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# Gravitation and Electrostatics as Particle-Count Interactions: Toward a Unified Framework

**Hai-Feng Ji***

College of Art and Science, Drexel University, Philadelphia, PA 19104, USA

## *Corresponding Author

Hai-Feng Ji, College of Art and Science, Drexel University, Philadelphia, PA 19104, USA, Tel: +1-215-895-2562, E-mail: hj56@drexel.edu

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## Abstract

A reformulation of Newton's law of gravitation and Coulomb's law of electrostatics is introduced in terms of discrete particle counts. In this framework, gravitational interaction is expressed as a function of nucleon numbers (N) corrected by a factor that accounts for binding energies, electron contributions, and other energy-related effects, while electrostatic interaction depends on net charge counts (Z). The resulting count-based force law places both forces on parallel mathematical footing, with coupling strengths set by derived constants. This re-parametrization introduces no fundamentally new physics but highlights the discreteness of matter as a common substrate for mass and charge. It provides a pedagogical bridge between classical laws and quantum field theory, where couplings determine interaction strengths. While remaining fully compatible with established physics, this perspective may offer new insights for cosmological interpretation and for exploring analogies between gravitational and electromagnetic wave generation.

**Keywords:** Gravitation and Electrostatics; Newton's law; Gravitation; Coulomb's law; Nucleon numbers

## 1. Introduction

Newton's law of gravitation [1] and Coulomb's law are two of the most fundamental inverse-square laws in physics. Traditionally, gravitation is expressed in terms of mass and Coulomb's law in terms of electric charge. However, both can be reformulated in terms of fundamental particle counts: nucleons for mass and integer charge counts for electrostatics. This brief note presents one expression for the long-range interactions between two bodies by combining gravitation (expressed in terms of nucleon counts) and electrostatics (expressed in terms of integer charge numbers). This perspective highlights the discrete microscopic structure of matter and provides a conceptual bridge between mass-based and charge-based interactions. Reformulating these laws in terms of particle counts does not seek to replace the classical laws, but serves three specific purposes: (i) it makes explicit the compositional origin of gravitational and electrostatic sources, (ii) it allows a transparent comparison of how different forms of matter contribute to force generation through dimensionless counting variables, and (iii) it provides a pedagogical bridge to particle and quantum-field descriptions, where interactions are inherently defined by particle number and coupling constants. The usefulness of the reformulation is therefore conceptual and bookkeeping-based rather than predictive.

## 2. Gravitation in Nucleon Count Form

The Newtonian gravitational force between two bodies of mass $m_1$ and $m_2$ is:

$$F = G\frac{m_1 m_2}{r^2}$$

Where *F* is the force between the objects; *G* is the Newtonian constant of gravitation ($6.674\times10^{-11}$ $m^3\cdot kg^{-1}\cdot s^{-2}$); $m_1$ is the mass of the first object; $m_2$ is the mass of the second object; *r* is the distance between the centers of the masses.

If $m_1$ and $m_2$ are made of atoms, then the gravitational mass of an object is basically the sum of the masses of all its atoms, minus a tiny correction from binding energies (nuclear and chemical) [2] since binding energy contributed to effective mass according to equivalence of mass and energy ($E=mc^2$):

$$m \approx N_{\text{atoms}} \times m_{\text{atom}}$$

Each atom has a mass that is the sum of the mass of its protons + neutrons (electrons are ~1/2000 of a proton, so their contribution is small).

$$F \approx G\frac{N_{1\text{atom}} m_{\text{atom}} \times N_{2\text{atom}} m_{\text{atom}}}{r^2}$$

When binding energies, the contributions of electrons, the small mass difference between protons and neutrons, and all other energy-related effects (such as nuclear binding corrections and electromagnetic self-energies) are included for accuracy, a correction factor η (close to 1) is introduced. This factor accounts for the deviation of a nucleus's effective mass per nucleon from that of a free neutron.

Thus, the mass of a body can be expressed as:

$$m = N \cdot m_n \cdot \eta$$

where N is the nucleon count (protons + neutrons), and $m_n$ is the free neutron mass. With this substitution, the gravitational law becomes:

$$F = G\frac{\eta_1 N_1 \times \eta_2 N_2}{r^2}$$

where G=Gmn2 ≈ 1.87 × $10^{-64}$ N·$m^2$ is defined as the nucleonic gravitational constant (a redefinition for bookkeeping purposes and not a new fundamental constant), r is the distance between the two bodies, and $N_1$, $N_2$ and $\eta_1$, $\eta_2$ are the nucleon counts and correction factors for the two bodies, respectively. η includes contributions from nuclear binding energy and the small but non-negligible electron mass and others per nucleon so that energy affects gravity by altering effective particle weights. Thus, both nuclear and electronic effects are implicitly included in this nucleon-based gravitational formulation, which is the nucleon count-based Newton's law of gravitation.

The correction factor η accounts for deviations of the average mass per nucleon from the free neutron mass due to nuclear binding, proton–neutron mass differences, and electronic contributions. Using tabulated nuclear binding energies, η differs from unity at the percent level. For example, η ≈ 0.992 for carbon, ≈ 0.991 for iron, and ≈ 0.992 for uranium. Across naturally occurring elements, η varies at the level of ~1%.

To illustrate that the count-based formulation is numerically equivalent to the classical one, consider two 1 kg neutral iron spheres separated by r = 1 m. Classical Newtonian gravity gives

$$F = G\frac{m^2}{r^2} = 6.67 \times 10^{-11}\,\text{N}.$$

For iron, the average nucleon mass corresponds to η ≈ 0.9988, and N ≈ (1 kg)/(1.675×$10^{-27}$ kg × η) ≈ 6.0×$10^{26}$. Using the count-based law yields

$$F = G'\frac{N^2\eta^2}{r^2} \approx 6.67 \times 10^{-11}\,\text{N},$$

recovering the identical value to within rounding error. This explicitly demonstrates that the count-based formulation introduces no numerical deviation from the classical law.

## 3. Coulomb's Law in Charge Count Form

Coulomb's law is normally:

$$|F| = K_e\frac{|q_1||q_2|}{r^2}$$

where q is measured in coulombs, $k_e$ is Coulomb's constant. If instead we use integer charge numbers $Z_1$ and $Z_2$ such that q = Z e (e is the elementary charge, 1.6x$10^{-19}$), then:

$$|F| = K_e\frac{|Z_1 e|\,|Z_2 e|}{r^2} = \kappa\frac{|Z_1|\,|Z_2|}{r^2}$$

where,

$Z = N_p - N_e$ is the net charge number (in units of e), defined as the difference between proton count $N_p$ and electron count $N_e$. It determines the Coulomb interaction strength. Thus, $Z > 0$ for proton excess, $Z < 0$ for electron excess, and $Z = 0$ for neutral matter.

κ simplifies Coulomb's law written in terms of charge numbers Z. Numerically, $\kappa = k_e e^2 = 2.31\times10^{-28}\ \mathrm{N\cdot m^2}$, which is the Coulomb constant expressed in terms of the elementary charge. κ is always positive. The sign of the Coulomb force is determined by the product $Z_1Z_2$. attractive when $Z_1Z_2 < 0$ and repulsive when $Z_1Z_2 > 0$.

The above two laws in the count form are the core laws of the particle count formulation.

### 4. Nucleon-Based Force Law (gravity + electrostatics)

The above nucleon-based gravitation force law and charge-based electrostatics force law are the two core count-based force laws. The total force between two bodies, incorporating both nucleon-based gravitation and charge-based electrostatics, is:

$$\vec{F}_{12} = \left[\mathcal{G}\frac{(\eta_1 N_1)(\eta_2 N_2)}{r^2} + \kappa\frac{Z_1 Z_2}{r^2}\right]\hat{r}$$

where $\hat{r}$ is the unit vector pointing from one body to the other. This compact form unites gravitational and electrostatic interactions on the same footing.

The combined expression provides a compact algebraic representation of the simultaneous gravitational and electrostatic forces, but it should be understood strictly as a mathematical parallelism rather than as a physical unification in the sense of a shared dynamical origin.

## 5. Discussion

The nucleon-count formulation makes the gravitational term parallel in structure to Coulomb's law. By expressing the two in unified, parallel forms, the framework emphasizes the discrete particle basis underlying both mass and charge. Strictly speaking, no fundamentally new physics is introduced—this is essentially a rewrite or re-parametrization of Newton's and Coulomb's. Using nucleon counts (N) and net charges (Z) in place of masses and charges is algebraically equivalent, provided that η correctly accounts for binding and electron contributions. However, although the new formulation does not generate results beyond what we already know and the new form may not be as convenient as the original ones for practical calculations, its conceptual implications are significant. By framing both gravitation and electrostatics as bookkeeping of particle counts, the formulation underscores the discreteness of matter as the common foundation of forces, opening the door to conceptual unification, and offering potential new insights into both cosmology and quantum theory.

### 5.1. Implications for Understanding the Universe

The reformulation of gravitational and electrostatic laws in terms of nucleon and charge counts suggests a deeper discreteness underlying the continuous mathematical forms of Newton and Coulomb. Instead of describing forces as fields acting on smooth masses or charges, one can state simply that:

"The fundamental forces governing the universe can be viewed as nothing more than rules describing how basic particle counts interact across space."

From this perspective, Newton's gravitational law emerges as the bookkeeping of nucleon counts, while Coulomb's law emerges as the bookkeeping of net charge counts (proton excess minus electron excess). Both laws therefore share the same essential structure: forces are determined by the identities and numbers of the basic particles in each body.

This has several consequences:

- **Discrete underpinning of continuity**. The apparently continuous laws of force are in fact emergent averages over enormous numbers of discrete particles. Gravitation is thus not a continuous "mass–mass" attraction, but the aggregate effect of nucleon–nucleon interactions. In this sense, the discreteness of matter becomes the key to understanding the forces that govern the universe. Forces are not external agencies imposed on particles; instead, they may be nothing more than the systematic consequences of how particles are counted and related across space.

- **Coupling Symmetry.** Gravitation couples uniformly to all nucleons, while electrostatics couples only to charge imbalance. The essential difference between the two lies not in the particles themselves, but in the constants (G versus κ) that determine their relative strength. At microscopic scales electrostatics dominates, whereas gravity governs macroscopic and astronomical systems. Viewed through the particle-count framework, both forces reduce to functions of discrete counts, with their distinction emerging as a matter of coupling weights. This mirrors the role of couplings in quantum field theory [3], where parameters such as the fine-structure constant α set interaction strengths and evolve with energy scale under renormalization. In the count-based law, κ and G play the role of weights that translate counts into force—effectively constant at everyday scales, but expected to flow with scale in a deeper microscopic theory. This perspective suggests that unification may not require introducing new entities, but rather reframing known forces as parallel bookkeeping rules applied to the same fundamental building blocks.

- **Same wave speed c** (why EM and gravitational waves [4] share a limit speed). This framework *can* provide a natural way of thinking about why electromagnetic waves and gravitational waves propagate at the same speed. Both Maxwell's equations and Einstein's field equations independently predict wave speed of both Electromagnetic waves Gravitational waves = c. In the particle-count framework, if both gravity and electromagnetism are simply rules describing how basic particle counts interact across space, then: The information about changes in particle configurations (mass distribution for gravity, charge distribution for electromagnetism) must propagate through the same underlying space-time structure, thus the natural limit for propagation speed is the same universal constant c.

Thus, the equality of speed is not an accident, but a consequence of both forces being tied to the same discrete substrate (particle counts) and the same transmission medium (space--time itself). If both bookkeeping rules ride on disturbances in space that cannot outrun information transfer, it is natural that they share the same propagation speed.

This gives a unification-style interpretation: *Electromagnetic waves and gravitational waves both travel at c because they are different "bookkeeping expressions" of the same discrete particle-based universe. The limit speed is not a property of the force itself, but of the underlying space-time medium through which all changes must propagate or all such bookkeeping rules are enforced.*

### 5.2. Connections to Quantum Field Theory

The major challenge of physics has been unifying quantum theory with gravity. This reformulation suggests both are already linked by a shared principle: discrete particle counts. Electromagnetism couples to net charges, gravitation couples to nucleons, but both propagate information at the same speed c. The reformulation is consistent with the discrete source structure emphasized in quantum field theory, but it does not modify QFT dynamics or its field equations. Its role is interpretive rather than predictive. The particle-count reformulation of force laws may also provide a novel perspective on several observations in quantum field theory (QFT). By treating forces as bookkeeping rules applied to discrete particle counts, many quantum phenomena can be understood in new light:

- **Quantization**. In QFT, charges occur only in discrete multiples of e, and nucleons possess nearly identical masses. In the count-based framework, this quantization emerges naturally, since forces depend directly on integer particle counts (N,Z), making discreteness intrinsic to the formulation. The near-constancy of "mass per nucleon" is captured by the correction factor η, defined as the average baryon mass relative to a free neutron. This factor remains close to unity across matter, with only small element-dependent variations arising from nuclear binding, electron contributions, and other energy-related effects such as photons, neutrinos, and pressure.

- **Approximate composition independence.** Because η varies little across elements, gravitational coupling is nearly composition independent, consistent with the equivalence principle [5] at practical levels.

- **Vacuum fluctuations and zero-point energy**. Quantum electrodynamics predicts that the vacuum contains fluctuating fields (virtual pairs, zero-point modes). Within the particle-count view, these fluctuations may be interpreted as local , transient variations in particle-count bookkeeping, consistent with conservation rules. You still use standard QFT machinery to compute them, but conceptually: fields "wiggle" the *effective counts* that sources and detectors feel.

- **Wave–particle duality**. In QFT, particles behave like both localized particles and delocalized waves. QFT treats particles as excitations of fields; amplitudes (waves) spread and interfere. In this framework, discrete particles are the counts, while the wave aspect represents how count-effects propagate through the space-time medium. Duality becomes a natural complementarity of discreteness and propagation. The "mystery" softens: discreteness is in the sources and absorbers, wave-like behavior is in the transmission of their influence.

### 5.3. Broader Applications of the Particle-Count Framework

The particle-count formulation extends far beyond gravity and electromagnetism. As we already know, macroscopic forces—such as gas pressure on a container—along with temperature and entropy, are framed in terms of particle-count statistics, demonstrating that all emergent thermodynamic forces arise from count interactions at small scales.

This approach may also be generalized to other domains, including the following:

a. Nuclear Forces (Strong & Weak Interactions): While it may be too strong a claim now to assert that the strong force is merely bookkeeping of quark–gluon exchanges (effective nucleon clustering) and the weak force is bookkeeping of flavor counts (neutron ↔ proton transformations), the idea is nonetheless natural. It may offer an intuitive way to understand why nuclear forces saturate—acting only at nearest neighbors.

b. Astrophysics & Cosmology: Cosmic microwave background (CMB): Patterns could be reinterpreted as the earliest large-scale bookkeeping imbalances of nucleon/charge counts. However, the observations remain fully within the domain of standard cosmology and are not explained or resolved by the present reformulation.

- Structure formation: Galaxy clustering comes from the simple rule "counts attract counts," scaled to cosmic proportions.

- c. Condensed Matter Physics: Forces in solids (lattice vibrations, bonding energies) could be recast as count-mediated interactions between nucleons and charge imbalances; Superconductivity and collective electron behavior might be framed as synchronized bookkeeping states, where electrons effectively "share" their count information coherently.

- d. Quantum Information & Computation: Since the framework highlights that forces are informational bookkeeping rules, it has resonance with quantum information theory. The propagation of "count information" at speed c parallels the notion that information has a maximum speed (no faster-than-light signaling), which may yield a count-based ontology for quantum states, where qubits represent bookkeeping registers of nucleon/charge states.

- e. Unification of Constants: Right now, physics uses separate constants: $G, k_e, \hbar, c$. In the count framework, many of these constants can be seen as conversion factors that turn discrete counts into force strengths, which may open a path toward rescaling physics into purely dimensionless ratios of counts.

### 6. Generation of Electromagnetic vs. Gravitational Waves

Electromagnetic waves are generated whenever charged particles, such as electrons, accelerate or vibrate. An accelerating charge causes the surrounding electric and magnetic fields to readjust, but because these adjustments cannot occur instantaneously, a disturbance propagates outward at the finite speed c, forming an electromagnetic wave. The lowest multipole that radiates is the dipole, which makes EM radiation relatively strong and common.

By analogy, gravitational waves are generated whenever mass–energy distributions accelerate. In the particle-count framework, this corresponds to the acceleration or vibration of nucleons (and other forms of energy such as electrons and photons). The surrounding curvature of spacetime cannot readjust instantaneously, leading to ripples that propagate outward at speed c. However, because gravity couples universally to all energy and always with the same sign, dipole radiation is forbidden by momentum conservation. The lowest allowed multipole is the quadrupole, making gravitational waves vastly weaker than electromagnetic waves.

Thus, while a vibrating electron in a laboratory can readily generate detectable electromagnetic waves, detectable gravitational waves require astrophysical-scale coherent accelerations of enormous numbers of nucleons, such as in merging black holes or neutron stars. In this way, the particle-count perspective preserves the structural analogy between the two phenomena while naturally explaining the extreme weakness and rarity of gravitational waves.

## 7. Conclusion

Rewriting Newton's and Coulomb's laws in terms of nucleon and charge counts reveals a natural symmetry in their structure. The introduction of a nucleonic gravitational constant G allows gravity to be expressed in the same discrete framework as electrostatics. The nucleon count method summarizes the two most important long-range forces in physics and could lead to new ways of thinking about unification at the microscopic level. It provides intuition, pedagogical clarity, and a heuristic bridge toward unification, highlighting that both gravity and electromagnetism act on discrete inventories (baryon number and net charge) with different coupling weights.

In summary, the framework has the potential to act as a common language for interpreting forces as bookkeeping of discrete counts. The particle-count perspective not only reframes classical force laws but also offers a conceptual bridge to quantum field theory, suggesting that discreteness is the true foundation beneath both classical and quantum descriptions of the universe. QFT's fundamental degrees of freedom are quarks, leptons, and gauge bosons; nucleons are emergent (low-energy) composites, so the particle-count law is an effective description for ordinary matter, not a replacement for the Standard Model or GR, or at least at this moment. It reframes rather than overturns them.

## References

1. Newton I (1687) Philosophiae Naturalis Principia Mathematica. London: Royal Society.

2. Krane KS (1988) Introductory Nuclear Physics. Wiley.

3. Peskin ME, Schroeder DV (1995) An Introduction to Quantum Field Theory. Addison-Wesley.

4. Abbott BP, et al. (2017) (LIGO Scientific Collaboration and Virgo Collaboration). "GW170817: Observation of Gravitational Waves from a Binary Neutron Star Inspiral." Physical Review Letters, 119: 161101.

5. Will CM (1993) Theory and Experiment in Gravitational Physics. Cambridge University Press.

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