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The Unification between Mass-Gravitational and Electromagnetic Force

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Abstract

The unification of the four fundamental forces represents the ultimate goal and primary challenge of modern physics. Previously, we explicitly unified the strong and weak nuclear interactions within an electromagnetic framework. In this paper, we further demonstrate that gravitational mass likewise arises from the superposition of electromagnetic forces. By reexamining and elaborating on Einstein's Equivalence Principle (EEP), we extend the field equations to encompass all four fundamental forces and microscopic particles. Within the framework of spacetime curvature, a philosophical definition of inertial mass is proposed, leading to a wave equation that generalizes quantum mechanics to celestial bodies and black holes. Most significantly, this work identifies hidden variables within the uncertainty principle, thereby refuting the existence of quantum superposition and entanglement. It is ultimately shown that quantum mechanics and Einstein's field equations are unified.

Keywords

General Relativity, Black Holes, Spacetime Curvature, Grand Unified Theory

1. Introduction

Humankind has classified natural forces into four fundamental interactions. To date, strong and weak nuclear forces have been successfully unified with electromagnetism. However, the nature of gravitational mass remains enigmatic, presenting persistent challenges to its unification with the other forces [1].

In 1915, Einstein proposed the Equivalence Principle (EEP) and Equationted the equations of General Relativity within the framework of Riemannian geometry. According to the mathematical structure of these equations, mass causes space to contract and time to dilate. In four-dimensional spacetime, matter always follows the path of minimal elapsed time, moving toward regions where time passes most slowly. When objects travel along geodesics in this four-dimensional continuum, their motion appears in three-dimensional space as if influenced by a gravitational force. Thus, Einstein concluded that gravitational force does not exist as a fundamental interaction but rather emerges as a manifestation of curved spacetime.

In 2024, Liu Yun's research team fundamentally revealed the true nature of the strong and weak nuclear forces, demonstrating that both are manifestations of electromagnetic force superposition under high-speed rotation [2]. Based on this finding, they proposed that gravitational mass similarly arises from electromagnetic superposition at low velocity regimes. However, integrating electromagnetic force into the framework of spacetime curvature theory remains a key challenge. This paper revisits the concept of spacetime from a philosophical perspective, logically derives a new definition of mass, and reframes the Equivalence Principle (EEP) to incorporate all four fundamental forces into a unified field equation. The study employs natural units ($c = 1$, $\hbar = 1$), treating mass and energy as fully equivalent.

2. Materials and Methods

2.1. The Philosophical Definition of Time and Space

To investigate spacetime curvature, the following philosophical definition of spacetime must be established: The essence of time and space is emptiness, nothing at all.

Based on this definition, spacetime exhibits the following physical characteristics:

A) Spacetime length is scalable. Since spacetime contains nothing, without reference to the material world, different scales of traversal are indistinguishable. It is commonly assumed that a faster-moving object must traverse more space—but this is merely a conclusion drawn from observing material references. Thus, spacetime can be arbitrarily scaled, and different scaling outcomes are physically indistinguishable.

B) The speed of light is constant in any frame of motion. Precisely because spacetime is scalable, observers in different frames automatically perceive the speed of light in vacuum as constant. In fact, the constancy of light speed is a habitual inference based on the assumption that physical laws are the same in all frame.

C) Physical laws are identical in all frames of motion. The assumption that physical laws remain consistent across frames is also a matter of convention. The scalability of spacetime automatically adjusts to preserve this convention. Conversely, if spacetime were considered non-scalable, the speed of light would have to vary with direction—a view that could also explain the Michelson-Morley experiment but would lead to inconsistent physical outcomes in different directions.

D) No absolutely stationary reference frame can be identified. Due to the indistinguishability of spacetime scaling, it is impossible to experimentally determine an absolutely stationary reference frame or identify any region of spacetime as truly at rest. Any frame can be regarded as stationary with equal validity. Philosophically, however, the center of mass of the universe must represent an absolutely stationary space.

E) Objects moving faster than light cannot be observed. From a philosophical perspective, when observing an object at light speed, photons emitted from ahead are redshifted to infinite wavelength with zero frequency, while photons from behind are compressed to the object's surface with infinite frequency and zero wavelength—time appears frozen, yet light speed remains constant ($\infty \times 0 = c$). Due to extreme frequency shifts, such objects become undetectable. Philosophically, it can be inferred that their gravitational influence persists, and such entities may correspond to dark matter.

F) Special relativistic time dilation cannot be measured. Time dilation falls into two categories: special relativistic time dilation and general relativistic time dilation. Special relativistic time dilation arises from relative motion, where each frame considers itself at rest and perceives the other's clock as running slower. However, when the two clocks are reunited, no actual difference is observed. If such a difference existed, it would allow the determination of an absolute rest frame—contradicting the philosophical logic of spacetime. In contrast, clock slowdown caused by strong gravitational fields, as predicted by Einstein's field equations, is measurable [3] [4].

G) The speed of light as a human-defined constant. Why is the speed of light exactly c, and not some other value? This is ultimately a consequence of how we define units of spacetime measurement. When one second and one light-meter (the distance light travels in a second) are treated as equivalent in measuring spacetime, the speed of light becomes unity. The resulting system is known as natural units [5]. In natural units, several fundamental constants—including the speed of light and Planck's constant—are normalized to 1. This reveals that such constants essentially function as conversion factors between human-defined units, devoid of deeper mystery.

Our research further indicates that mass alone can be expressed in at least eight distinct unit dimensions, related by the conversion Equation:

$$\begin{aligned} 1(\mathrm{Hz}) &= h(\mathrm{J}) = \frac{h}{c^2}(\mathrm{kg}) = Ch(\mathrm{eV}) = \frac{h}{K_B}(\mathrm{K}) \\ &= \frac{1}{c}\left(\mathrm{m}^{-1}\right) \approx \frac{h}{4.184}(\mathrm{cal}) = \frac{h}{3.6\times 10^6}(\mathrm{kwh}) \end{aligned} \tag{1}$$

where K is Kelvin, K_B is Boltzmann's constant, C is Coulomb's constant, h is Planck's constant, and c is the speed of light—all being human-defined conventions, kwh stands for kilowatt-hour. This further confirms the essential identity between energy and mass.

2.2. Inertial Mass Statistics in Space-Time

In natural units, energy and mass are fully equivalent. Philosophically defined: the inertial mass within any given space equals the total energy contained in that space. Thus, the inertial mass equation for a particle's spatial domain is given by [6]:

$$M = m + V, m = \sum_{i=1}^{i=k} \frac{m_{0i}}{\sqrt{1 - v_i^2}}, V = \frac{1}{2} \sum_{i=1,k=1}^{i=j,i=k} V_{jk} \tag{2}$$

In the Equation, M denotes the total rest mass (also called inertial mass) within the spatial region. Here, m acts as an operator representing the sum of the relativistic masses of all particles in the system. The orbital velocity of a particle is defined relative to the center of mass. V is the total potential energy among all particles, with attractive potential counted as negative and repulsive potential as positive.

For example, to rigorously compute the total inertial mass within the spatial domain of a helium atom, assume the two electrons are labeled as particle 1 and particle 2, and the nucleus as particle 3. The nucleus velocity is taken as zero relative to the center of mass, so the proton's relativistic mass equals its rest mass. At a given moment, the velocities of the electrons relative to the center of mass are v_1 and v_2. Because the total energy of a stable particle system is self-consistent, the inertial mass inside the helium atom's spatial region at any time is:

$$M = m + V, m = \left(\frac{m_e}{\sqrt{1 - v_1^2}} + \frac{m_e}{\sqrt{1 - v_2^2}} + m_3 \right), V = V_{12} + V_{23} + V_{31} \tag{3}$$

The calculation of the total potential energy in the Equation can be done using the following matrix equation:

$$V = \frac{1}{2} \sum_{i=1,k=1}^{i=j,i=k} V_{jk} = \frac{1}{2} \begin{pmatrix} V_{11} + V_{12} + V_{13} \\ V_{21} + V_{22} + V_{23} \\ V_{31} + V_{32} + V_{33} \end{pmatrix} = V_{12} + V_{23} + V_{31} \tag{4}$$

This approach unifies the statistical method for calculating the inertial mass of all particles. The Equation remains equally applicable when treating the entire solar system as a particle system. Based on this mass Equation, the Hamiltonian within the spatial domain can be more accurately expressed as:

$$H = M - m_0 = (m + V) - m_0, m_0 = \sum_{i=1}^{i=k} m_{0i} \tag{5}$$

In the Equation, m_0 similarly acts as an operator representing the sum of the rest masses of all internal particles. Once the Hamiltonian is calculated, the wave equation for the particle can be established.

The mass Equation also facilitates the derivation of the photon redshift ratio. Suppose M_1 is the mass of a star, and its black hole radius is R_{s1}. Physically, the black hole radius refers to the boundary where even photons cannot escape—specifically, the radius at which the gravitational potential energy of a photon equals its total mass-energy. Thus, we have:

$$\frac{Gm_\gamma M_1}{aR_{s1}} - m_\gamma = 0 \to R_{s1} = GM_1, c = 1 \tag{6}$$

In the equation, m_γ represents the mass of the photon. Assume the photon is produced and emitted at a distance of $1aR_{s1}$ from the center of the star, with an initial frequency f_0. The mass of the photon can be written as f_0h. When the photon propagates to the Earth's surface, its frequency becomes f. Let the mass of the Earth be M_2, and the distance between the Earth and the star is d, which is considered infinitely far from us. Then, according to Equation (2), when the photon is emitted from the star, the total mass of the star and the Earth can be expressed as:

$$\begin{aligned} M &= M_1 + M_2 + f_0 h - \frac{Gm_\gamma M_1}{aR_{s1}} - \frac{Gm_\gamma M_2}{d} - V_{12} \\ &\xrightarrow{d\approx\infty} \approx M_1 + M_2 + f_0 h\left(1 - \frac{1}{a}\right) - V_{12} \end{aligned} \tag{7}$$

Similarly, when the photon propagates to a position at distance r from the center of the Earth, the apparent rest mass of the entire system remains M, which may also be referred to as the total mass in the center-of-mass frame:

$$\begin{aligned} M &= M_1 + M_2 + fh - \frac{Gm_\gamma M_1}{d} - \frac{Gm_\gamma M_2}{r} - V_{12} \\ &\xrightarrow{d\approx\infty} M_1 + M_2 + fh - V_{12} \end{aligned} \tag{8}$$

Under both states, the total system has no energy exchange with the external environment. Therefore, the total rest mass of the system remains unchanged in both cases. This allows us to derive the gravitational redshift ratio z of the star:

$$f = f_0\left(1 - \frac{1}{a}\right) \to z = \frac{f_0 - f}{f} = \frac{1}{a - 1} \tag{9}$$

When $a > 1$, the emission point is outside the black hole radius. If $f_0 < f$, z is negative, indicating a blueshift. This corresponds to the photon moving from a weaker gravitational field to a stronger one (without considering Doppler effects). When $a > 1$ and $f_0 > f$, z is positive, indicating a redshift, which means the photon is moving from a stronger gravitational field to a weaker gravitational. When $a <$ 1, the emission point lies inside the black hole, and in principle, the photon cannot be observed. This is consistent with the derivation result of the field equation.

2.3. The Evolution and Improvement of the Particle Wave Equation

The wave equation of a particle primarily describes the evolution of a free particle in a potential field over time. At low velocities, the Hamiltonian for an electron in the gravitational (electrostatic) field of a proton in a hydrogen atom is:

$$H = T + V \approx \frac{1}{2}m_e v_e^2 + V = \frac{p_e^2}{2m_e} + V, V = -a_e \frac{q_e q_p}{r^2} \tag{10}$$

The use of the approximately equal sign in the Equation indicates that this is an approximate result valid at low velocities. The wave equation of the particle is:

$$\left.\begin{aligned} & i\hbar\frac{\partial}{\partial t}\psi = H\psi, p_e = m_e v_e \\ & H\psi = \left(\frac{p_e^2}{2}+V\right)\psi \end{aligned}\right\} i\hbar\frac{\partial}{\partial t}\psi = \left(\frac{p_e^2}{2m_e}+V\right)\psi \tag{11}$$

This is the renowned Schrödinger equation, presented by Erwin Schrödinger in 1926. This equation provides highly accurate calculations for particles rotating at low velocities but exhibits significant errors when applied to particles rotating at high velocities. Consequently, Klein and Gordon proposed the relativistic wave equation for particles:

$$\left(i\hbar\frac{\partial}{\partial t}\psi - qV\right)^2\psi = \left(-\hbar c^2\nabla^2 + m^2c^4\right)\psi \tag{12}$$

In this equation, V represents the potential energy and q denotes the generalized coordinate. Shortly after its introduction, the physics community identified a series of issues with this Equation [7]. In 1928, Dirac modified the Klein-Gordon equation and, through analysis, proposed a new Hamiltonian:

$$H = c\alpha\cdot P + \beta mc^2 \tag{13}$$

In the equation, P is the momentum operator, α and β are undetermined coefficients, m is the particle mass, and c is the speed of light constant. The Dirac equation can thus be expressed as:

$$i\hbar\frac{\partial}{\partial t}\psi = H\psi = \left(c\alpha\cdot P + \beta mc^2\right)\psi \tag{14}$$

The Dirac equation provides precise calculations of the fine structure energy levels of electrons in hydrogen atoms, showing excellent agreement with experimental values. However, it still presents the following limitations [7]:

A) When applied to higher-velocity regimes, the equation exhibits significant errors. For instance, calculations for quarkonium show deviations on the order of 200 MeV—comparable to the energy scales of the levels themselves.

B) Its applicability remains limited, it cannot even account for the hyperfine structure in hydrogen atoms.

C) It fails to accurately compute particle magnetic moments, predicting a magnetic moment of zero for the neutron, which contradicts experimental measurements.

Based on the rigorous definition of inertial mass, the Hamiltonian of a particle can be precisely calculated. Accordingly, we have established a new wave equation [6]:

$$E\psi = H\psi \to i\hbar\frac{\partial}{\partial t}\psi = \left(m + V - m_0\right)\psi \tag{15}$$

When the velocity of internal particles is much lower than the speed of light, the Hamiltonian for a specific spatial region can be approximated as:

$$\begin{aligned} H &= M - m_0 = \left(m+V\right) - m_0 \\ &\approx \frac{1}{2}mv^2 + V \approx \frac{p^2}{2m} + V, \frac{p^2}{m} = \sum_{i=1}^{i=k}\frac{p_i^2}{m_i} \end{aligned} \tag{16}$$

The wave equation derived from the approximate Hamiltonian returns to the form of the Schrödinger equation. As Equation (15) is a first-order partial differential equation in time, it can be solved following a methodology analogous to Dirac's approach.

It is worth noting that as early as 1916, Arnold Sommerfeld in Germany suggested that electron orbits could be elliptical or circular. By incorporating relativity and path integration of energy, he derived fine-structure energy levels that aligned perfectly with experimental observations—even with higher precision than the Schrödinger equation. However, due to the prevailing view that quantum phenomena were too mysterious to be explained by classical physics, Sommerfeld's and Bohr's theories were largely set aside as "old quantum mechanics" after the introduction of the Schrödinger equation. Nevertheless, concepts introduced by Sommerfeld, such as the azimuthal quantum number and the fine-structure constant, remain in use within modern quantum mechanics.

In fact, Sommerfeld's Equation has always been valid. When the energy splitting due to electron spin is taken into account, Sommerfeld's results become fully consistent with those of the Dirac equation. Compared to Sommerfeld's approach, solving the wave equation extensively employs averaging operators, which is essentially a form of statistical mechanics applied to large ensembles of particles. As a result, this method is more straightforward and better suited for handling probabilistic descriptions. Finally, by integrating Sommerfeld's Equation with Dirac's approach, we present the mass Equation for a two-body particle system as follows [6]:

$$M=\frac{m_{10}}{\sqrt{1+\frac{a^2/(1+b)^2(l+1)^2}{\left[\frac{n}{l+1}-1+\sqrt{1-\frac{a^2}{(1+b)^2(l+1)^2}}\right]^2}}}+\frac{m_{20}}{\sqrt{1+\frac{a^2b^2/(1+b)^2(l+1)^2}{\left[\frac{n}{l+1}-1+\sqrt{1-\frac{a^2b^2}{(1+b)^2(l+1)^2}}\right]^2}}} \quad (17)$$

Here, n is the principal quantum number, l is the orbital angular momentum quantum number, M is the rest mass of the quark particle, and a is the gravitational coefficient of the n-th principal shell, $b = m_1/m_2$ is the dynamic mass ratio of the orbital particles. Regardless of the nature of the gravitational force that forms bound-state particles, the quantum rules they follow are consistent. Therefore, this equation is applicable to all two-body particles, including binary star systems.

Essentially, each particle behaves as a microscopic magnet. The distinct coupling configurations and resultant spin combinations manifest as orientation variations between these magnetic dipoles, reflecting differential charge motion trajectories. According to relativistic principles, such variations induce modifications in the gravitational coupling coefficients. While the equation form remains invariant, the coefficients exhibit subtle quantum-state-dependent variations—this fundamentally accounts for hydrogen's hyperfine structure. Crucially, incorporating this conceptual advancement into Equation (17) renders them universally applicable across all quantum states off all particles. For details on quantization of celestial bodies, refer to [6].

For decades, theoretical calculations of the hyperfine structure of the hydrogen atom—particularly the frequency of the 21-cm hydrogen line—have consistently deviated from experimental values, with the source of the discrepancy remaining unresolved. However, Liu Yun's research team applied Equation (17) and obtained results that show excellent agreement with experimental data.

Furthermore, using Equation (17), the accuracy in studying quarkonium systems has been improved by more than 2000-fold, with mass errors reduced to within 1 MeV. It is precisely this high computational precision that has unequivocally demonstrated that the interaction between quarks arises from the total superposition of internal electromagnetic contributions. Our findings also indicate that quarks possess a well-defined internal structure.

2.4. Restatement and Extension of the Equivalence Principle (EEP)

We propose that electromagnetic force is likewise a manifestation of spacetime curvature, based on the following arguments:

A) In physics, electric charge and mass exhibit strict symmetry. If mass curves spacetime while charge does not, this symmetry would be violated.

B) Assuming spacetime curvature is independent of charge contradicts observable physics, as the gravitational effects generated by charge play a significant role.

C) If only mass curves spacetime, the response of charge and mass within the same particle to forces would be out of sync, leading to charge-mass separation. In reality, no such separation occurs. Particles that appear neutral result from the simultaneous presence of positive and negative charges.

D) If gravitational mass and electromagnetic force were fundamentally distinct, an electron in high-speed circular motion would inevitably exhibit charge-mass separation. In practice, however, an electron's mass and charge are inseparable.

E) Regardless of an observer's state of motion, it is fundamentally impossible to distinguish whether the experienced gravitational effect is not the result of superpositioned electromagnetic interactions.

Indeed, electric charge represents the separation of energy in space, with its potential energy being inversely proportional to spatial distance; while mass manifests as energy in time, with its frequency inversely proportional to time intervals. In natural units, frequency equivalently represents mass, and the total vibrational frequency of a particle is referred to as its Compton frequency. For example, the Compton frequency f_0 and static charge q of a hydrogen atom are expressed as:

$$\left.\begin{array}{l} f=\dfrac{f_{0e}}{\sqrt{1-v_e}}+\dfrac{f_{0p}}{\sqrt{1-v_p}}, f_c=\dfrac{Mc^2}{h} \\ f_{0e}=\dfrac{m_e c^2}{h}, f_l=\dfrac{v_e}{2\pi r_e}=\dfrac{v_p}{2\pi r_p} \end{array}\right\} \begin{cases} f_c=f-nf_l \\ Q=q_1-q_2 \end{cases} \tag{18}$$

In this expression, M represents the total inertial mass of the particle, n is the principal quantum number, v_e denotes the orbital velocity of the electron, and f_l signifies the orbital frequency, also referred to as the particle's spin frequency. This Equation effectively represents the mass Equation (Equation (2)) with frequency.

Like charges exhibit repulsion, which generally manifests as static support forces or dynamic support forces—impact being a form of the latter. When the net force on an object is attractive, the state is described as free fall or weightlessness. To encompass a broader range of physical states of motion within the framework of general relativity, it is necessary to redefine the Einstein Equivalence Principle (EEP) as follows:

When inertial forces due to mass are taken into account, the net force acting on any object in any state is always zero. Mathematically, this is expressed as:

$$F \equiv 0, F = \sum_{i=1}^{i=k} F_i + F_m, F_m = -ma \tag{19}$$

Here, F_m is the inertial force of mass, a represents the acceleration, and the negative sign indicates that the direction of the inertial force is opposite to that of the acceleration. Based on this derivation, the total superposition of all forces acting on an object (including electromagnetic forces) is equivalent to its own mass-inertial force. In the absence of any reference, the total gravitational force experienced cannot be distinguished from the mass-inertial force. This constitutes the strong equivalence principle (EEP) in its extended form.

When an object possesses repulsive forces, the restatement remains valid:

If repulsive forces are weaker than gravitational forces, the object remains in free fall.

If repulsive forces exceed gravitational forces, the object enters a state of collision.

If repulsive and gravitational forces are balanced, the object remains relatively stationary.

When the object carries no net charge, the principle reduces to the weak equivalence principle. In essence, all forces can be regarded as superpositions of electromagnetic forces. By reinterpreting the gravitational constant G in the equations as a coefficient representing the combined effect of electromagnetically superimposed interactions, the framework becomes applicable to all four fundamental forces, all particle types, and even celestial bodies and galaxies—which themselves constitute large-scale particle systems.

2.5. The Curvature of Spacetime Formed by Electric Charges

Charge constitutes two energy vortices separated in space, analogous to the crest and trough of a water wave—the crest manifests as positive charge, while the trough manifests as negative charge. Therefore, charges must always appear in pairs.

The smallest charged particle discovered to date is the electron, though its internal structure remains unclear. Calculations based on the electron's radius and magnetic moment suggest that the electron is formed by the combination of a muon and a Z^0 boson [6]. Experiments have shown that when a photon with an energy of 1.022 MeV strikes a charged particle, it can excite the production of an electron-positron pair.

The spacetime curvature induced by charge resembles a ripple deviating from the straight spacetime geodesic L (see **Figure 1**).

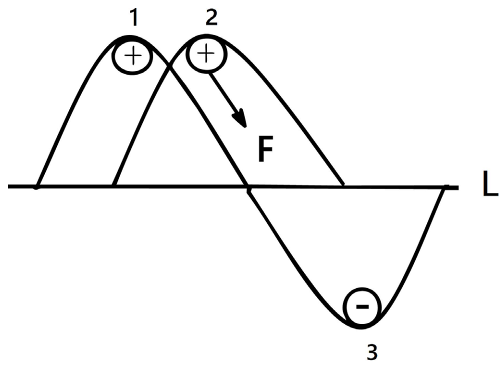

Figure 1. Spacetime Curvature Induced by Energy and Charge Pairs. The line L represents the axis of flat spacetime, where time dilation is minimal. Charges 1 and 2 exhibit motion and tendencies along the curved surface toward the L-axis. Specifically: Charge 2 tends to move closer to Charge 3 but farther away from Charge 1, reflecting the phenomenon *like charges repel*, *opposite charges attract*. This illustrates how energy-induced spacetime curvature governs electromagnetic interactions at a fundamental level.

According to **Figure 1**, the slope represents the spacetime curvature coefficient. In a vacuum, the curvature coefficient between any two charges is universally 1/137. When relative motion exists between two charges, the curvature coefficient increases according to the rules of relativity. To calculate the total spacetime curvature between two macroscopic objects, the curvature coefficients between every pair of charges within the objects must be summed. This refined definition leads to a more concise Equation of general relativity: Charges tell spacetime how to curve; curved spacetime tells mass how to move; and all mass must inherently contain charge.

Only when a pair of positive and negative charge particles completely overlap does full annihilation occur, resulting in zero rest mass. Conversely, for any system with equal numbers of positive and negative charges, as long as they do not perfectly coincide, rest mass must be preserved, and the resulting electromagnetic field cannot be zero. The electromagnetic field manifests as magnetic moments, and particles that appear to have a net magnetic moment of zero actually exhibit symmetrically oscillating magnetic moments.

If the electromagnetic fields generated by all internal charges of the particles are superimposed, the interaction coefficient between the two particles can be obtained. For example, the interaction coefficient between a proton and an antiproton is given by the Equation (20), for detailed derivations, please refer to Reference [6].

$$\left\langle a_{p\bar{p}} \right\rangle_{s=1} \approx a_e + \frac{a_e}{2} \frac{1+4r^2/d^2}{\left(1-4r^2/d^2\right)^2}\left(\beta_{2p}-1\right) - d^2 F_{0B}, v_{2p} = \frac{2v_p}{1+v_p^2}$$
$$\left\langle a_{p\bar{p}} \right\rangle_{s=0} \approx a_e + \frac{a_e}{2}\left(\beta_{2p}-1\right) - d^2 F_{0B}, \beta_{2p} = \frac{1}{\sqrt{1-v_{2p}^2}} \tag{20}$$

In the Equation, d represents the proton separation distance, r denotes the proton radius, and F_{0B} corresponds to the superposition of electromagnetic forces from all charges within the proton center.

From the Equation (20), it is evident that at high spin rates, particles generate immense electromagnetic forces. Conversely, at lower spin rates, the resulting electromagnetic force tends to be proportional to the net charge of the particle. If the particle carries no net charge, the superposition of electromagnetic forces manifests as gravitational mass attraction (see **Figure 2**) [6].

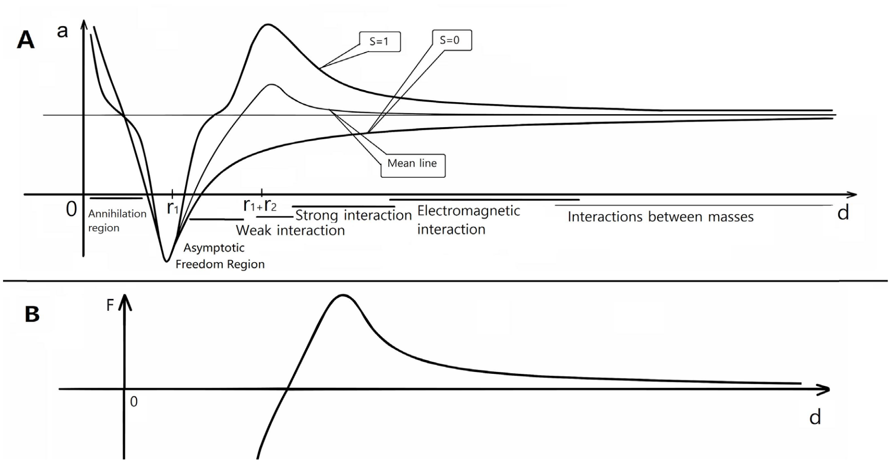

Figure 2. The unity of the four basic interactions. (A): The relationship between the interaction coefficient of quarks and distance. (B): The relationship between intermolecular forces and distance. This is very similar to the average force line between quarks.

When we initially proposed this hypothesis, a question arose: when particle–antiparticle pairs combine to form a new particle—such as positronium—the magnetic moment of the resulting system is always zero. Does this mean such particles cannot generate gravitational mass effects? After further study, we have reached the following conclusion: although the average magnetic moment of such a system is zero, the magnetic moment actually oscillates symmetrically—analogous to alternating current. When a large number of such particles aggregate, slight asynchronies inevitably arise, such as differences in rotational phase. These minor discrepancies necessarily produce a weak gravitational effect, much like how phase differences in alternating currents result in a net voltage.

2.6. The Formation of Mass Gravity

The above argument demonstrates that the force between charges can likewise be equivalent to spacetime curvature, and the higher the relative velocity between charges, the more severe the spacetime curvature.

In a hydrogen atom, the velocity of the electron is much higher than that of the proton, so the spacetime curvature caused by the electron must be more significant than that caused by the proton, manifesting as a negative magnetic moment. When two hydrogen atoms combine, their magnetic moments always pair in an antiparallel configuration, resulting in the smallest total magnetic moment for the pair. As more atoms aggregate, the total external magnetic moment becomes increasingly smaller.

In an object like Earth, which consists of countless atoms and charges, when the number is sufficiently large, the overall gravitational force becomes very small compared to the inter-charge gravitational force. Therefore, gravitational mass attraction is much weaker than charge-based attraction. Calculations show that the gravitational force between hydrogen atoms due to mass is 44 orders of magnitude weaker than the electrostatic force between their charges. However, the gravitational effect induced by magnetic moments between hydrogen atoms is 31 orders of magnitude stronger than their mass-based gravitational attraction.

By extension, between two 1-kilogram collections of hydrogen atoms, only about 10^{-15} kg of atoms rotating in the same direction is sufficient to reach the strength of mass-based gravity. For a large sphere like Earth, with a total mass of approximately 6×10^{24} kg, if only about 10^{9} kg of atomic magnetic moments are not fully canceled, the resulting gravitational force would be sufficient to reach the level of mass-based gravity. In reality, due to the principle of the lowest energy state, the probability of atomic magnetic moments exhibiting attraction exceeds the probability of full cancellation (see Figure 3).

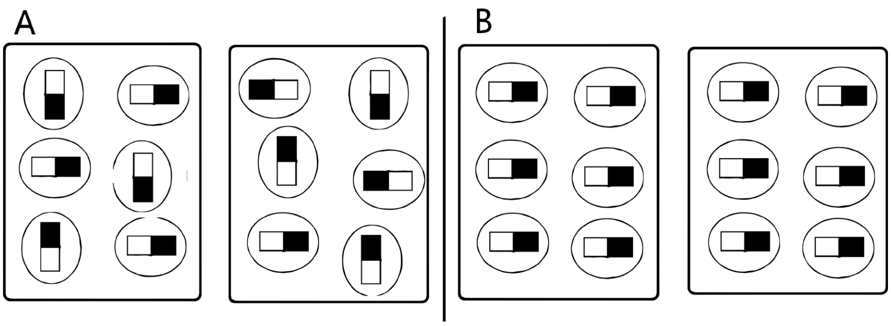

Figure 3. Demonstration of the lowest energy level principle. This illustrates that if weak degrees of freedom exist in the internal magnetic moments of an object, they will generate gravitational effects. (A): When magnets on two panels are fixed in random orientations, the mutual gravitational force between the panels approaches zero. (B): When the magnets on both panels are free to rotate, they spontaneously align as the panels approach, maximizing the gravitational attraction between the panels. This configuration corresponds to the lowest energy state for the system of particles.

We have summarized eight key pieces of evidence demonstrating that gravitational mass arises from the superposition of electromagnetic forces:

A) The coefficient of interaction between masses is not a fixed constant.

Different types of particles exhibit varying internal charge velocities. Consequently, if materials of different compositions are used to measure the gravitational constant, the results will inevitably differ. This is highly consistent with experimental observations: no two research teams have obtained identical measurements of the gravitational constant. For example, in 2018, a Chinese team led by Professor Luo Jun at Huazhong University of Science and Technology measured the gravitational constant using tungsten-gold alloy spheres and obtained a value greater than 6.6742×10^{-11} (SI units), while the average value measured using ordinary spheres was 6.672×10^{-11} [8].

B) Elongated Comet Tails. The interaction forces between different substances are independent of mass and are determined solely by the quantity and motion of charges within the mass. Consequently, different materials exhibit variations in gravitational attraction. Galileo's falling body experiment showed that objects of different masses fall at the same rate because the gravitational constant is extremely weak and the experimental distances were small, making differences undetectable. However, such differences become apparent in comet tails. Different materials in a comet's tail experience varying gravitational interactions with the Sun. Over thousands of years of gradual separation, particles with smaller gravitational coefficients gradually drift farther from the Sun. For example, Halley's Comet exhibits a tail stretching up to 1 billion kilometers in length.
[Source: https://baike.sogou.com/v6313.htm]

C) Unity of Charge and Mass within Electrons. If gravity and electromagnetic force were fundamentally distinct, the electron orbiting a proton at high velocity would experience mass-charge separation due to their independent responses to gravitational and electromagnetic interactions. However, no such separation is observed, indicating a unified nature of these forces.

D) Photon Redshift. If gravity were solely mass-derived, photons would be expected to change velocity rather than frequency when traversing gravitational fields—contradicting the principle of invariant light speed. Instead, gravitational redshift is consistently explained through spacetime curvature and electromagnetic wave interference theory. In regions of spacetime far from massive celestial bodies, the density of electromagnetic waves must be lower, corresponding to a reduced energy density. When photons propagate through regions of space with lower energy density, their speed increases. According to general relativity, this is equivalent to time compression and spatial expansion. As a result, photons exhibit a redshift as they move away from the massive body. In summary, without relativity, it would be impossible to adequately explain not only the Michelson-Morley experiment but also the redshift of photons in gravitational fields.

E) Influence of Magnetism and Charge on the Gravitational Constant. When one sphere is magnetized or electrostatically charged while an identical sphere remains neutral, the gravitational coefficient between them measurably changes, demonstrating the electromagnetic contribution to gravitational effects.

F) Universal Weak Magnetism of Celestial Bodies. Even with internally disordered charge arrangements, the lowest-energy principle induces weak magnetic alignment when two bodies approach. This weak magnetism is the source of gravitational attraction, explaining why most celestial objects exhibit detectable magnetic fields.

G) Galactic Rotation Planes. Gravitational effects are significantly stronger within the rotational plane of galaxies. Conversely, gravity weakens perpendicular to this plane. The predominant disk-like structure of galaxies—rather than spherical distributions—contradicts isotropic mass-based gravity but aligns with electromagnetic superposition as the origin of gravitational effects.

H) The absence of antiparticles. If the gravitational force of mass is independent of charge, then the positive and negative particles should be symmetrically distributed in the same celestial body. It is precisely because massive celestial bodies are aggregations of magnetic moments that on the large spiral arms symmetrical to the Milky Way, there should be a large number of positive magnetic moment atoms symmetrically distributed. The nuclei of these atoms may be composed of negative protons, while the periphery is composed of positrons.

2.7. Analysis and Improvement of the Gravitational Field Equation

First, Einstein employed partial differential mathematics to derive the second Bianchi identity. Second, Einstein defined the Ricci spacetime curvature tensor as the contraction of the Riemann curvature tensor, resulting in the following expression [9]:

$$R_{\mu\nu} = \partial_\mu \Gamma^\lambda_{\lambda\nu} - \partial_\lambda \Gamma^\lambda_{\lambda\nu} + \Gamma^\lambda_{\mu\xi}\Gamma^\xi_{\lambda\nu} - \Gamma^\lambda_{\lambda\xi}\Gamma^\xi_{\mu\nu} \tag{21}$$

where $R_{\mu\nu}$ is the Ricci curvature tensor obtained by contracting the Riemann curvature tensor. Third, based on the energy-momentum conservation condition in general relativity, Einstein further proposed the following equation:

$$\nabla_\mu T_{\mu\nu} = 0 \to R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R \propto T_{\mu\nu} \tag{22}$$

In the equation, $T_{\mu\nu}$ represents the energy-momentum tensor, $g_{\mu\nu}$ is the metric tensor, R is the curvature scalar, and the symbol ∝ indicates a proportional relationship. Fourth, based on the Newtonian weak-field approximation, Einstein conjectured that the proportionality constant is $8\pi G/c^4$, where G is the gravitational constant and c is the speed of light. Thus, the equation becomes:

$$R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R = \frac{8\pi G}{c^4} T_{\mu\nu} \tag{23}$$

Fifth, subsequent observations of Hubble's law of cosmic redshift indicated that the universe appears to be expanding at an accelerating rate. Therefore, Einstein noted that the equation should originally have included a constant term, known as the cosmological constant. After adding this constant Λ, the equation becomes:

$$R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R + \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu} \tag{24}$$

After incorporating the cosmological constant, the equation can predict the expansion of the universe and account for phenomena associated with dark matter and dark energy. However, whether the universe is truly expanding remains a subject of ongoing debate. For this reason, we do not advocate including the cosmological constant in the equations.

Based on the derivation of the general relativity field equations, we summarize the following characteristics of the equation:

A) The equation is a set of second-order nonlinear partial differential equations. It describes the trajectory of a single free particle and variations in the gravitational field but remains an approximation and cannot achieve precise calculations.

B) The equation cannot be extended to describe the other fundamental forces.

C) When a particle is extremely close to the center, the potential energy diverges to negative infinity, leading to a massless singularity. This implies that the universe originated from a zero-mass singularity, which violates the conservation of energy.

D) The equation fails to capture quantum phenomena. In its derivation, the Lagrangian Equation is used, which implicitly assumes the absence of collisions. Consequently, quantum energy levels do not emerge (see Section 2.8 for details).

E) When applying the Lagrangian, the reference point for potential energy must be specified. This indicates that spacetime curvature is also a relativistic quantity. To accurately describe the spacetime curvature of an object, the distance and relative velocity between two objects must be considered. Therefore, the field equation must be fully compatible with the superposition theory of electromagnetic fields.

F) If the gravitational constant G in the equation is replaced by an effective superimposed constant G_e, the equation remains valid. G_e is calculated as follows:

$$G_e = \frac{c\hbar a}{m_1 m_2}, a = \frac{1}{2}\sum_{i=1}^{i=k,i=j} \frac{a_e}{\sqrt{1-v_{jk}^2}}, a_e \approx \frac{1}{137} \tag{25}$$

where a_e is the electromagnetic force constant. The superposition method involves summing the relativistic gravitational coefficients between all charges within a mass, which is equivalent to the total superposition of spatial curvature. The difficulty lies in the fact that it is challenging to determine the internal charge distribution within a mass. As with solving wave equations, extensive approximations are necessary. Therefore, the improved equation is still an approximate equation.

2.8. Explain Quantized Orbits and Energy Levels Using Classical Physics

A particle is a spatial entity in which energy rotates with relative stability. According to the de Broglie matter-wave hypothesis, a stable standing wave can only form when the matter wave of a particle resonates with its rotational orbit, thereby confining energy within a specific region. Research indicates that when one particle orbits another, the trajectory is invariably elliptical. From a philosophical perspective, a circular orbit is an ellipse with equal major and minor axes, while linear oscillation is an ellipse with a minor axis of zero. In the absence of external influences, aside from precession, elliptical orbits remain unchanged and persist indefinitely.

However, any particle within the universe is subject to influences from surrounding particles and electromagnetic fields, including collisions, which are inevitable probabilistic events. Consequently, every particle has a inherent lifespan and half-life, which are nearly impossible for humans to alter. The numerous impact craters on the Moon further attest to the frequency of particle collisions.

When an electron orbits an atomic nucleus, if its trajectory does not conform to quantization, there are three possible ways to correct the quantized orbit and energy level:

A) it spontaneously transitions to a lower energy quantum state, simultaneously emitting a photon.

B) it collides with an incoming particle, correcting the quantized orbit and energy level.

C) the electron detaches from the atom, and the proton recaptures the electron.

Experiments show that after an atom receives a photon that strikes the electron, the electron will typically detach from the atom within 10^{-9} seconds. Generally, the orbital period of an electron around a proton is about 10^{-15} seconds, indicating that the quantization screening of the electron's orbit in an atom is completed within an extremely short time. It must be emphasized that quantized energy levels still possess a certain width rather than being a single line. However, energies within the same quantum level cannot deviate significantly. The quantization of particle energy levels must be a statistical effect arising from a large ensemble of particles.

Theoretically, this rule also applies to celestial bodies. However, due to the extremely large principal quantum number n of celestial systems (for how to calculate the n value of a celestial body, please refer to [6]), their quantized energy levels are exceedingly subtle, leading to the common perception that quantum phenomena are absent in astrophysical contexts. Moreover, celestial objects exhibit extremely long orbital periods and immense masses, requiring vastly extended timescales for the evolution of quantized orbits. For instance, the disappearance of Halley's Comet may span thousands of years. Each time it passes near the Sun or reaches the aphelion of its elliptical orbit, hundreds of millions of tons of material may be shed from the comet. The dissipation of many other comets remains unrecorded by human observation. Nevertheless, after hundreds of millions of years of dynamical evolution, the solar system has come to closely resemble an atomic system: planetary orbits are nearly circular and exhibit remarkable regularity [10].

According to Sommerfeld's theory, the velocity of an elliptical orbit at its perihelion (closest point) is given by (For the equation derivation, please refer to [6]):

$$v_1 \approx \frac{1}{1+b}\frac{a}{l}\left(1 \pm \sqrt{1-\frac{l^2}{n^2}}\right) \tag{26}$$

It can be seen that the smaller the azimuthal quantum number l, the higher the orbital eccentricity. If the semi-major axis is regarded as the average orbital radius—that is, the average of the farthest point A and the closest point B—then the average radius should be:

$$\left.\begin{aligned}\langle r_1\rangle &= \frac{r_A+r_B}{2}=\frac{l}{2(1+b)}\left(\frac{\hbar}{m_1 v_A}+\frac{\hbar}{m_1 v_B}\right)\\ v_A &\approx \frac{a}{l(1+b)}\left(1-\sqrt{1-\frac{l^2}{n^2}}\right), v_B \approx \frac{a}{l(1+b)}\left(1+\sqrt{1-\frac{l^2}{n^2}}\right)\end{aligned}\right\}\langle r_1\rangle = \frac{n^2\hbar\sqrt{1-v_1^2}}{m_{10}a} \tag{27}$$

From the above equation, it can be seen that although electrons move in elliptical orbits, the maximum probability region is a perfect circle, and the radius of each principal quantum layer is only related to n.

The angular momentum distribution of a particle is quantized. The maximum value in any direction is $l\hbar$,and in the absence of a magnetic field, the orientation occurs with equal probability. Assuming the direction is along the Z-axis, the possible values are: l, $l-1$, $l-2$, …, 0, …, $-(l-2)$, $-(l-1)$, $-l$; In total, there are $2l+1$ possible quantum states. The sum of the squares of all possible quantum state values, multiplied by 3, indicating the sum over three directions, and then divided by the number of states, gives the average value per state:

$$\begin{aligned}&\left[l^2+(l-1)^2+\cdots+(-l)^2\right]\frac{3}{2l+1}\hbar^2\\ &=2\left(1^2+2^2+3^2+\cdots+l^2\right)\frac{3}{2l+1}\hbar^2=l(l+1)\hbar^2\end{aligned} \tag{28}$$

This operator is widely used in quantum mechanics, particularly when solving the wave equation. This indicates that quantum mechanics, as a statistical mechanics for studying large ensembles of particles, cannot be applied to the investigation of individual particles. Even when studying hydrogen atomic spectra, we are effectively conducting statistics on the collective behavior of a vast number of hydrogen atoms.

This demonstrates that the classical electromagnetic notion that an electron emits radiation simply due to circular motion is incorrect. Similarly, two celestial bodies in stable orbital motion should not radiate gravitational waves. Additionally, while some argue that photon energy levels must be integer multiples of h, this is not accurate. Photon energy is simply proportional to its frequency. For example, a photon with a frequency of 0.5 Hz carries an energy of 0.5h joules.

2.9. The Unification of General Relativity and Quantum Mechanics

According to the gravitational field equations, the trajectory of a particle is continuous, while quantum physics has always held that the orbit of a particle is a probabilistic region rather than a continuous path. The position operator X and momentum operator P of a particle conform to the following Equation:

$$[P,X]=i\hbar \to \Delta p\cdot\Delta x \ge \frac{\hbar}{2} \tag{29}$$

This equation represents the uncertainty principle, which traditionally states that the position and momentum of a particle cannot be simultaneously determined [11]. However, we propose a different interpretation. From the perspective of classical physics, matter waves represent the kinetic energy wavelength of particles, forming standing waves when orbital resonance occurs. For a two-particle system, assuming m_2 is the larger-mass particle, then:

$$\left.\begin{array}{l}\lambda = \dfrac{h}{p} = \dfrac{h}{m_1 v_1 + m_2 v_2} \\ 2\pi r = n\lambda, b = \dfrac{m_1}{m_2} \le 1\end{array}\right\} \rightarrow (1+b) m_1 v_1 r_1 \sin\theta = n\hbar \tag{30}$$

In the equation, θ represents the angle between the radius vector and the orbital plane. This Equation corresponds to Bohr's quantum rule, known as the **old quantum theory**. Note that v_1 is along the direction of the track (see **Figure 4**), not in any direction. Particles in an elliptical orbit also have partial velocities along the radial direction, so we have:

$$\left.\begin{array}{l}v_1 = \dfrac{\Delta x}{\Delta t}, r_1 = r_a + v_r \Delta t, m_1 v_r = \Delta p_r \\ \dfrac{r_a}{\Delta t} = 0, \sin\theta \le 1, b = \dfrac{m_1}{m_2} \le 1, n \ge 1\end{array}\right\} \Delta p_r \Delta x \ge \frac{\hbar}{2} \tag{31}$$

Here v_r represents the radial velocity, r_a denotes the semi-major axis of the ellipse, and p_r indicates the radial momentum. We consistently define m_2 as the particle with the larger mass. Thus, the physical significance of the uncertainty principle is as follows: when one particle orbits another, the possible trajectories are limited to various elliptical orbits. When the rate of change of momentum is small, the orbit tends to be closer to a perfect circle, and the probability distribution of the particle along the elliptical orbit is larger. When the rate of change of momentum is large, the elliptical orbit approaches linear vibration, and the probability distribution of the particle along the orbit becomes smaller.

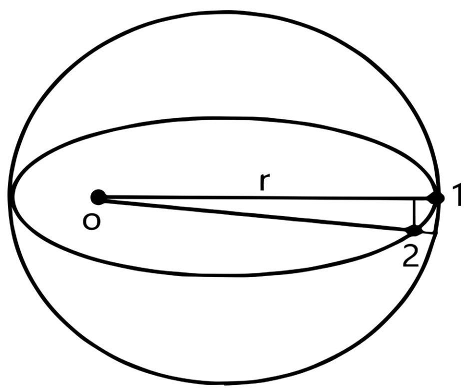

Figure 4. Possible elliptical orbits of an electron orbiting a proton. (Move position).

If the momentum in the Equation is expressed as the product of time and force, it can be derived as follows:

$$F\Delta t \cdot \Delta x \geq \frac{\hbar}{2} \to F\Delta x \cdot \Delta t \geq \frac{\hbar}{2} \to \Delta E \cdot \Delta t \geq \frac{\hbar}{2} \tag{32}$$

The physical meaning of the above equation is: When a particle's orbit approaches a perfect circle, even if the gravitational interaction persists for an infinite duration, the particle at any point on the circular orbit still satisfies the wave equation. In an infinite period of time, Δx can be infinitely large, but it must be in a circular orbit and obtained by the particle moving at its original speed, it is not allowed to exceed the optical speed. Conversely, when the particle's motion approximates linear vibration, the energy change at the center point becomes infinite, but the interaction time is zero. At this central point, the particle also satisfies the wave equation. At the central point, the particle's velocity reaches the speed of light, time becomes stationary, and this must be consistent with the principles of general relativity.

We have collected some cases to demonstrate the validity of the above content:

A) In a hydrogen atom, the proton and electron experience the same momentum change, obey the same quantum rules and equations, and the uncertainty principle applies equally to the proton. If Δx could be in any direction, the proton's position would be able to leave the center and disperse throughout the universe. However, observations of hydrogen atoms show that the proton always moves within a very small range around the center of mass.

B) In a hydrogen atom, if the electron must simultaneously occupy the entire probability region—meaning it is uniformly distributed over the spherical surface and only collapses to a point when detected—then the proton should remain at the center of mass to ensure the center of mass remains fixed before detection. However, the spectral lines emitted by hydrogen atoms indicate that the proton possesses an extremely small velocity and orbital radius, demonstrating that the proton is not located at the center of mass.

C) When the Moon orbits the Earth in an approximately circular path, according to the uncertainty principle, the momentum uncertainty Δp of the Moon is nearly zero, so Δx should tend toward infinity. The Moon's probability distribution should thus spread throughout the entire universe. If so, when no one observes the Moon, it should disperse to every part of the probability region, and tidal phenomena on Earth would not occur. However, even when everyone on Earth is asleep, tidal phenomena still exist. This indicates that whether people observe the Moon or not, it remains at a specific point—no different from an electron orbiting a proton.

D) Initially, Sommerfeld proposed that electron orbits were elliptical. By incorporating relativity, he calculated quantum energy levels that fully matched experimental values, particularly for the fine structure. The only shortcoming was that electron spin had not yet been considered, which prevented the prediction of the fine structure doublet.

E) Theoretically, when an electron is infinitely far from a proton and its velocity approaches zero, the electron does not "know" whether it will orbit a proton on the left or on the right—thus its orbital direction remains undetermined. However, both its position and momentum are well-defined. This contradicts Heisenberg's interpretation but aligns with our explanation: regardless of the particle's mass, as its velocity approaches zero, its de Broglie wavelength becomes infinite, and the entire universe becomes its probability region. Yet within this probability region, all physical laws must still be obeyed, including the speed of light as the ultimate limit and the conservation of energy, the particle must still obey the Einstein field equations.

According to recent measurements, the electron radius may be smaller than 10^{-22} meters. In a hydrogen atom, capturing the linear trajectory of an electron would require taking approximately 10^{29} photographs per second, which is practically impossible for humans. Additionally, the elliptical orbit of an electron undergoes precession, leading early researchers analyzing hydrogen atom images to conclude that the electron's position is indeterminate. However, by continuously photographing and magnifying a proton, we can ultimately reveal its continuous trajectory, thereby demonstrating that the previous interpretation of the uncertainty principle was incorrect.

We find that many of the perceived peculiarities in quantum mechanics stem from a misinterpretation of the uncertainty principle, particularly the notion of superposition states, which has led to apparent contradictions between quantum mechanics and classical physics.

2.10. The Wave Nature of Particles

Based on the principles of special relativity, when an atom moves at relativistic speeds, the velocity of the internal electron is subject to relativistic addition of velocities via the Lorentz transformation, ensuring that the resultant speed never exceeds the speed of light. Figure 5 should illustrate the relativistic composition of the electron's orbital velocity and the atom's bulk motion.

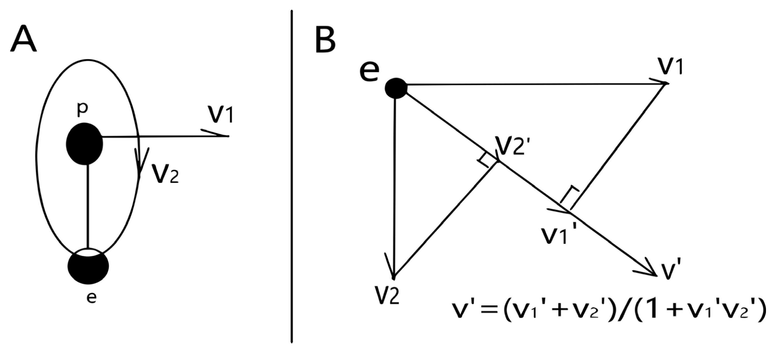

Figure 5. (A): When the hydrogen atom-spin is perpendicular to its direction of motion. (B): Velocity Composition Rule for Perpendicular Motions.

Figure 5 illustrates that no particle within a spinning structure can exceed the speed of light. Both electrons and photons are rapidly spinning particles. Therefore, when encountering a small aperture, an orbiting particle may collide with the aperture wall due to its rotation perpendicular to the direction of motion, generating momentum in that perpendicular direction. Therefore, whether it is the refraction or reflection of photons, including the diffraction of particles, it must ultimately conform to the conservation of momentum.

According to Einstein's equations, particles with smaller masses exhibit higher spin rates, experience more significant internal contraction, and possess smaller radii. This enables them to pass more easily through small apertures and produce broader diffraction patterns.

When a thin foil with a small aperture is placed in water and its mass is reduced, the transverse momentum of electrons passing through it is partially transferred to the foil. As a result, the diffraction pattern becomes blurred. If the foil's mass is sufficiently small, the diffraction pattern disappears entirely. When a detection device is placed near the slit, it essentially carries away part of the electron's momentum, thereby causing the diffraction pattern to disappear. This can also explain why the double-slit interference pattern disappears when electrons are detected (**Figure 6**).

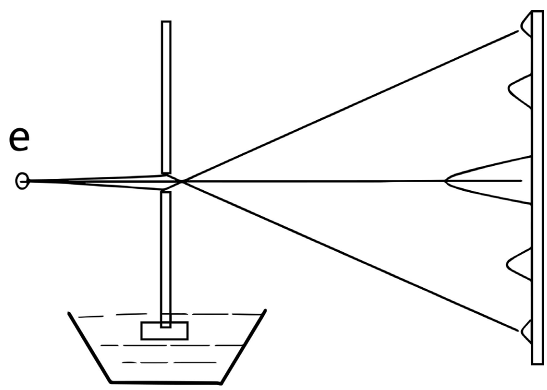

Figure 6. A piece of tin foil with a small aperture is floated on water, the diffraction pattern of electrons becomes blurred, and when the mass of the tin foil is sufficiently small, the diffraction pattern disappears, because the tin foil takes away part of the momentum of the electrons.

When the slit is sufficiently large, it is equivalent to the superposition of many small slits, it is equivalent to the superposition of the wave functions of each slit. After the superposition of diffraction patterns, only the central part is enhanced, while the peripheral patterns cancel each other out. As a result, an image corresponding to the shape of the aperture appears on the screen. When the width of a single slit is large, the distant patterns cancel out, likewise resulting in no visible pattern. In double-slit interference, if the frequencies differ, no pattern appears, as the distant fringe patterns similarly cancel out.

According to Equation (18), it can be inferred that the rest mass of a particle itself also exhibits wave-like properties, known as the Compton wavelength λ_0, which relates to the total mass wavelength λ_E of the particle as follows (SI System of units):

$$\left.\begin{array}{l}\lambda_D = \dfrac{h}{mv} = \dfrac{v}{f_D}, \lambda_0 = \dfrac{h}{m_0 c} = \dfrac{c}{f_0} \\ \lambda_E = \dfrac{h}{mc} = \dfrac{c}{f_E}, m = \dfrac{f_E c^2}{h}\end{array}\right\} \left\{\begin{array}{l}\dfrac{1}{\lambda_E^2} = \dfrac{1}{\lambda_0^2} + \dfrac{1}{\lambda_D^2} \\ f_E^2 = f_0^2 + \dfrac{c^2}{v^2} f_D^2\end{array}\right. \tag{33}$$

Here λ_D represents the de Broglie wavelength, which determines the step size of the particle's advance and thus the probability distribution ahead. It is evident that the de Broglie wavelength is unrelated to the physical size of the particle. Even within the uncertainty principle, the product of the particle's step length and frequency remains constant and equal to its velocity v, thus superluminal speed is also forbidden.

Therefore, the uncertainty principle should be correctly stated as: The more precise the spatial position of a particle is, the more uncertain its future permitted range will be. This aligns with Bohr's principle of complementarity: The greater the momentum of a particle, the stronger its particle-like behavior, the more defined its direction and trajectory become, resulting in reduced wave-like behavior and a narrower diffraction width. If the measurement affects temporal and frequency properties—such as by altering the particle's momentum—the particle exhibits particle-like behavior. If the observation only influences spatial characteristics—such as when passing through a narrow slit—it displays wave-like behavior.

Quantum mechanics is a form of statistical mechanics and often provides inaccurate descriptions of individual particles. This is analogous to repeatedly tossing a coin: the probability of heads is half, but when recording the result of a single toss, the actual outcome must be either heads or tails—which does not align with the statistical result or the wave equation. Therefore, to remain consistent with both the statistical outcome and the equation, one can only describe it as a superposition of half heads and half tails. In the double-slit experiment, a single particle is described as a superposition of passing through slit A and slit B. However, even if the two slits are alternately blocked, provided the electron's momentum remains unchanged, the accumulated result can still exhibit a wave-like pattern—which is essentially the superposition of diffraction effects.

2.11. Bell's Inequality and EPR

Einstein and his colleagues published a paper arguing that the perceived existence of superposition must be the result of some hidden variables. They maintained that if superposition truly existed, it would inevitably lead to superluminal quantum entanglement. Since the first letters of the three authors' surnames formed "EPR," this theory became known as the EPR paradox [12]. The Hungarian mathematician John von Neumann quickly derived a equation that directly refuted Einstein's hidden variable theory. Because von Neumann was a highly esteemed mathematician, his results were widely accepted without question [13].

It was not until 1964, two decades later, that British physicist John Bell published a paper titled "On the EPR Paradox" [14] [15]. Bell pointed out that von Neumann's equation was incorrect, as it was derived from five assumptions, the fifth of which stated: "If the average height of 70 people is 170 cm, then that all 70 individuals have the same height." This demonstrates that, regardless of an expert's prestige, we should not blindly accept their conclusions. Instead, we must examine their derivation process and only adopt results that are unequivocally correct.

Bell likewise derived a new inequality, asserting that if Einstein's theory were correct, the inequality should hold. A series of experiments were promptly conducted, yet the results demonstrated that Bell's inequality does not hold, thereby once again refuting Einstein's hidden variable theory. Since Bell's inequality involves the EPR paradox and touches upon whether quantum mechanics can be unified with classical mechanics, we must reexamine Bell's inequality from a new perspective.

A) Bell considered observing a pair of entangled-like particles along three spatial directions, with opposite spin values (+ or –) in each direction. This leads to a total of 8 possible combinations: (see Table 1).

Table 1. According to Bell's assumption, Particle A and Particle B have eight discrete combination states.

A	N_1	N_2	N_3	N_4	N_5	N_6	N_7	N_8
X	+	-	+	+	+	-	-	-
Y	+	+	-	+	-	+	-	-
Z	+	+	+	-	-	-	+	-
B	N_1	N_2	N_3	N_4	N_5	N_6	N_7	N_8
X	-	+	-	-	-	+	+	+
Y	-	-	+	-	+	-	+	+
Z	-	-	-	+	+	+	-	+

B) The probability of each combination occurring is denoted as N_1, N_2, …, N_8, with the total probability being 1.

C) Correlation is defined as follows: if two simultaneously generated particles have opposite spins, it is called negative correlation and denoted as $-N$; if they have the same spin, it is called positive correlation and denoted as $+N$. A correlation can be established between any two spatial directions, for example the P_{xy} is:

$$P_{xy} = -N_1 - N_2 + N_3 + N_4 + N_5 + N_6 - N_7 - N_8 \tag{34}$$

D) Calculating particle correlations: The correlation between the X-axis and Z-axis differs from that between the Z-axis and Y-axis:

$$\left|P_{xz} - P_{zy}\right| = 2\left|\left(N_3 + N_4\right) - \left(N_5 + N_6\right)\right| \tag{35}$$

E) Considering that the angle between the orientations ranges from 0 to π, the relationship between the difference in these correlations and the probabilities is as follows:

$$\left|P_{\text{xz}}-P_{\text{zy}}\right|=2\left|\left(N_3+N_4\right)-\left(N_5+N_6\right)\right|\le 2\left|N_3+N_4\right|+2\left|N_5+N_6\right|$$
$$\rightarrow\left|P_{\text{xz}}-P_{zy}\right|\le 1-P_{xy} \tag{36}$$

This is the renowned Bell's inequality, widely regarded in the physics community as a derivation of rigorous logical reasoning. However, we will soon discover several key flaws:

A) If the emission direction of particles is random, then the probability integral over all directions should equal 1. However, the terms N_1 to N_8 in Bell's inequality represent discrete states and do not encompass all possible outcomes. Therefore, assuming that the sum of probabilities $N_1 + N_2 + \cdots + N_8 = 1$ is incorrect.

B) When Bell finally presented the inequality, he considered a small angle between P_{xz} and P_{zy}, indicating that the emission orientations may not be mutually perpendicular. This implicitly assumes that the particle emission directions are arbitrary, in which case the condition $1 = N_1 + \cdots + N_8$ can no longer be applied too.

C) The derivation assumes the emission of a pair of entangled particles and presupposes that they remain in opposite states even at an infinite distance. This directly negates the possibility of hidden variables as proposed by Einstein, leading to the inevitable conclusion that experimental verification of the equation would rule out hidden variables.

For example, when two wires are connected to a sealed AC generator, it is impossible to determine which wire is positive without measurement—each wire can only be described as a superposition of positive and negative states (see Figure 7).

However, if the generator casing is transparent, allowing observation of the internal coils and magnet positions, we can calculate when each wire becomes positive. Here, the position of the magnet inside the generator acts as a hidden variable. Additionally, the voltage signal generated by the motor can only propagate along the wires at the speed of light, which is another hidden variable. Imagine the wires extending several light-years: the electric potential at the far end would depend on the length of the wires and must be calculated accordingly. However, assuming that the two wire ends must always exhibit opposite polarity is equivalent to directly denying the hidden variable of light-speed signal propagation.

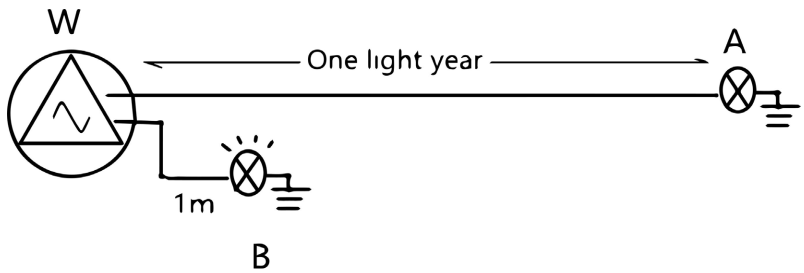

Figure 7. From an AC generator W, two wires are extended. When terminal B of the wire carries a voltage, terminal A still has none. This indicates that the electrical signal propagates only at the speed of light. The polarity of the wires represents what people imagine as the quantum entangled state.

Therefore, Bell's inequality cannot be used to verify the existence of hidden variables, nor can it be taken as a refutation of EPR theory.

3. Results and Conclusions

3.1. Simple principles and Quantum Field Theory

In physics, there exists an intangible philosophical principle: the simpler a physical rule or Equation, the more correct it is and the broader its applicability. This principle is known as the Principle of Simplicity. If the mathematical formula of a theory is very complex or must be supplemented with manual correction, then this theory is bound to need improvement.

To date, guided by the gauge transformation theory of Yang-Mills [16], the Standard Model theory [17] has been established. Both Einstein's field equations and the wave equation have also achieved significant success. These theories have their limitations, they must ultimately be unified and point toward a new frontier in physics: quantum field theory (see **Figure 8**).

Based on the arguments presented in this paper, the unified framework of quantum field theory should be structured as follows:

A) From photons to black holes, including galaxies and microscopic particles, all constitute particle systems. The inertial mass of all particles must conform to the mass Equation (3) and Equation (18). The Standard Model's assumptions regarding the structure of the proton are incompatible with these formulas and must therefore be incorrect.

B) When particles move within a potential field, they transition from non-quantum states to quantum states through a filtering process. Locally, particles obey field equations, while stable-state particles collectively obey wave equations.

C) The gravitational coefficient between any two particles is formed by the superposition of spacetime curvature caused by all moving charges within the particles, equivalent to the total superposition of electromagnetic fields generated by each charge. Moreover, particles and antiparticles are distributed regionally in the universe and exhibit asymmetry in the Milky Way.

D) An increase in the rest mass of particles must result from the conversion of an equivalent amount of kinetic energy. When multiple particles form a stable bound state, the internal gravitational potential energy must exceed the repulsive potential energy. The formation of stable particles requires the release of kinetic energy, reducing the rest mass. Conversely, an increase in the distance between internal particles requires the absorption of kinetic energy, increasing the rest mass. It follows that particle collisions alone can generate or increase rest mass, rendering the Higgs field fundamentally unnecessary.

E) The released kinetic energy can be carried by the generated particles or by massless particles. When carried by massless particles, these particles must manifest as electromagnetic waves—the only zero-mass particles, which are pure kinetic energy entities requiring motion at the speed of light. The frequency of electromagnetic waves can be less than 1, and gravitational waves are a typical example of low-frequency electromagnetic waves.

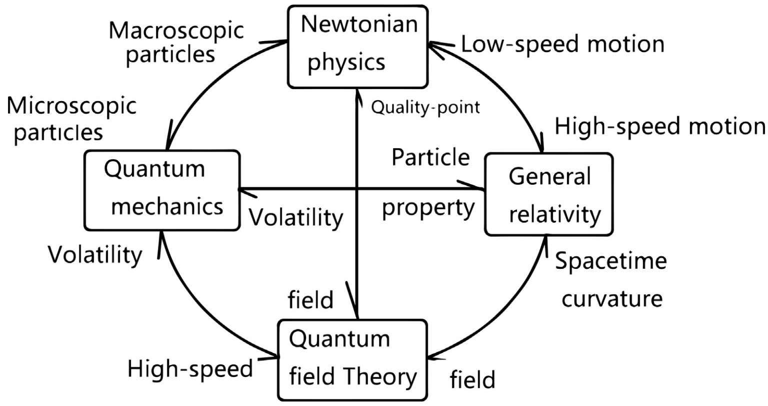

Figure 8. The overall theoretical framework of physics.

F) All multiple particles can attract each other and rotate mutually to form particle systems, though their stability varies. When the repulsive force exceeds the attractive force, the resulting system lacks stability and does not constitute a bound state. Therefore, there is no need to designate certain particles as fundamental particles.

G) According to the philosophical definition of spacetime, spatial translation, temporal translation, spatial symmetry transformation, temporal symmetry transformation, and synchronous rotation of spacetime are indistinguishable. Therefore, in the processes of particle synthesis and decay, the following must be conserved: momentum, energy, charge, parity, and angular momentum. In any reaction where these quantities are not conserved, there must exist particles that have not been statistically accounted for. We have demonstrated that in weak interaction reactions, if all participating photons and neutrinos are fully accounted for and their parity is correctly determined, every reaction adheres to the conservation of parity [6].

H) Any change in the energy levels of particles involves the exchange of particles and energy. Conversely, forces between particles still exist even in the absence of particle exchange. The origin of interaction forces between particles lies not in the exchange of any particles, but in the curvature of spacetime induced by their internal charges and the motion of those charges. Therefore, the interaction force between any two particles results from the total superposition of spacetime curvature contributions from all charge pairs. Since electric charge is quantized, the gravitational field must also be quantized. This constitutes the most accurate description of quantum field theory.

3.2. The Physical Rules from Photons to Black Holes

When two electrons approach each other from infinity without any energy exchange, they will repeatedly move along elliptical orbits. If energy exchange occurs (e.g., due to collision or emission of electromagnetic waves), the two electrons rapidly transition into a quantum state, forming positronium.

If two electrons are brought extremely close together and then released to undergo linear oscillation, theoretically, an artificial zero-mass particle system can be created. Negative-mass particles can also be artificially created. However, quantized particles cannot be of negative mass. So far, no negative-mass particles have been discovered. According to Equation (2), the distance d between the electrons is:

$$\left.\begin{aligned} M &= 2m_e c^2 - \frac{a_e \hbar}{d} = 0 \\ a_e &\approx \frac{1}{137}, \hbar = 1, c = 1 \end{aligned}\right\} d = \frac{a_e}{2m_e} \approx \frac{2.82}{2} \times 10^{-15}\ \text{m} \tag{37}$$

Here, the zero-mass particle refers to the photon. Thus, the radius of the photon can vary within this range. When the orbit is a perfect circle, it corresponds to circularly polarized light. Naturally occurring stable particles can only exist in quantum states obeying the wave equation. When rotating at high speeds close to the annihilation state, the most stable configuration is the $l = n - 1$ state. In this case, the mass M of the two-body particle system is given by [6]:

$$M = \frac{(1+b)m_{01}}{\sqrt{1-v_1^2}}\left(\frac{1}{b} - v_1^2\right), b = \frac{m_1}{m_2} \tag{38}$$

In the Equation, m_{01} represents the initial rest mass of particle 1. From this expression, it can be seen that when the masses of the two particles are asymmetric, b can only approach 1, and the mass cannot reach zero. Therefore, only particle–antiparticle pairs can undergo complete annihilation into photons.

During particle annihilation, the orbital velocity may approach the speed of light, and the mass of the orbiting particle tends toward positive infinity. According to the radius Equation (27), the orbital radius must shrink to zero, while the potential energy approaches negative infinity, resulting in a total particle mass of zero and transformation into a photon. This demonstrates that photons represent the final state of particle annihilation. The kinetic energy of a photon equals its relativistic mass m:

$$\left.\begin{aligned} m &= \frac{M}{\sqrt{1-v^2}} \\ M &= 0, c = 1 \end{aligned}\right\} \to \begin{cases} m = 0, v < c = 1 \\ m = \dfrac{0}{0} = fh, v = c = 1 \end{cases} \tag{39}$$

Here, f represents the frequency of the photon. Particles formed by the combination of electrons can further recombine to create more complex particles. For example, an electron can combine with a proton to form a hydrogen atom. Theoretically, the electron is a particle spinning at high speed and can generate strong gravitational effects at close range. The electron neutrino is an example of a particle formed at extremely short distances through the interaction between an electron and a π meson [6].

Similarly, when two celestial bodies approach each other, their mutual orbit can only be elliptical. Galactic collisions may gradually adjust the orbit until it stabilizes into a quantum-compliant trajectory. This implies that more stable quantized orbits tend to approach perfect circular orbits. During celestial mergers, processes such as structural reorganization and high-energy collisions occur, emitting significant gravitational waves. However, since all gravitational interactions are considered superpositions of electromagnetic forces, the essential nature of gravitational waves remains electromagnetic.

For massive celestial bodies, the superposition of internal electromagnetic forces approximates the universal gravitational constant G. When the masses of a binary system are highly asymmetric, the radius at which the total mass of the smaller body relative to the center of mass becomes zero is given by:

$$M_1 = m_1 - \frac{1}{1+b} V_{12} = 0 \rightarrow r_1 = \frac{G m_2}{(1+b)^2 c^2}, b \approx 0 \tag{40}$$

When the smaller celestial body is a photon, the equation still holds. Therefore, this radius is referred to as the black hole critical radius, also known as the Schwarzschild radius. Theoretically, any celestial body with sufficient density and small enough volume has its own Schwarzschild radius. For example, Earth's Schwarzschild radius is approximately 4×10^{-3} meters.

When the total mass of a binary system is less than zero, a zero-mass system emerges. The theoretical radius in this case is given by:

$$M = m_1 + m_2 - V_{12} = 0 \rightarrow r_1 = \frac{G m_1}{(1+b)^2 c^2}, b = \frac{m_1}{m_2} \approx 1 \tag{41}$$

In the equation, b is approximately 1 because the mass of the smaller celestial body also increases with velocity, eventually leading to nearly equal masses between the two bodies—though never exactly equal—consistent with the rules governing microscopic particle annihilation. Under natural conditions, negative-mass celestial bodies cannot form; instead, zero-mass systems may arise, moving at the speed of light and manifesting as low-frequency, high-intensity photons. This means that the so-called black hole singularity is essentially a photon. Mass cannot come into being from nothing. All rest mass must be converted from kinetic energy. Both kinetic energy and rest mass are inertial masses.

A question of particular interest is the physical laws governing the interior of a black hole. If Earth were to fall into a black hole without colliding with other matter, it would experience weightlessness. Humans on Earth would still only feel Earth's gravity, no different from being in the Solar System—they might not even realize they are moving inside a black hole and could, in theory, enter and exit the black hole repeatedly along an elliptical orbit.

However, collisions near black holes would become more frequent, leading to celestial restructuring and potentially even the destruction of Earth. Such processes, accompanied by intense radiation, would reduce the total rest mass of the celestial system, and increase kinetic energy. This constitutes the overall balance and cycle of mass and kinetic energy. Additionally, if two celestial bodies transfer their kinetic energy to the external environment during mutual descent, it is

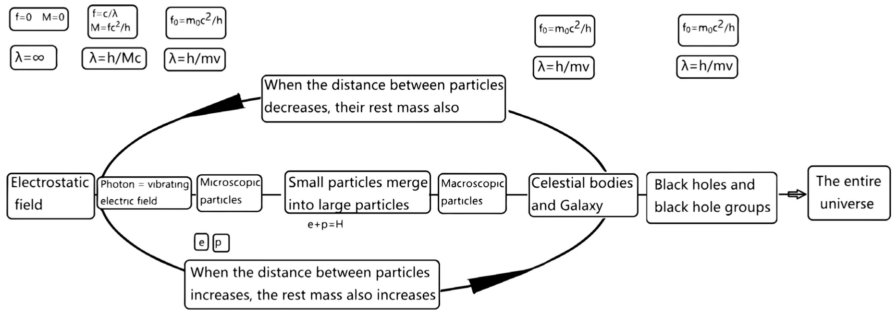

Figure 9. The entire universe can be regarded as the largest particle system. From electrostatic fields to the universe, they all follow a common rule: particles as a whole abide by the wave equation, and particles locally abide by Einstein's field equation.

possible to form a black hole with negative mass. As such a negative-mass black hole adjusts toward zero mass, it would inevitably consume mass—though the probability of forming a negative-mass black hole remains extremely low. Similar to microscopic particles, the probability of zero-mass celestial bodies is relatively high, and any zero-mass system can only annihilate into photons (see **Figure 9**).

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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