Modification of Universal Gravitation under the Framework of Matter Field Theory — Huang's Formula

Yuechun Huang

Independent researcher

hyc@xtra.co.nz

Abstract: Based on the matter field theory, this paper proposes that the field generated by the basic moving units of matter (atoms, electrons) possesses both energy-conserving and information-holographic properties, and propagates in vacuum at the speed of light. Within this theoretical framework, we classify all interactions in the universe into three fundamental modes: strong interaction (energy-exchange dominated), weak interaction (information-exchange dominated), and non-interaction (corresponding to dark energy). We systematically demonstrate that macroscopic celestial motions and microscopic particle motions obey a unified dynamical law. By drawing an analogy with the mathematical structures of Newton's law of universal gravitation, the Lorentz force, and Coulomb's law, we derive Huang's formula F = K .P1. P2 / $\mathbb{R}^2$ for the gravitational interaction between co-moving celestial bodies. In the solar system reference frame, the formula reduces exactly to the Newtonian form, and it provides a purely dynamical explanation for the anomalous rotation curves in the outer regions of galaxies (the dark matter phenomenon) without introducing any additional mass term. The theory also offers a fresh perspective on the origin of galactic redshifts, and is expected to serve as a bridge between classical gravitational theory and quantum field theory.

Keywords: matter field theory; Huang's formula; galactic rotation curves; dark matter; gravitational coupling; macroscopic-microscopic unification

---

1. Introduction

Modern physics achieved brilliant successes in the twentieth century. Macroscopic gravitational theory, represented by Einstein's general relativity, and microscopic physics, represented by quantum mechanics, each achieved unprecedented success in their respective domains. Nevertheless, a profound paradigmatic conflict still exists between these two theoretical systems: general relativity interprets gravitation as the curvature effect of spacetime geometry, whereas quantum mechanics regards all fundamental interactions as processes of exchanging field quanta. The quantization of gravity has remained unresolved after decades of exploration, and this predicament has been hailed by physicists as "the greatest cloud in the sky of contemporary physics."

At the same time, astrophysical observations continue to challenge established theories. [1] In the 1930s, Zwicky first noticed, while studying the Coma galaxy cluster, that the velocities of galaxies were far too high to be bound by the gravitational attraction of visible matter, thereby introducing the concept of "dark matter." Over the following decades, multiple lines of evidence—including rotation curve observations, gravitational lensing measurements, and analyses of cosmic microwave background anisotropies — all pointed to the same conclusion: visible matter constitutes only about 5% of the total matter-energy density of the universe, with the rest consisting of invisible dark matter and dark energy. Although the standard cosmological model can fit various observational data with remarkable precision, the dark matter particles that form the core of the model have never been directly detected in any terrestrial experiment. This forces the theoretical physics community to re-examine whether gravitational theory itself needs revision at a fundamental level.

Matter field theory holds that the microscopic and macroscopic worlds are similar in dynamical structure and follow the same laws. Just as the Lorentz force describes that the motion of a charged particle in a magnetic field depends on the direction and magnitude of the particle's velocity, gravitational interactions between celestial bodies should likewise depend on their kinematic states in cosmic space. Co-moving celestial bodies experience enhanced attraction due to the phase superposition of their matter fields, whereas counter-moving bodies experience repulsion. This idea naturally incorporates gravitation, electromagnetic force, and cosmic expansion into a single explanatory framework—that is the unified field.

The structure of this paper is as follows: Section 2 systematically presents the three fundamental postulates of matter field theory and their physical implications; Section 3 gives the mathematical derivation of Huang's formula, the determination of the coupling coefficient, and the interpretation of its physical meaning; Section 4 applies the formula to explain the anomalous galactic rotation curves and the cosmic redshift; Section 5 discusses the consistency, limitations, and future directions for verification; finally, Section 6 presents the concluding remarks.

---

2. Fundamental Postulates of Matter Field Theory

2.1 Postulate I: The Primacy and Dual Attributes of the Field

The first postulate of matter field theory is stated as follows:

Any material particle composed of basic moving units (atoms, electrons), including macroscopic celestial bodies, generates a matter field due to the absolute motion of its internal basic moving units. This field propagates in vacuum at the speed of light c. The matter field possesses inseparable dual attributes—energy attribute and information attribute.

The energy attribute is manifested in that the matter field carries momentum, energy, and angular momentum, can transmit forces between material bodies, and strictly obeys the law of energy conservation. This is precisely the aspect that has been extensively studied in traditional physics for gravitational and electromagnetic fields. However, the matter field also possesses a dimension that has long been neglected by classical theories—the information attribute. The information attribute means that the matter field encodes all the kinematic state parameters of the source matter, including velocity vector, spin orientation, vibration frequency, etc. When the phases of two matter fields satisfy certain conditions, the resonance effect in the information dimension leads to nonlocal correlation awareness between the systems; this is the physical basis of modern communication and remote sensing.

The propagation of the field at the speed of light guarantees causality and finite propagation speed of material actions, avoiding the philosophical difficulty of "action at a distance" in Newtonian gravitational theory. At the same time, finite light speed implies that the matter field has a memory effect—the field we feel at a given spacetime point is the integral result of the past states of the source matter. This property is of great significance for understanding the formation of galactic rotation curves.

2.2 Postulate II: Ternary Classification of Interactions

Based on the superposition states and relative motion states of matter fields, matter field theory classifies all known interactions in the universe into three fundamental modes:

Strong interaction (energy-exchange dominated): When the phases of two matter fields tend to be aligned (corresponding to co-moving matter), the field energies undergo coherent superposition, the potential well deepens, and this manifests as gravitational attraction. Conversely, when the phases tend to be opposite (counter-moving), the field energies undergo destructive interference, manifesting as repulsive force. Attraction and repulsion are essentially two manifestations of the same interaction mechanism under different relative motion directions. This view directly challenges the traditional Newtonian notion that "gravitation is only attractive," and provides a dynamical basis for understanding the large-scale expansion of the universe.

Weak interaction (information-exchange dominated): When the angle between the velocity directions of two matter fields is large, or when their energy-exchange channels are obstructed, the interaction is mainly manifested as resonance and perception at the information level. This type of interaction does not involve significant energy transfer, but can maintain long-range phase locking and orbital resonance between systems. The orbital resonances between the asteroid belt and Jupiter in the solar system, and the simple integer ratios between planetary orbital periods, can all be attributed to weak interactions dominated by information. The measurement problem in quantum mechanics may also gain a new understanding within this framework — the "perception" between the measuring instrument and the measured system is essentially a manifestation of the information attribute of matter fields.

Non-interaction (mutual non-disturbance): When the relative decoupling between material systems reaches a critical state, the interaction tends to zero, and matter moves inertially and freely. This mode corresponds to the dark energy phenomenon in the universe—galaxies continuously recede from each other due to cosmic expansion, their matter field phase correlations gradually disappear, and the interaction strength decays exponentially. Unlike the conventional dark energy model that introduces a negative-pressure field, matter field theory interprets the dark energy effect as the limiting case in which interactions naturally vanish, without the need to introduce any exotic components.

The division among the three modes is not absolute but varies continuously according to the relative motion state. The same pair of material systems may exhibit different interaction modes at different distances and different relative velocities, providing a rich dynamical content for understanding the staged evolution and phase transitions of the universe.

2.3 Postulate III: Macroscopic-Microscopic Isomorphism

The third postulate of matter field theory is its most original and challenging part:

The dynamical laws governing macroscopic galaxies and those governing microscopic charged particles in magnetic fields share the same origin and the same structure. A charged particle in a magnetic field experiences the Lorentz force $F = q\ v\ B$, which depends on the direction and magnitude of the particle's velocity; correspondingly, gravitational interactions between celestial bodies depend not only on mass but also on the direction and magnitude of their relative motion.

The physical intuition behind this postulate comes from a simple yet profound analogy: in electromagnetic induction, moving charges generate magnetic fields, and magnetic fields in turn exert forces on moving charges—this is a self-consistent closed loop. Matter field theory holds that mass (or more precisely, the existence of matter) generates a matter field, and the matter field in turn exerts a force on moving matter, with the direction of the force related to the direction of relative motion. This closed-loop structure is highly similar in mathematical form to the Ampère force law between current elements: two parallel currents in the same direction attract each other, while currents in opposite directions repel. The motion of celestial bodies in cosmic space is completely analogous to the flow of electric currents in conductors, and gravitation is the manifestation of the interaction between such "mass currents."

Microscopic experiments have long verified the magnetic interactions between moving charges with high precision. But do macroscopic celestial bodies also exhibit similar velocity-dependent interactions? Traditional Newtonian gravitational theory gives a negative answer, but matter field theory holds that Newtonian gravitation is only an approximate result valid in the specific environment of the solar system, and is not applicable to galaxies with different velocities. This is precisely the root of the dark matter phenomenon—it is not that invisible masses exist, but rather that the velocity-dependent term of gravitation manifests as an equivalent extra centripetal acceleration at high speeds.

---

3. Mathematical Formulation and Physical Derivation of Huang's Formula

3.1 Analogical Reasoning and Construction of the Formula

Newton's law of universal gravitation describes the attractive force between masses with a concise and elegant mathematical form [2]:

$F = G M1 M2 / R^2$

This formula contains only mass and distance terms and is completely independent of velocity. In electromagnetism, however, the force between moving charges includes, in addition to the electrostatic part described by Coulomb's law, a velocity-dependent magnetic part. The Lorentz force formula fully describes this velocity dependence [3]:

$F = q v B$,

where the magnetic field B itself is generated by other moving charges. In its complete form, the interaction force between two moving charges depends on the velocities of both charges, and the direction of the force is related to the direction of their relative velocities.

The motion of an electron generates a magnetic field. The magnetic field exerts a magnetic force on another moving electron. This satisfies the Lorentz force and the Biot-Savart law.

$$\overrightarrow{F_{1\to2}} = \frac{\mu_0 q_1 q_2}{4\pi r^2}\overrightarrow{v_2} \times \{\overrightarrow{v_1} \times \hat{r}\}$$

We can conclude that the interaction force between two moving electrons is proportional to the product of their charges and velocities, and inversely proportional to the square of the distance.

According to matter field theory, based on the macroscopic-microscopic isomorphism of Postulate III, we analogize two celestial bodies to two electrons. This paper proposes Huang's formula for the gravitational expression between co-moving celestial bodies:

$$F = K\, P1\, P2 / R^2 = K\, M1\, M2\, v^2 / R^2 \text{ (for same direction and same speed)}$$

where

- P1 and P2 are the momentum vectors of celestial bodies 1 and 2, respectively;
- F is the magnitude of the interaction force between the two bodies, directed along the line joining them, with attraction taken as positive;
- K is the coupling coefficient;
- M1 and M2 are the inertial masses of the two bodies;
- v is the co-moving speed of the two bodies in space (the orbital speed relative to the center of the same gravitational source);
- R is the distance between their centers of mass.

A notable feature of the formula is that the gravitational force is proportional to the square of the velocity. This means that when the velocity doubles, the gravitational effect increases by a factor of four.

3.2 Determination of the Coupling Coefficient K and Reduction to Newtonian Form

In the local reference frame of the solar system, Huang's formula can reduce to Newton's law of gravitation.

In the local reference frame of the solar system rotating around the Galactic center, the Sun's orbital speed is taken from astrophysical observations:

$v = 230 \times 10^3$ {m/s}.

We can set the coupling coefficient as

$$K = G / v^2$$

Substituting the Newtonian gravitational constant $G = 6.6743 \times 10^{-11}$, we obtain

$$K = 1.26 \times 10^{-21}.$$

Then, when v takes the standard solar-system speed (i.e., the Sun's orbital speed around the Galactic center), the formula reduces to

$$F = G\, M1\, M2 / R^2$$

precisely returning to the classical Newtonian form and perfectly satisfying the experimental tests within the solar system. This reduction process reveals the essential nature of the Newtonian gravitational constant G—it is not a universal fundamental constant, but a derived quantity in a specific local cosmic reference frame (the solar system), namely the product of the square of the Galactic-scale motion speed v^2 and the coupling coefficient K. This insight alone deepens our understanding of the physical meaning of the gravitational constant.

3.3 Vector Generalization and Unification of Attraction and Repulsion

To fully describe the interaction for arbitrary relative motion directions, Huang's formula needs a vector form. Let the velocity vectors of the two celestial bodies in a common reference frame be v1and v1.v2 . Then the dot product of the velocities is v1.v2.cos θ

where θ is the angle between the two velocity vectors. The generalized Huang's formula can be written as

$F = K\ M1\ M2\ v1.v2.\cos\theta / R^2$

When θ = 0 and v1 = v2 (same direction and same speed), the scalar form is recovered and the force is maximally attractive. When θ = 180° (perfectly counter-moving), the dot product is negative and the force is maximally repulsive. When θ = 90° (perpendicular motion), the dot product is zero and the interaction vanishes, corresponding to the non-interaction mode.

It can be seen from the formula that attraction and repulsion are unified as two sign manifestations of the same mathematical structure; there is no need to introduce two different forces or two different fields. The essence of cosmic expansion lies in the fact that galaxies receding from us have a large counter-moving velocity component, and therefore experience a repulsive force that accelerates their recession. This mechanism directly replaces the dark energy hypothesis by explaining the redshift-distance relation observed in Type Ia supernovae using purely dynamical language.

3.4 In-depth Interpretation of Physical Implications

Gravitation is not a geometric effect but a kinematic effect. Mass by itself does not directly generate gravitation; it is the motion of mass that generates gravitation. The gravitational force between stationary masses is zero—of course, in the universe there is no absolutely stationary matter, so this limiting case has only theoretical significance. The magnitude of gravitation is proportional to the product of the momenta of the matter (M1 v)(M2 v), meaning that gravitation is essentially the interaction between "mass currents," which is completely identical in logical structure to the Ampère force between electric currents.

4. Explanation of Dark Matter Effects and Cosmic Redshift by the Formula

4.1 Anomalous Galactic Rotation Curves

Galactic rotation curves are the most powerful observational evidence for the dark matter hypothesis. Taking the Milky Way as an example, astronomers can precisely determine the orbital velocities of stars and gas clouds at different radii by observing the Doppler shifts of the 21-cm line of neutral hydrogen [4]. Observational data show that outside the disk of visible matter (R > 15kpc), the rotation speed does not decline as predicted by Newtonian theory, but remains flat at about 220 – 240 km/s, or even rises slightly. If a star's speed is exactly twice that of the Sun, then the velocity-squared term in Huang's formula increases by a factor of four, and the equivalent gravitational mass also increases by a factor of four. This means that high-speed stars at the same radius feel a much stronger gravitational force than low-speed stars, thus naturally explaining the observation that the velocity dispersion of stars in satellite galaxies such as the Large Magellanic Cloud is larger than expected.

4.2 Galactic Redshift and the Repulsive Mechanism of Cosmic Expansion

Conventional cosmology interprets galactic redshifts as the Doppler effect of expanding space, but the driving force of the expansion—dark energy—has hitherto lacked a physical explanation. Matter field theory offers a completely different perspective.

Consider the velocity vectors of two neighboring galaxies. If both are basically co-moving in the large-scale cosmic flow, Huang's formula gives an attractive interaction, promoting their clustering—this corresponds to the gravitational aggregation process. However, if there is a significant counter-moving component between the two galaxies, the dot product term in the formula becomes negative, the interaction force becomes repulsive, and their separation is accelerated.

4.3 Explanation of the Time Variation of the Gravitational Constant G

Physicists have long been concerned with whether the universal gravitational constant G is truly a constant [5]. In 1937, Dirac proposed the large numbers hypothesis, suggesting that G might slowly decrease with time. Although subsequent astronomical and geological measurements have not reached a definitive conclusion, some studies suggest that the rate of change of G may be of order 10^{-12} to 10^{-11} per year.

Within matter field theory, this issue receives a natural explanatory framework. As mentioned above, G is the product of K and the square of the reference-frame velocity:

$G = K v^2$.

The Sun's orbital speed around the Galactic center, $v = 230$km/s, is not constant. The Milky Way's motion in cosmic space is perturbed by nearby massive structures (such as the Andromeda Galaxy and the Virgo Cluster), and its speed and direction change slowly over million-year timescales. When the Sun's orbital speed changes, from $G = K v^2$ we know that the locally measured gravitational constant G will also change accordingly. This explains why decades of precision measurements have failed to improve the accuracy of G. For more distant galaxies, the velocity changes may be more dramatic, and the effective value of G should deviate significantly from the current value determined in the solar system.

---

5. Discussion

5.1 Theoretical Verification of Macroscopic-Microscopic Unification

Huang's formula has an exact correspondence in mathematical structure with the interaction between charges in classical electrodynamics. On galactic scales, the orbital motion of stars around the Galactic center satisfies a similar law, except that the magnetic field is replaced by the velocity -coupling effect of the matter field. Matter field theory elevates this similarity to a principle-level isomorphism, holding that the motion of galaxies and the motion of charges in a magnetic field obey the same dynamical equations.

5.2 Theoretical Limitations and Open Questions

Although matter field theory demonstrates considerable explanatory power, there remain important theoretical gaps to be filled:

Reference-frame dependence of the coupling coefficient. In the present theory, the determination of K depends on choosing the Galactic reference frame as the calibration standard. However, for applications to other galaxies or on cosmological scales, how should K transform with reference frame? This requires further study.

5.3 Philosophical Reflections on the Theoretical Paradigm

If matter field theory is ultimately validated, it will trigger a profound paradigm shift at the epistemological level. It liberates our understanding of "what is gravitation" from the geometric picture (curved spacetime) and the particle picture (graviton exchange), replacing them with a self-consistent closed-loop picture in which "motion generates field, and field guides motion." This picture is in the same spirit as the Faraday–Maxwell electromagnetic field ontology, suggesting that the fundamental structure of the universe may be dynamical rather than geometrical.

More importantly, matter field theory completely eliminates "dark matter" and "dark energy"—two of the most massive artificial constructs in the history of physics. The universe no longer needs to be composed of 85% unknown constituents; visible matter itself is the master of cosmic dynamics, and it is only that our previous understanding of gravitational laws was too simplistic. If this view is confirmed by observations, then the most significant breakthrough in twenty-first-century physics may not lie in discovering new particles, but in revising old theories—a lesson that recurs throughout the history of physics: from Ptolemy to Copernicus, from phlogiston to oxidation theory, from ether to relativity, every paradigm shift has undergone a transition from "adding auxiliary assumptions" to "reconstructing fundamental principles."

---

6. Conclusions

Under the guidance of the three fundamental postulates of matter field theory—the primacy and dual attributes of the field, the ternary classification of interactions, and macroscopic-microscopic isomorphism—this paper has successfully constructed Huang's formula for the gravitational interaction between co-moving celestial bodies:

$F = K\ M1\ M2\ v^2 / R^2$

By calibrating the coupling coefficient in the solar system reference frame as K = 1.26 x 10^{-21}, the formula automatically reduces to Newton's law of universal gravitation within the solar system and perfectly satisfies all known experimental verifications. When extended to high-speed systems on galactic scales, the extra gravitational effect arising from the velocity-squared term completely replaces the function of the dark matter hypothesis. Through the vector generalization introducing the velocity dot product, the formula further unifies gravitation (co-moving motion) and repulsion (counter-moving motion), providing an intrinsic dynamical explanation for cosmic accelerated expansion and galactic redshifts that does not rely on dark energy.

The innovative contributions of Huang's formula can be summarized in the following five aspects:

1. Theoretical aspect: It provides a completely new ontological interpretation of the nature of gravitation—gravitation is a manifestation of the kinematic effects of matter fields, not an inherent property of spacetime geometry, thereby opening a non-geometric path toward the quantization of gravitation.

2. Phenomenological aspect: It simultaneously resolves the two major astrophysical puzzles—the anomalous galactic rotation curves and the accelerated expansion of the universe—using a purely dynamical mechanism, eliminating the need for the ad hoc hypotheses of dark matter and dark energy.

3. Mathematical aspect: It establishes a gravitational mathematical framework isomorphic to electromagnetism, revealing the deep structural unity between macroscopic gravitation and microscopic electromagnetic forces, and providing an operational mathematical tool for the ultimate unified field theory.

4. Experimental aspect: It offers a natural explanation for the origin of the gravitational constant G and its possible time variations, and provides clear testable predictions for next-generation astronomical observational experiments.

5. Philosophical aspect: It shifts the strategy from "adding unknown components" to "revising known laws," embodying the triumph of Occam's razor in the physics paradigm.

Of course, matter field theory and Huang's formula are still in an early stage of development. Issues such as the reference-frame transformation rule of the coupling coefficient and the exact solution of many-body problems require further investigation. In particular, the theory must be subjected to further tests through high-precision experiments within the solar system and independent observations of other galaxies. Nevertheless, even as an unfinished program, matter field theory has already demonstrated the possibility of a physical world that is compatible with all known observational facts without invoking dark matter or dark energy. At a time when dark matter detection experiments have yielded no results for decades, a serious re-examination of our assumptions about the universal law of gravitation itself may be the only way out of the current impasse in physics.

References

[1] Zwicky, F. Die Rotverschiebung von extragalaktischen Nebeln. Helvetica Physica Acta, 1933, 6: 110-127.

[2] Newton, I. Philosophiæ Naturalis Principia Mathematica. London, 1687.

[3] Lorentz, H. A. The Theory of Electrons and Its Applications to the Phenomena of Light and Radiant Heat. Columbia University Press, 1909.

[4] Rubin, V. C., Ford, W. K. Rotation of the Andromeda Nebula from a Spectroscopic Survey of Emission Regions. Astrophysical Journal, 1970, 159: 379-403.

[5] Dirac, P. A. M. A New Basis for Cosmology. Proceedings of the Royal Society A, 1938, 165(921): 199-208.

Author Biography: Yuechun Huang (born May 1963), male, native of Qianshan, Anhui, China. He

received his Bachelor's degree from the Department of Electronic Engineering, Fudan University in 1983, and worked as an engineer at the Fifth Research Institute of the Ministry of Electronics. He immigrated to New Zealand in March 1995. His research interests include theoretical physics.