Why is Gravity so Weak?

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Abstract

Why is gravity weak? Gravity is plagued with this and many other questions. After decades of exhausting work we do not have a clear answer. In view of this fact it will be shown in the following pages that there are reasons for thinking that gravity is just a composite force consisting of the long-range manifestations of short range nuclear forces that are too tiny to be measured at intermediate or long ranges by particle colliders. My logical theory is consistent with Einstein's mathematical proposal in 1919, expressing his vision beyond general relativity.

1 Introduction

Newtonian gravity encounters issues for microscopic dimensions and cannot explain the nuclear binding force. Experimentalists and string theorists face a yet incomplete task of detecting and incorporating the spin 2 graviton into a fully quantized and renormalized theory. If we use the surface-to-surface separation between these particles to quantify the gravitational attraction instead of the center-to-center separation, at small separations relative to the particle radii the force between these particles grows much larger than classical gravity, and may resolve the above issues. The first step in the road map suggested by Richard Feynman for consistency in our physical theories is to see if Newton's law can be modified to be consistent with Einstein's law and can be further modified to be consistent with the uncertainty principle [1]. "Discovery of deviations from Newton's gravity at any distance scale would revolutionize knowledge of the physical world [2]."

As a conceived consequence of my original concept that the spin of a particle is the cause of the gravitation, if Newtonian gravitation is modified to use surface-to-surface separation between particles, the modified Newtonian gravitation can have the strength of nuclear force between nucleons. This may be justified by possible existence of quantum wormholes in particles. All gravitational interactions would be between coupled wormholes, emitting graviton flux in proportional to particle size, allowing for the point-like treatment above. When the wormholes are 1 Planck length apart, the resultant force is 10^{40} times the normal gravitational strength for nucleons. Since Yukawa was trying to explain attractive nuclear force, pions were assumed to mediate attractive force, now explained as "residual" force mediated by gluons.

2 Modification of the Inverse Square Law

As an example, for two coupled nucleons (Fig. 1a), I chose the Planck length $L = (Gh/c^3)^{0.5}$ as the surface separation, as it is the minimum possible spatial distance that makes any sense in physics. Assuming zero separation distance would imply that the two particles are joined to form one particle, losing their distinctions as separate particles. The diameter of the nucleon is about 1 fm (10^{-15} meters). The Newtonian gravitational force is then

$$F_N = Gm^2/D^2, \tag{1}$$

where D is the center-to-center distance, ~ 1 fm. If we select the surface-to-surface separation instead, the force would become

$$F_P = Gm^2/d^2, \tag{2}$$

with $d = L = 10^{-20}$ fm. The ratio of these two forces is

$$\frac{F_P}{F_N} = \frac{D^2}{d^2} = 10^{40}, \tag{3}$$

which is also the strength of the proposed gravity relative to Newtonian gravity. As the nucleons are separated, D/d shrinks, and F_P rapidly approaches F_N. Mathematically,

$$\lim_{D\to\infty} \frac{D}{d} = 1. \tag{4}$$

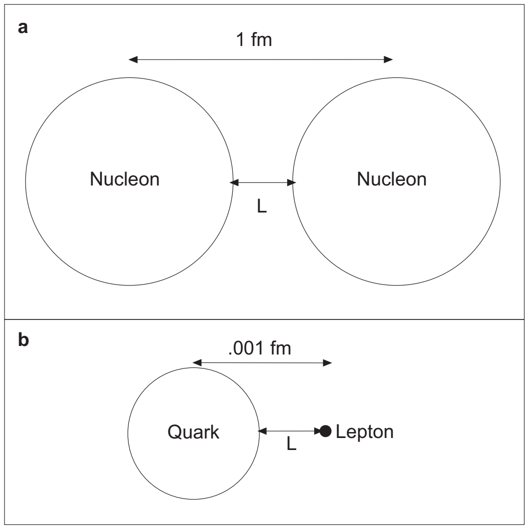

Figure 1: Pictorial view of gravitational interaction showing surface and center separations (not to scale). L is the Planck length, 10^{-20} fm. **a,** Two nucleons at minimum separation; **b,** A quark and a lepton, also at minimum separation. The standard inverse-square law would use the center-to-center distances to calculate the force between the particles; using the surface-to-surface distance yields a much stronger force for these separations, equal to the relative strengths of the strong and weak nuclear forces, respectively.

A similar analysis can be made of the quark-lepton interaction (Fig. 1b).

Nucleons are responsible for over 99 percent of the gravity of an atom, therefore they are the primary focus of this paper. For nucleons, I recover Newtonian gravity at practically 1000 fm. This modification yields a force with high intensity at short range, rapidly falling off to a very low intensity at long range.A plot of the potential shows no discrete drop [3, 4].

"Einstein, in a paper written in 1919, attempted to demonstrate that his gravitational fields play an important role in the structure and stability of elementary particles. His hypothesis was not accepted because of gravity's extreme weakness" [5]. The paper's abstract says: "Neither the Newtonian nor the relativistic theory of gravitation has so far led to any advance in the theory of the constituent of matter. In view of this fact it will be shown in the following pages that there are reasons for thinking that the elementary formations which go to make up the atom are held together by gravitational forces [6]."

While Einstein's attempt is worth mentioning, it is not the foundation of my theory. Einstein could be wrong, but it seems he may not be. "It has been proposed that the gravitational constant inside a hadron is very large, $\sim 10^{38}$ times the Newtonian G" [5]. This "strong gravity" inside the hadron is similar to my proposed modification, but in my modification, instead of needing to change G itself, I change the distance measurement and get the same result. The variation of G is not a necessary condition for deriving the coupling constant per my theory. The short range forces are weakened at long range by a high order of magnitude. This makes other attributes of the short range forces, infinitesimal at long range.

One may question the mathematically simple application of the Planck scale to a problem where the relevant distances seem to be fm. Frank Wilczek has written a series of articles [7], explaining how these scales can be reconciled and has provided responses. While this may seem simplistic, it seems to be mathematically valid, and frequently significant problems can be solved simply in the end, as also illustrated by Morris and Thorne [8]. Complexity in physics lies in the abstraction of simplicity. Classical centers of shapes and therefore surfaces, though used here only for intuitive reasoning are invoked in nuclear coupling constants by implicit comparison to Newtonian gravity and in other descriptions in modern physics. My modification is very consistent and therefore suggestive, however it does not reconcile the fact that nucleons overlap. Thanks are due to Gerald 't Hooft for this comment. Quantum wormholes, as currently theorized, may resolve this issue and give a mathematical foundation to my model. If quantum wormholes do not resolve the issue, we face a challenge to investigate some other verifiable quantum entity to explain this phenomenon.

3 Quantum Wormhole Connection

I postulate that each nucleon has a quantum mouth, potentially matching the mouth of a quantum wormhole. The existence of quantum wormholes was examined by Visser [9]. The wormhole's mouth then represents the entire mass of the particle and propagates its $1/r$ potential to the rest of the universe. All gravitational interactions become interactions between these wormholes. Radiation by nucleons would consist of energy being emitted by the mouth of the wormhole. This would justify a quantum source of gravity. The mouth emitting the gravitational radiations does not have to be at the surface, allowing the nucleons to overlap. This may sound like a radical approach, but it is not. The direction of my proposal coincides with that in the particle related article by Einstein and Rosen entitled "The Particle Problem in the General Theory of Relativity", introducing what is now known as Einstein–Rosen bridges [10]. The abundance of Planck-length size wormholes required could have evolved from perturbations in the initial big-bang density.

Stable wormholes require "exotic", negative energy matter. "... it is not possible to rule out the existence of such material; and quantum field theory gives tantalizing hints that such material might, if fact, be possible [8]." The stability of wormholes is on firmer grounds now. "...the theoretical analysis of Lorentzian wormholes is "merely" an extension of *known physics*-no new physical principle or fundamentally new physical theories are involved [11]." Literature search reveals no detection of any central force within nucleons, raising a question about the existence of gravitons within nucleons. Fig. 2 shows the mental picture of the graviton flux from nucleons with some background data. Richard Feynman seems to have investigated transfusion of two particles into gravitons [12], but not in this context. There is a sense in which two bosons make a boson [13]. One may question the hypothetical graviton or gluon. Since all bosons can occupy the same state, my theory is not challenged by that question. The exclusion principle allows all bosons to occupy the same state. The quantum mouths of the wormhole may not occupy the same state consistent with the exclusion principle. As two fermions approach each other nature must intervene to keep them from occupying the same state. The structure of the quantum space-time is *foamy* [14]. The potential conversion of two gluons into one graviton and vice versa would be debatable. However, such *foamy* structure may give a green light for some other form of a particle mechanism. There have been cause-relations between wormholes and coupling constants proposed in the past as in the paper titled, "Do Wormholes fix the Constants of Nature?" by S. Hawking[15]. My picture is equivalent to the classical picture of an accretion disc drawing the energy out of a black hole and ejecting a relativistic jet of energy in all directions from the center of the accretion disc.

Some long range forces are potentially simple, cumulative long range manifestations of their short range counter parts and vice versa with their intermediate range immeasurable by microscopic or macroscopic means. My

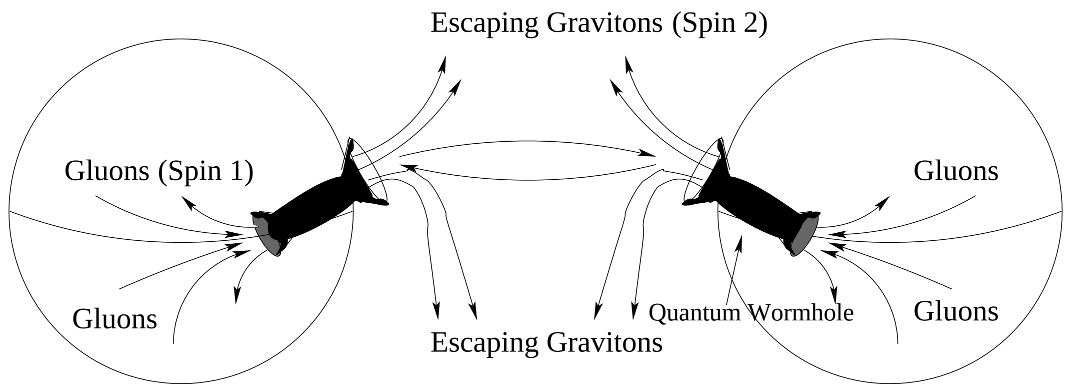

Figure 2: Mental image of nuclear interactions via quantum wormholes. The graviton flux would be proportional to the mass of the interacting particle, yielding couplings of 10^{40} for nucleons and 10^{34} for lighter quark-lepton pairs.

modification showing the strong gravity as a function of D^2 instead of particle mass (logical function of D^3) is consistent with the holographic principle. As long as the observable characteristics of the proposed wormholes are stable, their stability and types are of secondary importance because the coupling constants are averages of observations. The understanding of the coupling constants lies at the heart of our understanding other important issues. "Using the concept of strong gravity, one can show the stability and structure of elementary particles, which could not be achieved by weak gravity" [5]. The sudden decrease in nuclear potential near the surfaces of nucleons may be a result of pion intervention pushing the nucleons apart as needed to stabilize the nucleus against the potential collapse by strong gravity. Pions may not be pulling the nucleons together as originally theorized, they may be pushing them apart. Since pions are observed to be spin-zero and their range matches the size of nuclei, this possibility cannot be ruled out. The following paragraph in recent publication by B. A. Robson [16] gives a historical perceptive on this issue.

"In 1954 Yang and Mills, and Shaw attempted to model a field theory of the strong interaction along the same lines as the U(1) gauge theory of the electromagnetic field by introducing the concept of a non-Abelian strong isospin SU(2) gauge theory. In this approach, gauge invariance required the introduction of an isospin triplet (W^+, W^0, W^-) of vector bosons, which were analogues of the photon in electromagnetic theory. On the other hand, these gauge bosons, unlike the photon, were self-interacting, leading to a non-linear field equations and considerable complexity. However gauge invariance required the gauge bosons, like the photons, to be massless, in contradiction with Yukawa's meson theory and the known short-range nature of the strong interaction. In hindsight, this approach failed because the nuclear strong interaction associated with the strong isospin symmetry of pions and nucleons is not a fundamental interaction arising from an SU(2) gauge theory. In the SM, this interaction is now regarded as a "residual" interaction of the strong color force, responsible for binding quarks in hadrons. This latter force is described in terms of a local gauge involving massless gluons."

The fifth force is a force in addition to Newtonian gravity noticeable at small distances. My modification explains at least some of the additional force without having to consider it as a fifth force.

4 Potential Consistencies

4.1 Mach Principle

I have shown the consequences of my original concept that the cause of gravitation is the spin of the particles. The particles see the entire universe spinning in their reference frames. The relative spin of the particles in the reference frame of the universe and vice versa is the potential cause of gravitation. Mach principle implies that the universe spinning in the reference frame of the nucleons is the cause of gravitation. However, two neutrons do not form a binding system as do a neutron and a proton. This may be due to the difference in the spin characteristics of neutrons and protons. The nucleons with the same spin characteristics may not bind.

4.2 Analogy

Einstein compared the curvature of a mattress created by a football placed on top of the mattress to the curvature of space-time. A thought experiment would reveal that the curvature of the bed created by a steel ball of the same weight will have steeper slope in the vicinity of the steel ball as shown in fig 3. This can be qualitatively explained by the fact that the density of steel is higher than the average density of football material. The density of neutron

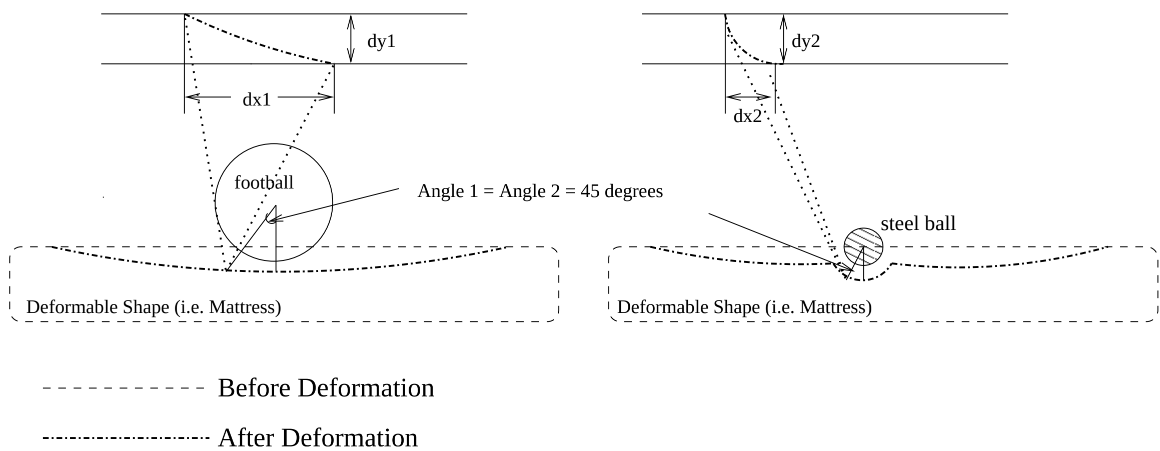

Figure 3: Depiction of Einstein's analogy. The slopes, $\frac{dy_1}{dx_1} \ll \frac{dy_2}{dx_2}$ and the densities of the steel (ρ_s) and the football (ρ_b) are related as follows, $\rho_s \gg \rho_b$. Likewise the analogy extends to my theory and the neutron density (ρ_n) is $>$ the density of the neutron star ($\rho_n s$).

is higher than that of a neutron star. Therefore, the steepness expressed in terms of the slope (dy/dx) for a neutron near its vicinity would be higher than that for a neutron star, qualitatively consistent with my theory that the gravity is stronger near the neutron compared to that near the neutron star.

Connecting neutrons to neutron stars maybe an intermediate step to our quest to understand the connection between quarks and the cosmos implicit in ref [2].

4.3 Double Slit Experiment

Per my theory, in a two-slit experiment (Fig. 4), the network of geodesics downstream of the slits would depend upon whether both slits are open or only one of them is open, not upon the number of slits used for shooting the photons at the same time. The shortest line implied by a geodesic is along curved space-time. My introduction of "strong gravity" at the edge of the slit impacts the curved space-time downstream of the slits and the entire network of geodesics. It does not matter whether the experiment shoots the photons through one slit or both. The screen pattern is a function of the network of geodesics.

4.4 The Uncertainty Principle

We are the "observers" and the particles are the "observed". The quantum wormholes lie between the two with their attributes of quantum time and quantum energy, potentially impacting the information passing through. It is amazing that the product of these attributes yields the uncertainty principle as shown below.

$$\Delta E = (10^{19}GeV \times 10^{9}eV/GeV)/(1.6 \times 10^{19}eV/J) = 0.6 \times 10^{9}J \tag{5}$$

$$\Delta t = 10^{-43}s \tag{6}$$

Multiplying the above equations

$$\Delta E \times \Delta t = 0.6 \times 10^{19}J \times 10^{-43}s = 0.6 \times 10^{-34} \cdot s. \tag{7}$$

This yields Heisenberg's Uncertainty, which is

$$\Delta E \times \Delta t \geq 0.5 \times 10^{-34}J \cdot s \simeq \hbar/2 \tag{8}$$

It is difficult to understand the mechanics behind this coincidence.

In my theory, I do not have to express the range of nuclear force as "short" with an unanswered question as to *precisely* how short. The difference between the two large dynamic numbers of proposed strong gravity and the proposed repulsive Yukawa force may be responsible for the observed short range, short enough to fix the size of the nucleus.

The values of a field and its rate of change with time are like the position and velocity of a particle. This modification meets the uncertainty principle requirement that the field can never be measured to be precisely zero. The sudden drop in potential at the edge of nucleons may be due to pion intervention and other complex phenomena.

4.5 The Early Universe

If God created the universe from nothing, my theory shows that mass energy on one side of the throat of the quantum wormhole is equal to the gravitational field energy on the other side of its throat, both canceling each other.

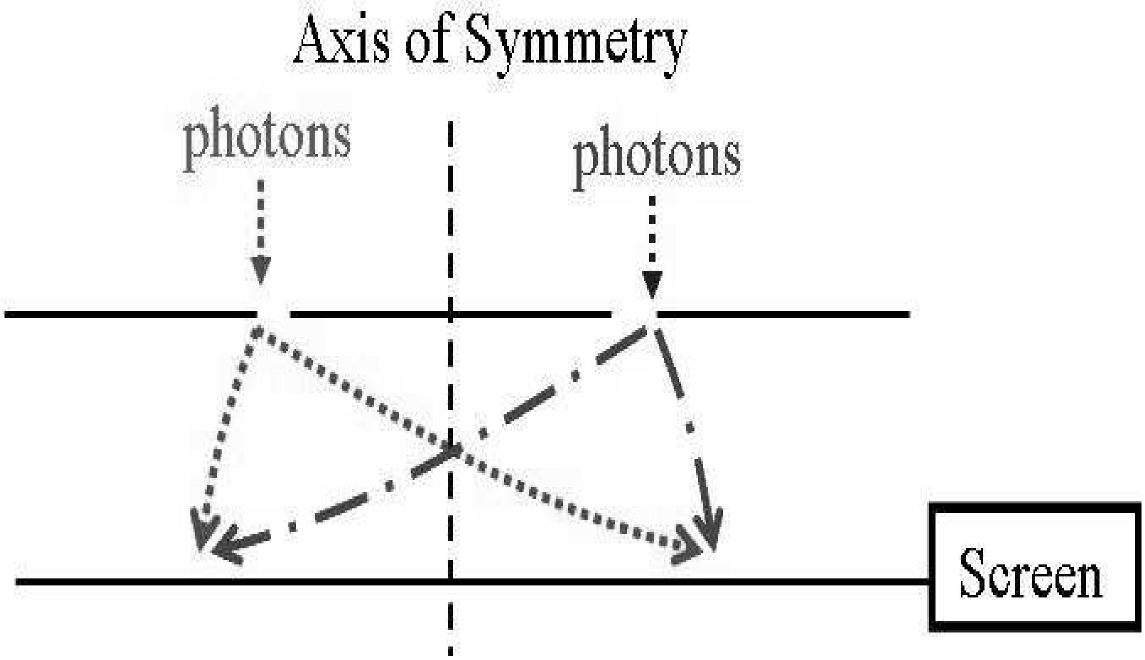

Figure 4: Depiction of double slit experiment. As shown, the screen pattern is independent of whether the left, right, or both slits are used, as long as the slits are open.

This would imply that the gravitational field is negative energy considering that mass is positive energy. This is consistent with inflationary universe, no matter how big is the universe. “There is nothing known that places any limit on the amount of inflation that can occur while the total energy remains exactly zero [17].” My paper does not explain the observations of quark confinement, their asymptotic freedom and infrared slavery. It need not. These observations are results of gluon interactions. My theory deals with the tensor field alone and stops at the mouth of the quantum wormhole.

There is a coincidence that estimated number of gluons (about a billion) per nucleon is the same as the estimated number of photons per nucleon. Despite difference between their energies, this potential one-to-one relationship is noteworthy in light of the facts that (1) the energy difference may be explained in terms of violation of null energy condition and (2) the photon is speculated as a potential mediator of gravity by some scientists, trying to reconcile repulsive gravity implicit in the expanding universe.

4.6 Renormalization

“If gravitational constant is taken as Newtonian gravitational constant G_N, in case of hadrons these two limits are vastly different. If a condition is imposed that these two limits are equivalent in the hadronic domain, then $G = G_f = 1/2m^2_{proton} \sim 1 = 10^{38}G_N$. This condition is also equivalent to quantization of the gravitational charge $m\sqrt{G_f}$ which gives $\frac{Gm^2}{\hbar_e} = 1$ (in natural units $m\sqrt{G_f} = 1$). This relation also gives the value of $G_f = 10^{38}G_N$ for m to be a typical mass of hadron (proton). It is amazing that the value of strong coupling constant is obtained in a natural way. This shows that, inside a hadron, gravitational constant acquires a large value leading to a strong gravity. The corresponding Planck mass for strong gravity will be $(G_f)^{-1/2} = (10^{38}G_N)^{-1/2} = 1$ (as $G_N =$ (Planck mass)$^{-2}$ in natural units).

The field equations for this theory are derived from the action

$$S_{f-g} = \int d^4x \left[\frac{\sqrt{-f}}{2\kappa_f} R(f) + \frac{1}{2\kappa_g}\sqrt{-g}R(g) + I(fg) \right], \tag{9}$$

where $R(f)$ is the Ricci scalar curvature with the metric component, $f_{\mu\nu}$ such that the infinitesimal distance $ds^2_f = f_{\mu\nu}dx^\mu dx^\nu$ which is analogous to the atomic metric used by Dirac, $R(g)$ is the usual Ricci scalar obtained by the usual metric $g_{\mu\nu}(ds^2 = g_{\mu\nu}dx^\mu dx^\nu)$ used in non-Euclidean geometry, $I(fg)$ is the interaction term, $\kappa_f = 16\pi G_f$ and $\kappa_g = 16piG_N$. f ... is the determinant of the matrix $f_{\mu\nu}$ as $g = det|g_{\mu\nu}|$.”

The above quotation comes from reference [5], which clarifies a renormalization problem with the proposal described in the quotation. My theory removes the need to renormalize gravity, since the value of “r” is never zero. The minimum value of “r” is the Planck length.

5 Prediction

My modification provides a consistent, intuitive and simplistic, but mathematical explanation of the observed relative values of coupling constants, something no other theory has done. If a theory explains observations, it need not predict. Experimentally, my theory may be explored by a careful examination of the nuclear force at distances above 10 fm. My theory predicts that the measured range of the nuclear forces will keep on increasing as the accuracy of measurement keeps on increasing. It is possible that the relationship between the weak nuclear force and electromagnetic force is analogous to the relationship between the strong force and gravitation more clearly presented here. Recently published test results verified the gravitational inverse square law down to 218μm [18]. The test results do not verify the higher dimensional theories that motivated the test, but they are not in conflict with my theory, as at these separations my modified force should be indistinguishable from Newtonian gravity. The generalized equation in the predicts a string coupling constant of $(10^{-35})^2 = 10^{-70}$ [13].

If the predictions are known, they do not defy the theory if they can be explained as consequences of the theory proposed. Pions are believed to cause attractive nuclear force. All fermions may be wormholes with quantum mouths communicating with the rest of the universe. My theory gives a reason to think that pions may be creating a repulsive force instead of attractive force. Yukawa was looking for the explanation of force believed to be attractive. Quantitatively, Yukawa coupling does not explain the observations of strong coupling. The assumption of gravity as a separate fundamental interaction is questionable.

Since the spin dependent nuclear forces could be attractive as well as repulsive, the gravity must contain a small repulsive component at microscopic scale. Combining this with observations of expanding universe results into a significant possibility that gravity is not ideally attractive throughout its entire range.

The assumption that gravity is fundamental interaction should be revisited, considering that almost a century of work and associated expenses cannot unify gravity. This paper shows the opposite. My theory consistent with the views of Einstein [20] and Rutherford [21], the giants associated with gravity and nuclear force respectively, should not be considered an alternate theory. Some health related biological issues potentially involving the cause of cancer maybe better understood with an open mind to revisit the basis of the prevailing views. The strong gravity at the around the nuclei of galactic dust and gas may cause gravitational lansing effect, partially contributing to the estimation of dark matter. On the horizon I see that my theory potentially throws light on many such issues, obligatory to fundamental physics.

6 Conclusion

In summary, in the early part of last century, when the nuclear force was declared to be a separate force, the Planck length and its implications were not well understood. Planck's system of fundamental units was considered heretical until came the proposal by Peres and Rosen [19]. The weakness of gravity was unquestioned. Therefore, it was impossible to explain strong gravity force in terms of Newtonian gravity and Einstein's view was undermined. I have explained why gravity is weak at long range and also raised a question: Is it weak at short range? Conceptual methods can now be used to grasp the strong side of gravity proposed mathematically by Einstein in 1919. In light of my article this issue needs to be revisited. My consistent results show that strong gravity creates an illusion of a different force between nucleons. Mathematically, the strong force coupling constant $C_s = D^2$, where D = nucleon diameter in Planck lengths.

7 Acknowledgements

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