31}{24},$$

used in the electroweak and mass-hierarchy sectors, together with two gravity-sector indices, Ψ_G and Ψ_G^*.

Within this framework, we have shown that:

- the gravitational constant is expressed as

$$\sqrt{G} = \frac{\alpha S}{\pi \Psi_G},$$

- the proton-side and electron-side gravitational couplings are derived as

$$\alpha_{Gp}, \qquad \alpha_{Ge},$$

- the observed value of G is reproduced with high precision,
- the Planck mass, proton mass, and electron mass scales are recovered through the same structural bridge,
- the extremely small magnitude of gravitational coupling is interpreted as a residual structural effect.

A central result of this work is that the residual suppression entering gravitational coupling is not introduced as an independent parameter, but is derived from the global structural index and its bridge residual as

$$\Psi_G^* = 4\Psi_G - 3\left(1+\frac{1}{\Psi_{G0}}\right), \qquad \Psi_{G0} = RS^2(12\cdot 24).$$

This demonstrates that gravity is not governed by an additional freely adjusted scale, but emerges as a residual effect of the same structural architecture that defines the global branching configuration.

A particularly important feature of the present formulation is that the structural expression for G is entirely dimensionless, while still reproducing the observed SI value. This suggests that the dimensional appearance of G may be associated with observational representation, rather than requiring an additional dimensional input within the present formulation.

The results suggest that the smallness of gravity, as well as the numerical value of G, can be understood as consequences of structural organization and projection, rather than requiring separate dynamical assumptions.

Taken together, these findings indicate that gravity can be interpreted as a residual structural sector within a unified framework that also governs electromagnetic coupling and particle mass hierarchy.

All reported quantities are obtained from fixed structural relations without parameter fitting.

A Comparison with Observational Data

Observed values are taken from CODATA 2022 [3] and PDG 2024 [4].

The theoretical predictions are compared with representative observed values. All quantities are derived without parameter fitting, using only fixed structural relations.

Quantity	Theory	Observation	Abs. diff	Rel. diff (%)	σ
α_{Gp}	$5.906183221787 \times 10^{-39}$	$5.906149433384 \times 10^{-39}$	$+3.38 \times 10^{-44}$	$+5.72 \times 10^{-4}$	—
α_{Ge}	$1.751819421756 \times 10^{-45}$	$1.751809399864 \times 10^{-45}$	$+1.00 \times 10^{-50}$	$+5.72 \times 10^{-4}$	—
$\sqrt{G}$	$8.169662286139 \times 10^{-6}$	$8.169638914909 \times 10^{-6}$	$+2.34 \times 10^{-11}$	$+2.86 \times 10^{-4}$	—
G	$6.674338186956 \times 10^{-11}$	$6.674300000000 \times 10^{-11}$	$+3.82 \times 10^{-16}$	$+5.72 \times 10^{-4}$	$+0.254580$
M_{Pl}	$2.176428116519 \times 10^{-8}$	$2.176434000000 \times 10^{-8}$	-5.88×10^{-14}	-2.70×10^{-4}	-0.245145
M_P	$1.672621925955 \times 10^{-27}$	$1.672621925950 \times 10^{-27}$	$+4.71 \times 10^{-39}$	$+2.81 \times 10^{-10}$	$+0.009054$
M_E	$9.109383713904 \times 10^{-31}$	$9.109383713900 \times 10^{-31}$	$+4.29 \times 10^{-43}$	$+4.71 \times 10^{-11}$	$+0.001533$

Table 1: Updated comparison between theoretical predictions and observed values. All quantities are derived without parameter fitting using fixed structural relations.

B Minimal Reproducible Code

The following minimal implementation highlights the structural origin of gravity.

```
from fractions import Fraction
import math

R          = Fraction(13, 6)
S          = Fraction(31, 24)

c          = 299792458.0
h          = 6.62607015e-34
hbar       = h / (2 * math.pi)

delta_e    = Fraction(1, 2) + Fraction(1, 5**2)
psi_e      = Fraction(13 * 31**2 - 7**2, 2) - delta_e
alpha_inv  = 4 * math.pi * (3 * R**2) / S * (1 + 1 / psi_e)
alpha      = alpha_inv**-1

delta_p    = Fraction(1, R * S**2 * (2*24) - Fraction(1, 6**2))
psi_p      = Fraction(3 * (13**2 * 31 + 7**2), 24) + delta_p
mp_over_me = alpha_inv * (8 * R) / S * (1 - 1 / psi_p)

psi_g      = (12 * (3 * R**2) * (4 * R) + 2 * R) / 4
psi_g0     = R * S**2 * (12 * 24)
psi_g_star = 4 * psi_g - 3 * (1 + 1 / psi_g0)

sqrt_G     = (alpha * S) / (math.pi * psi_g)
G          = sqrt_G**2

alpha_Gp   = alpha**24 * mp_over_me**4 / (1 + 1 / psi_g_star)
alpha_Ge   = alpha**24 * mp_over_me**2 / (1 + 1 / psi_g_star)

g_corr     = (1 + 1 / psi_g_star)**(-1/2)
M_Pl       = math.sqrt(hbar * c / G)
M_P        = M_Pl * alpha**12 * mp_over_me**2 * g_corr
M_E        = M_Pl * alpha**12 * mp_over_me * g_corr

print("alpha_Gp =", alpha_Gp)
print("alpha_Ge =", alpha_Ge)
print("sqrt(G)  =", sqrt_G)
print("G        =", G)
print("M_Pl     =", M_Pl)
print("M_P      =", M_P)
print("M_E      =", M_E)
```

A complete reference implementation is available at:
https://github.com/yasuotanakaresearch/zero-parameter-structure

References

[1] Isaac Newton. *Philosophiae Naturalis Principia Mathematica*. 1687.

[2] Albert Einstein. Die feldgleichungen der gravitation. *Sitzungsberichte der Preussischen Akademie der Wissenschaften*, pages 844–847, 1915.

[3] Peter J. Mohr, David B. Newell, Barry N. Taylor, and Eite Tiesinga. Codata recommended values of the fundamental physical constants: 2022. *Reviews of Modern Physics*, 97:025002, 2025.

[4] S. Navas et al. Review of particle physics. *Physical Review D*, 110:030001, 2024.