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A First-Principles Derivation of Higgs Boson Mass, Electroweak Coupling Constants, Strong Coupling Constant, and Newtonian Gravitational Constant

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DOI: https://doi.org/10.5281/ZENODO.23898588

Abstract

We present a first-principles derivation of the Higgs boson mass, electroweak coupling constants, strong coupling constant, and Newtonian gravitational constant, based on our fundamental particle spin model. We demonstrate that the spin angular momenta of fundamental particles arise from the circular motion of their fundamental charges (FCs). The reduced energy generated by the interactions of the FCs in a fundamental particle spread out as wave with wavelength equivalent to the speed of light divided by the frequency of the circular motion. While the motion of the FCs in a fundamental particle that generates the spin angular momentum is circular, the corresponding wave propagation is linear. For the linear distance of this wave to equal the diameter of the interaction sphere, the system's energy must be multiplied by π. In the case of the weak interaction, this energy corresponds to the sum of the rest energies of the W^+, W^-, and Z^0 bosons that mediate the interaction, the vacuum expectation value, or twice the rest energy of a Higgs boson. This provides a theoretical foundation for the non-zero vacuum expectation value of the Higgs field and yields equations for the electroweak coupling constants and the Higgs boson mass, allowing their derivation without relying on experimental data. For the strong interaction, the system's energy is π times the energy of a quark within a charged pion. Based on this energy, we determine the strong coupling constant at zero momentum transfer, quantitatively explaining the large difference in strength between the electromagnetic and strong interactions. For gravity, we derive the gravitational constant from the relative magnitudes of fundamental particle masses. The resulting theoretical coupling constants exhibit strong agreement with experimental values, and our accurate prediction of a Higgs boson mass of 125.5 GeV/c^2 further validates the model.

Keywords: Higgs boson mass, fine structure constant, weak coupling constant, electroweak coupling constants, strong coupling constant, gravitational constant, fundamental particle spin, first-principles theory.

1. Introduction

The strengths of the four fundamental forces in nature are characterized by specific coupling constants: the fine-structure constant [1,2] for electromagnetic force, the weak coupling constant [3,4] for the weak force, the strong coupling constant [5] for the strong force, and Newton's gravitational constant for gravity [6]. Gravitational interactions between charged fundamental particles are typically negligible compared to electromagnetic interactions. At its effective distance scale, the strong interaction is significantly stronger than both electromagnetic and weak interactions. The fine-structure constant, which characterizes the strength of the electromagnetic interaction, has a value of approximately 1/137 at low energies. In contrast, the strong coupling constant approaches 1 in the low-energy regime, reflecting its much greater strength. Despite considerable advancements, current theoretical frameworks lack a fundamental explanation for why the strong interaction's coupling constant is so much larger than that of the electromagnetic interaction.

In the Standard Model of particle physics, the coupling constants are the input parameters that must be supplied by experimental values. A key goal in theoretical physics is to derive these coupling constants from fundamental principles, minimizing reliance on experimental data and thereby enhancing the completeness of the Standard Model. Success in this endeavor would provide profound insights into the universe's fundamental nature and potentially address unresolved questions such as the hierarchy problem [7] and the nature of dark matter [8–11].

The Higgs boson is a neutral scalar particle resulting from the Higgs mechanism, which explains how the $W^{\pm}$ and Z^0 bosons acquire mass within the electroweak theory. Confirmed by experimental observation in 2012 [12,13], the Higgs boson's properties align with Standard Model predictions [14]. As a key component of the electroweak theory [15–17], predicting its mass from fundamental principles remains a critical goal for refining the Standard Model.

In this paper, we present a first-principles derivation of Higgs boson mass, electroweak coupling constants, strong coupling constant, and Newtonian gravitational constant, based on our fundamental particle spin model. The paper is structured as follows: Section 2 introduces our theory of fundamental particle spin. Section 3 details the derivation of the electroweak coupling constants. Section 4 presents the derivation of the Higgs boson mass. Section 5 presents the derivation of the strong coupling constant at zero momentum transfer. Section 6 presents the formulas that determine the Newtonian gravitational constant. Finally, Section 7 offers a discussion of these findings, followed by conclusions in Section 8.

2. The energies and wavelengths of fundamental particles

The electron spin plays a crucial role in the formation of covalent bonds in molecules [18] and the information storage and processing [19–21] in spintronics. Fundamental particles behave as point particles without substructure [22–33]. While electron spin has been known for a century [34,35], the mechanism by which a point-like electron generates its spin angular momentum and magnetic moment remains a subject of debate. In this section, we derive the spin angular momenta and

energy-frequency relation of fundamental particles from Newtonian classical mechanics. We propose that fundamental particles are composed of fundamental charges (FCs), defined as point charges with no spatial extent. For instance, a photon consists of one positive FC and one negative FC rotating around a common center of mass. Similarly, an electron is composed of two negative FCs and one positive FC, with the two negative FCs also rotating around the static positive FC. The angular momenta of fundamental particles arise from the circular motion of these constituent FCs.

For two FCs, one positive and one negative, separated by a (very small) distance $2r$, the mutual gravitational and electromagnetic fields reduce their energy to a potential energy proportional to the square of the distance between them [36]:

$$U(r) = \frac{kr^2}{2}, \tag{1}$$

$$k = \frac{8c^4}{Gr_e}, \tag{2}$$

where G is the Newtonian gravitational constant, c is the speed of light, and r_e is the radius of the charge interaction. Assume that each of the two FCs has a mass of $m_{FC}/2$ and orbits around the center of mass, which lies midway between them. The circular motion of these two FCs is described by classical Newtonian mechanics. Using the potential energy from Eq. (1), we determine the velocity (v), kinetic energy (E_k), and total energy (E) as follows:

$$\frac{m_{FC}}{2}\frac{v^2}{r} = \frac{kr}{2}, \tag{3}$$

$$v = \sqrt{\frac{k}{m_{FC}}}r, \tag{4}$$

$$E_k = \frac{m_{FC}v^2}{2} = \frac{kr^2}{2} = U, \tag{5}$$

$$E = E_k + U = m_{FC}v^2 = \frac{m_{FC}vrv}{r} = 2\pi m_{FC}vr\frac{v}{2\pi r} = 2\pi m_{FC}vrf. \tag{6}$$

The term $f = v/2\pi r$ in Eq. (6) represents the frequency of the circular motion and $m_{FC}vr$ denotes the angular momentum resulting from this motion. Eq. (6) shows that the energy is proportional to frequency, which is equivalent to Planck's relation [37]. The relation implies that $2\pi m_{FC}vr$ in Eq. (6) is equal to the Planck constant (h), meaning that the angular momentum ($m_{FC}vr$) is the reduced Planck constant ($\hbar$). This angular momentum generated by the circular motion of the two FCs (one positive and one negative) is equal to the spin angular momentum of a photon. It demonstrates that a photon consists of a positive FC and a negative FC, and its spin angular momentum is the orbital

angular momentum generated by the circular motion of the two FCs. The energy of the photon is proportional to the frequency of this circular motion.

An electron, consisting of a stationary positive FC at its center and two negative FCs orbiting around it, can be considered as a negative FC combined with a photon. The central positive FC effectively forms a photon with one of the negative FCs during one complete spatial revolution (a rotation of 2π radians) and then forms a photon with the other negative FC in the subsequent complete spatial revolution. Thus, it takes two complete spatial revolutions (a total rotation of 4π radians) for the system to return to its initial spatial position and physical state. The energy and spin angular momentum of the electron are determined by the following equations:

$$m_{FC}v^2 = E = hf = h\frac{v}{4\pi r} = \hbar\frac{v}{2r}\,, \tag{7}$$

$$m_{FC}vr = \frac{\hbar}{2}\,. \tag{8}$$

Therefore, the spin angular momentum of the electron is $\hbar/2$.

In summary, fundamental particles are composed of FCs. The intrinsic angular momenta of these particles arise from the circular motions of their constituent FCs. The wave-particle duality observed in a fundamental particle is a consequence of this circular motion; the particle's energy is directly proportional to the frequency of this motion. Given that the original FCs within a fundamental particle are extremely massive, a very small radius is sufficient for their circular motion to generate the required angular momentum, and this defines the particle's nature. The energy of these heavy FCs within the particle is modified by gravitational and charge interactions. To meet the angular momentum requirement, this reduced energy spreads out and propagates as a wave with a frequency equal to that of the circular motion of the FCs. This wave is described by the wavefunction in quantum mechanics.

3. The electroweak coupling constants

As detailed in Section 2, fundamental particles are composed of FCs; their angular momenta and energy-frequency relation arise from the circular motion of these FCs. The FCs within a fundamental particle are extremely massive, meaning that a small radius is sufficient for their circular motion to generate the particle's spin angular momentum. However, interactions between the FCs reduce the energy, and this reduced energy spread out and propagates as a wave with a wavelength equal to the speed of light divided by the frequency of the circular motion.

The weak interaction is mediated by W^+, W^-, and Z^0 bosons. The radius of weak interaction is the radius ($r_0 = \hbar/m_wc$) for the W boson mass to generate the angular momentum ($\hbar$). This radius defines a sphere of weak interaction and the wavelength of the W boson is equal to the diameter of this sphere multiplied by π:

$$\lambda_w = \frac{c}{f} = \frac{hc}{hf} = \frac{2\pi\hbar c}{m_w c^2} = 2\pi r_0 = \pi d_0 \,, \tag{9}$$

where d_0 ($2r_0$) is the diameter of the sphere.

While the motion of the FCs within a fundamental particle that generates the spin angular momentum is circular, the propagation of the corresponding wave is linear. For the linear distance of this wave to equal the diameter of the interaction sphere, the energy of the system must be multiplied by π. This implies that the energy within the weak interaction is equivalent to the rest energy of the W boson multiplied by π. This energy can be the sum of the rest energies of the W^+, W^-, and Z^0 bosons that mediate the weak interaction or the vacuum expectation value (V_{ev}):

$$2m_w c^2 + m_z c^2 = \pi m_w c^2 \,, \tag{10}$$

$$V_{ev} = \pi m_w c^2 \,. \tag{11}$$

This provides a theoretical foundation for the non-zero vacuum expectation value of the Higgs field. On the other hand, the V_{ev} is related to m_w in the Standard Model as follows [3]:

$$m_w c^2 = \frac{g_w V_{ev}}{2} \,. \tag{12}$$

Substituting Eq. (11) into Eq. (12), we obtain the following formula for the weak coupling constant g_w:

$$m_w c^2 = \frac{g_w V_{ev}}{2} = \frac{g_w \pi m_w c^2}{2} \,, \tag{13}$$

$$g_w = \frac{2}{\pi} \,. \tag{14}$$

Substituting the mass relation equation [3], $m_z = m_w / cos\theta_w$, from the electroweak theory [4] into Eq. (10), we obtain the Weinberg angle as follows:

$$2m_w + \frac{m_w}{cos\theta_w} = \pi m_w \,, \tag{15}$$

$$cos\theta_w = \frac{1}{\pi - 2} \,, \tag{16}$$

$$sin^2\theta_w = \frac{(\pi - 2)^2 - 1}{(\pi - 2)^2} \,. \tag{17}$$

Eq. (17) yields 0.2327 for $sin^2\theta_w$, which closely matches the value of 0.231 from experiments [1,2].

The coupling constants g_z and g_e are determined as follows:

$$g_z = \frac{g_w}{cos\theta_w} = \frac{2(\pi-2)}{\pi}, \tag{18}$$

$$g_e = g_w sin\theta_w = \frac{2}{\pi}\left(\frac{(\pi-2)^2-1}{(\pi-2)^2}\right)^{\frac{1}{2}}, \tag{19}$$

$$\alpha(m_\tau c^2) = \frac{g_e^2}{4\pi} = \frac{(\pi-2)^2-1}{\pi^3(\pi-2)^2}. \tag{20}$$

The theoretical fine structure constant at the rest energy of the tau lepton, obtained from Eq. (20), is 0.007504, which closely matches the reported value of 0.007493 [38], exhibiting an error of 0.14%.

The Z boson mass is related to m_w as follows:

$$m_z = \frac{m_w}{cos\theta_w} = (\pi-2)m_w. \tag{21}$$

As detailed in a separate manuscript [39] that derives the electron and W boson masses from first principles, the theoretical W boson mass is 79.9 GeV/c^2. Using this theoretical W boson mass, Eq. (21) yields a Z^0 boson mass of 91.2 GeV/c^2, which closely matches the experimental value of 91.2 GeV/c^2 [2].

The electron charge is an input parameter in all calculations involving electromagnetism, from quantum electrodynamics in high energy physics to atomic and molecular property calculations in chemistry, biology, and materials science. The electron charge is determined as follows:

$$\begin{aligned} e^2 &= 4\pi\varepsilon_0\hbar c\alpha(m_e c^2) = 4\pi\varepsilon_0\hbar c\frac{\alpha(m_e c^2)}{\alpha(m_\tau c^2)}\,\alpha(m_\tau c^2) \\ &= 4\pi\varepsilon_0\hbar c\frac{\alpha(m_e c^2)}{\alpha(m_\tau c^2)}\frac{(\pi-2)^2-1}{\pi^3(\pi-2)^2}. \end{aligned} \tag{22}$$

$$e = \left(4\pi\varepsilon_0\hbar c\frac{\alpha(m_e c^2)}{\alpha(m_\tau c^2)}\frac{(\pi-2)^2-1}{\pi^3(\pi-2)^2}\right)^{\frac{1}{2}}. \tag{23}$$

Using the ratio (1.027) of the fine-structure constant at $m_\tau c^2$ to that at $m_e c^2$ determined by Erler [38], Eq. (23) yields a theoretical electron charge of 1.603×10^{-19} C, which closely matches the experimentally determined value of 1.602×10^{-19} C [40].

In summary, the spin angular momenta and energy-frequency relation of fundamental particles arises from the circular motion of their FCs. The wavelength is equal to the speed of light divided

by the frequency of the circular motion. Within weak interactions, the system's length is the diameter of the weak interaction sphere, which aligns with the W boson's wavelength divided by π. For the linear distance of this wave to equal the diameter of the interaction sphere, the energy of the system must be multiplied by π. This energy can be the sum of the rest energies of the W^+, W^-, and Z^0 bosons that mediate the weak interaction or the vacuum expectation value. This requirement yields equations for electroweak coupling constants, enabling their derivation without experimental input. The resulting theoretical fine-structure constant exhibits strong agreement with experimental values (a discrepancy of only 0.14%), and the predicted electron charge (1.603×10^{-19} C) closely matches the experimentally determined value (1.602×10^{-19} C). As these equations define tree-level relationships, the derived coupling constants possess tree-level accuracy.

4. The Higgs boson mass

The Higgs boson is a neutral scalar particle that remains after the Higgs mechanism imparts mass to the $W^{\pm}$ and Z^0 bosons within the electroweak theory. As a scalar, the Higgs boson possesses spin 0 and therefore no intrinsic angular momentum. However, our theory determines that all fundamental particles must possess angular momentum. This necessitates the existence of two identical Higgs bosons whose combined angular momentum is equal to zero. For the linear distance of this wave to equal the diameter of the interaction sphere, the energy associated with these two Higgs bosons is equal to the rest energy of the W boson multiplied by π:

$$2m_H c^2 = \pi m_w c^2 \,, \tag{24}$$

$$m_H = \frac{\pi m_w}{2} \,. \tag{25}$$

Using the first-principles theoretical W boson mass of 79.9 GeV/c^2 [39], Eq. (25) yields a Higgs boson mass of 125.5 GeV/c^2, remarkably close to the experimentally determined value of 125.2 GeV/c^2 [2].

The masses of the Z^0 boson and the Higgs boson, along with the vacuum expectation value, are all determined by the W boson mass. In three separate manuscripts, we derived the masses of all fundamental particles, neutrino mixing angles and CP-violating phase in the Pontecorvo-Maki-Nakagawa-Sakata (PMNS) matrix, and quark mixing angles and CP-violating phase in the Cabibbo-Kobayashi-Maskawa (CKM) matrix from first principles. Moreover, as detailed in a separate manuscript, with our particle interaction theory, we resolved the persistent problem of divergent loop integrals in quantum field theory—a challenge that has plagued the field for nearly a century.

5. The strong coupling constant

Similar to the radius of weak interaction ($r_0 = \hbar/m_w c$), the radius of strong interaction is

$$r_s = \frac{\hbar}{m_{\pi^\pm} c}, \tag{25}$$

where $m_{\pi^\pm}$ is the charged pion mass. This is the radius for the energy of a quark (or antiquark) in the charged pion to generate the spin angular momentum ($\hbar/2$). Down-type quarks have a charge of -e/3, while up-type quarks have a charge of +2e/3. Because quarks possess fractional charges, they must be confined to ensure that the total charge of a system is an integer. As detailed in a separate manuscript that derive meson masses from first principles, this quark confinement generates the following mass relation between the mass of the charged pion and the mass of the electron:

$$m_{\pi^\pm} = \frac{2m_e}{\alpha}, \tag{26}$$

where α is the fine structure constant. Using the theoretical electron mass of 0.511 MeV from [39], Eq. (26) predicts a theoretical charged pion mass of 140.05 MeV, which closely matches the experimental value of 139.57 [2].

Similar to that of weak interaction, when the wavelength is equal to the diameter of the sphere of strong interaction, the corresponding energy is

$$E = h\nu = h\frac{c}{\lambda} = h\frac{c}{2r_s} = \frac{\pi\hbar c}{r_s} = \frac{\pi\hbar c}{\frac{\hbar}{m_{\pi^\pm} c}} = \pi m_{\pi^\pm} c^2 = \pi\frac{2m_e c^2}{\alpha} = 440 \text{ MeV}, \tag{27}$$

Since this energy is shared equally between the quark and antiquark, each of them possesses 220 MeV:

$$E_\Lambda = \frac{\pi m_{\pi^\pm} c^2}{2} = \frac{\pi\frac{2m_e c^2}{\alpha}}{2} = \pi\frac{m_e c^2}{\alpha} = 220 \text{ MeV}, \tag{28}$$

Without interaction between the quark and antiquark, a charged pion would theoretically possess a rest energy of 440 MeV (twice that of a single quark). However, the actual measured energy is lower due to the energy reduction caused by the strong interaction between the quark and antiquark.

The strong coupling constant, α_s, quantifies the strength of the strong interaction, while the fine-structure constant, α, characterizes the electromagnetic interaction. Both constants are functions of momentum transfer (q^2). At the limit of zero momentum transfer ($q^2 \to 0$), they are related as follows:

$$\frac{\alpha_s(q^2 \to 0)}{\alpha(q^2 \to 0)} = \frac{E_A}{m_e c^2} = \frac{\pi \frac{m_e c^2}{\alpha(q^2 \to 0)}}{m_e c^2} = \frac{\pi}{\alpha(q^2 \to 0)}, \tag{29}$$

$$\alpha_s(q^2 \to 0) = \pi . \tag{30}$$

The theoretical strong coupling constant, as given by Eq. (30), closely matches values derived from experimental data [41–43].

At low energies, the fine-structure constant, which characterizes the strength of the electromagnetic interaction, is approximately 1/137. In contrast, the strong coupling constant, characterizing the strength of the strong interaction, is approximately π when the momentum transfer approaches zero ($q^2 \to 0$). Therefore, the strong coupling constant is 430 (137π) times larger than the fine-structure constant at zero momentum transfer limit. This explains the vast difference in strength between the strong and electromagnetic interaction.

6. Newtonian gravitational constant

The masses of the third-generation particles are much larger than those of the first-generation particles. Furthermore, the masses of neutrinos are substantially smaller than the masses of charged leptons. These substantial differences in fundamental masses are partially determined by the Newtonian gravitational constant. Consequently, the gravitational constant can be calculated from the relative magnitudes of fundamental particle masses. For example, using lepton masses derived from first principles [44], we obtain the gravitational constant as follows:

$$G = \frac{\alpha^8[(\pi^2 - 4\pi + 8)(\pi - 2)^2 + 4(\pi^2 - 4\pi + 3)^2]^8}{2^{22}\pi^8(\pi^2 - 4\pi + 3)^{16}} \left(\frac{m_{v1}}{m_e}\right)^4 \frac{\hbar c}{m_e^2}, \tag{41}$$

where m_{v1} is the mass of the lightest neutrino, α is the fine structure constant, and m_e is the mass of the electron. This equation demonstrates that the gravitational constant is linked to the ratio of the lightest neutrino's mass to the electron's mass.

The transitions between different generations of quarks during weak interactions are described by Cabibbo-Kobayashi-Maskawa (CKM) matrix [45,46]. The gravitational constant is determined by the mixing angle ($\sin\theta_{23}$) between second and third-generation quarks within the CKM matrix as follows:

$$G = \frac{\alpha^4(sin\theta_{23})^{16}}{2^{14}\pi^{20}} \frac{\hbar c}{m_e^2}, \tag{42}$$

For $\sin\theta_{23}$=0.041857, Eq. (42) yields a theoretical gravitational constant of 6.67×10^{-11} $m^3\,kg^{-1}\,s^{-2}$. This equation demonstrates that the transition between the second and third-generation quarks is partially determined by the gravitational constant.

7. Discussion

In Section 2, we demonstrated that the spin angular momenta of fundamental particles arise from the circular motion of their FCs. The reduced energy resulting from the interactions of these FCs spreads out and propagates as a wave with a wavelength equivalent to the speed of light divided by the frequency of the circular motion. This wave is described by the corresponding wavefunction $\psi(\mathbf{r})$ in quantum mechanics and $|\psi(\mathbf{r})|^2$ represents the probability density of the particle at position $\mathbf{r}$. When the particle is located at a position $\mathbf{r}$, the circular motion of its FCs produces the spin angular momentum.

According to our particle spin theory presented in Section 2, the motion of the FCs within a fundamental particle that generates the spin angular momentum is circular but the propagation of the corresponding wave is linear. Geometrically, the circumference of a circle is equal to the diameter multiplied by π. Sections 3 and 5 demonstrate that this factor of π determines the strengths of the three fundamental forces (electromagnetic, weak, and strong). In [36,39], we showed that gravity in the universe is linked to spin. Section 6 demonstrates that the gravitational constant is partially determined by the relative magnitudes of fundamental particle masses.

The Standard Model of particle physics treats the mass of the Higgs boson and the coupling constants of all three fundamental forces (electromagnetic, weak, and strong) as input parameters that must be determined through experimental fitting. This work significantly enhances the Standard Model by deriving these fundamental coupling constants and the Higgs boson mass directly from first principles.

The electron's magnetic moment is a crucial property for Spintronics [1–3], a field holding significant potential for information storage and processing. While quantum theory relies on experimentally derived values for calculations, our first-principles theory successfully predicts the electron's magnetic moment of -9.28×10^{-24} J/T by utilizing theoretical values for its spin angular momentum, g-factor, charge (Eq. (23)), and mass (0.511 MeV) [39], without requiring experimental input.

Solving the Schrödinger equation for multi-electron systems is a major undertaking in quantum chemistry and related fields. The equations of these systems typically include electron’s mass and charge which are determined experimentally. Our theory derives these input parameters from fundamental principles, enabling the calculation of atomic and molecular properties across diverse fields—chemistry, materials science, and biology—without experimental input.

7. Conclusions

The spin angular momenta and energy-frequency relation of fundamental particles arise from the circular motion of their FCs. The reduced energy resulting from the interactions of these FCs spreads out and propagates as a wave with a wavelength equivalent to the speed of light divided by the frequency of the circular motion. While the motion of the FCs in a fundamental particle that generates the spin angular momentum is circular, the propagation of the corresponding wave is linear. For the linear distance (wavelength) of the wave to equal the diameter of the interaction

sphere, the energy of the system must be multiplied by π. For weak interaction, this energy is sum of the rest energies of W^+, W^-, and Z^0 bosons that mediate the weak interaction, the vacuum expectation value of the Higgs field, or twice the rest energy of a Higgs boson. This provides a theoretical foundation for the non-zero vacuum expectation value of the Higgs field and yields equations for the electroweak coupling constants and the Higgs boson mass, enabling their derivation without relying on experimental data. The resulting theoretical fine-structure constant exhibits strong agreement with experimental values (discrepancy of only 0.14%), and the predicted electron charge (1.603×10^{-19} C) closely matches the experimentally determined value (1.602×10^{-19} C). Furthermore, our theory accurately predicts a Higgs boson mass of 125.5 GeV/c^2, aligning with experimental data.

Similarly, for the strong interaction, the energy of the system is equal to the energy of a quark in a charged pion multiplied by π. Based on this energy, we determine the strong coupling constant at zero momentum transfer, providing a quantitative explanation for the large difference in strength between the electromagnetic and strong interactions.

The Standard Model of particle physics, while successful, relies on numerous experimentally determined parameters. Our theory enhances the Standard Model by determining the Higgs boson mass, electromagnetic, weak, and strong coupling constants without experimental input and determines the gravitational constant by the relative magnitudes of fundamental particle masses.

Acknowledgments

This preprint is a new version of my two previous preprints:

- Luo X. First-principles derivation of electroweak coupling constants and Higgs boson mass 2026. https://doi.org/10.5281/ZENODO.19917946.
- Luo X. First-principles determination of the strong coupling constant 2026. https://doi.org/10.5281/ZENODO.19885004.

This new version integrates the previous two and includes a new Section 5 on the Newtonian gravitational constant. It covers all four fundamental forces.

Data availability statement

The data that support the findings of this article are openly available [1,2,41–43]

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