The effect of particle creation on space

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Abstract. General Relativity and Quantum Mechanics have been successful at describing
their respective realms, but the two theories remain disjoint. We finesse this difficulty with a
classical model of the Universe that unites gravitational, nuclear and electromagnetic forces.
This model is derived by examining the nucleus and its atomic quanta. Newton’s Law of
Gravitation evolves into a formula for the gravitational field within an atom’s quantum layers
which has the form of Hooke’s Law for the potential energy of a spring. The inward force—
a reaction to the strain caused by introducing two particles into the space—drives particles
towards each other. Gravity is not a mysterious attractive force acting at a distance with no
mechanism, but a force acting locally with a well-defined mechanism. The force on the nucleons
from the spring stress in the nucleus provides a physical basis for the strong and weak forces
of quantum mechanics. The Fundamental Law of Nature gives the relationship between the
strong force stress on space, gravity and the wavelength of a photon. The new paradigm offers
an alternative to the Standard Model that is easy to integrate with gravitation.

1. Introduction
We present a new model of the physical Universe. The observations of atomic behavior are
presently modeled by Quantum Mechanics. The observations of very large bodies in space are
modeled by General Relativity. Both of these models have been successful at predicting observed
phenomena in their respective domains. But they remain intractably separate theories.

The attempt to knit together diverse mathematical models built to describe what appear
at the outset unrelated physical phenomena is understandably fraught with difficulty. Our
admittedly radical approach is to finesse the problem by presenting a single physical model for
gravitational and nuclear forces. Building unified mathematical models on top of this unified
physical model should then be easier.

How can a return to a physical model be a radical solution in physics? Isn’t physics, after
all, about physical reality? Yes, but Quantum Mechanics was founded on the assumption that
classical physical laws do not apply on the subatomic scale. Suggesting at this point that an
answer to the logjam in physics might be to utilize classical laws to explore subatomic physical
reality is swimming against a tide running strongly in the opposite direction for 90 years.

2. Results
2.1. Quantum law of gravitation
Newton presented his Law of Universal Gravitation in 1687, where the force of gravity \( G F \) is
given by

\[
G F = G \frac{m_1 m_2}{r^2}
\]
where $m_1$ and $m_2$ are the masses of two objects, $r$ is the separation of their centres, and $G$ is the Gravitational Constant, not measured until 71 years after Newton’s death. Until now $G$ has only been known by measurement. We show how $G$ relates to other physical constants.

Newton’s Law of Gravitation shows the force of gravity is dependent on two masses. We isolate a single mass by considering its gravitational field $\mathcal{G}U$ at distance $r$ from the centre of its mass $m$:

$$\mathcal{G}U = G\frac{m}{r^2}$$  \hspace{1cm} (2)

This expression has units m/s$^2$, and is the acceleration imparted towards mass $m$ on another object in its gravitational field. (We use italics for variables like mass ($m$) and normal case for units like meters (m).) Equation (2) implies that the gravitational field extends indefinitely from the object across the Universe.

**Figure 1. Bohr model of an atom.** This figure illustrates the first 8 quantum levels. (a) Quantum level 8; (b) Quantum layer 8. Drawn to scale: radius of each quantum level is proportional to the square of its quantum number. Nucleus is $10^4$ or $10^5$ times smaller than quantum level 1, depending on the element. The Bohr model was introduced in 1913. Since replaced by more accurate models, it’s simplicity and clarity still make it a useful starting place for a new model of atomic phenomena.

**Figure 2. Particle creation.** (a) Atomic nucleus. (b) Quantum level 1. (c) Quantum layer 1. (d) Stress of introducing nucleus into space causes strain in quantum layer 1: it acts like a spherical, double-ended, compressed spring. (e) Stress transmitted to quantum layer 2 in proportion to surface area of quantum level 1. This sets the stage for—but does not itself induce—gravitation. A second particle is required to interact with this one before gravitation arises. (Not drawn to scale.)

Figure 1. illustrates the Bohr model of the atom, in which electrons circulate around the nucleus in disjoint, spherical shells. The quantum levels of an atom do not stop with the level of an outmost trapped electron, but instead extend throughout space. In our model we imagine that each elementary particle or nuclear group thereof has such quantum levels.

Applying (2) to an atom with $A$ nucleons at distance of quantum level $n$, $n$ an integer $> 0$, gives
\[ A_{G}U_{n} = G \frac{A_{m}}{r_{n}^{2}} \] (3)

where \( A_{m} \) is the mass of the nucleus, \( r_{n} \) is the distance of the \( n \)th quantum level from the centre of the nucleus and \( G \) is the gravitational constant introduced by (1). An important implication of (3) is the consistency of the gravitational field throughout each quantum layer (Figure 1(b).) This is at root our notion of quantum gravity.

We start with the formula for the radius of the \( n \)th quantum of the nucleus with \( A \) nucleons,

\[ A_{r_{n}} = A_{r_{1}}n^{2} \] (4)

where \( A_{r_{1}} \) is the radius of the first quantum level. (Constants like \( 1_{r_{1}} \) are listed in Table 1.)

| Symbol | Value          | Units     | Meaning                                      |
|--------|----------------|-----------|----------------------------------------------|
| \( G \) | \( 6.93 \times 10^{-11} \) | m\(^3\)/kg\cdot s\(^2\) | Gravitational constant [4]                   |
| \( 1_{r_{1}} \) | \( 5.29 \times 10^{-11} \) | m         | Radius quantum level 1 of \(^{1}\)H[5]       |
| \( m_{p} \) | \( 1.67 \times 10^{-27} \) | kg        | Mass of proton [2]                           |
| \( 1_{\Omega} \) | \( 8.00 \times 10^{-17} \) | kg/m      | Quantum gravitational constant (8)           |
| \( 1_{r_{0}} \) | \( 1.58 \times 10^{-15} \) | m         | Radius of \(^{1}\)H nucleus[5]               |
| \( r_{p} \) | \( 0.875 \times 10^{-15} \) | m         | Radius of a proton[2]                        |
| \( \Omega \) | \( 8.00 \times 10^{-17} \) | kg/m      | Hardness of space (26)                       |

\[ A_{G}U_{n} = G \frac{A_{m}}{A_{r_{1}}^{2}n^{4}} \] (5)

We notice that \( A_{m} \) is just \( A_{m_{p}} \) where \( m_{p} \) is the mass of the proton. (The proton and the neutron have almost exactly the same mass, so for simplicity we will treat them as equivalent here.) This and (4) permit us to write (3) as

\[ A_{G}U_{n} = \frac{Gm_{p}A}{A_{r_{1}}^{2}n^{4}} \] (6)

To improve our understanding and simplify this expression we define

\[ A_{x_{n}}^{2} = \frac{A}{n^{3}} \] (7)

and define \( A_{\Omega} \) (using aleph, the first letter of the Hebrew alphabet) as

\[ A_{\Omega} = \frac{2Gm_{p}}{A_{r_{1}}^{2}} \] (8)

which enables us to express (6) as

\[ A_{G}U_{n} = \frac{1}{2} A_{\Omega} A_{x_{n}}^{2} \] (9)
This has the same form as the potential energy of a spring as given by Hooke’s Law: $A^\infty$ is the spring constant, and $A^x^2$ is the strain on (i.e. compression of) the spring. So (3)—the gravitational field of the nucleus of an element with $A$ nucleons at quantum level $n$—is analogous to the potential energy of an elastic spring at quantum level $n$ with spring constant $A^\infty$ and displacement $A^x^2$. But $\partial U^\infty$ is not potential energy: it has units of acceleration. This is because unlike a normal spring, gravity accelerates all objects at the same rate.

We turn our attention first to understanding $A^x^2$ better. As an acceleration $A^G$ has units of $m/s^2$, and all the units are in $A^\infty$. This is expected since deformation of springs is usually expressed as a unit-less ratio.

Now we need the usual model of the radius $A^r_0$ of the atomic nucleus of an element with $A$ nucleons[1] (adopting a convention that quantum level “0” is the edge of the nucleus):

$$A^r_0 = r_0 A^1$$  \hspace{1cm} (10)

This heuristic together with (4) yields an expression for the displacement of the “gravitational spring”:

$$A^x^2_n = \frac{A^S_1}{A^S_n} \frac{A^V_0}{V_0}$$  \hspace{1cm} (11)

The displacement of the “gravitational spring” in the nth quantum level depends inversely on the ratio of the surface area of the nth quantum level to the surface area of the first quantum level, and directly on the ratio of the volume of the nucleus of an element with $A$ nucleons to the volume of the $^1$Hydrogen nucleus. As the product of two ratios, it is without dimension. Strain is determined entirely by the geometry of the atom and its quanta.

This observation has implications on the nature of space itself. Our understanding of space is growing. We know the speed of light in space depends on the permittivity and permeability of space; just as does the speed of light in water or glass depend on those characteristics of those materials. Furthermore the conclusion of Einstein’s General Theory of Relativity—that space is curved in the presence of a gravitational mass—also implies that space is more than a totally empty void cavity.

One way to interpret the direct dependence of displacement $A^x^2$ upon the volume of the nucleus is that when an element is created, it does not replace space: it displaces the space that it now occupies. This is analogous to the insertion of a ball bearing (the nucleus) into a foam rubber block (the Universe.) But this analogy only goes so far. For one thing our model assumes the Universe, from the viewpoint of a nucleus, is divided into quantum levels, whereas in the foam rubber block compression is continuous.

Think of the insertion of the nucleus into the Universe as creating a pressure outward on the space within the first quantum layer (Figure 2(d.).) This pressure is distributed equally around the surface of the nucleus. Using the spring analogy, space is “compressed”. Think of this space as staying inside the quantum level, but being placed under stress by the strain of insertion. This stress creates an outward pressure on the quantum level 1, distributed around the surface area of the quantum, just as a compressed spring applies equal pressure to both ends. The pressure is the same at every quantum level, so as the surface area increases, the force applied to each surface decreases in proportion. Thus the pressure is the same on the inner surface and the outer surface of each quantum layer. The pressure exerted outward at quantum level 1 induces a stress on the 2nd quantum layer. And so on throughout the Universe.

This model asserts that gravitational acceleration is a side effect of the strain on space. A more elaborate model of this effect will be discussed when we have characterized a few more details about the nucleus.
Now let $A = 1$ and $n = 1$, the first quantum level of $^1\text{H}$. In this case we see the gravitational acceleration at the first quantum of $^1\text{H}$ is $1/2 \ ^1\aleph$. The spring constant $^1\aleph$ is easy to evaluate from the Table 1:

$$^1\aleph = 8.00 \times 10^{-17}$$

Combining (7) and (9) gives a “quantum law of gravitation”:

$$^A_GU_n = \frac{1}{2} \ ^A\aleph \frac{A}{n^4}$$

The quantum law of gravitation replicates applying Newton’s Law of Gravitation to the nucleus of an atom.

2.2. The fundamental law of nuclear gravitation

We want to look more closely at the insertion of a particle into space and the effect it has on the Universe. Consider formation of a single proton.

The energy necessary to create the proton is 938 MeV, but the energy needed to create its components, two up quarks and a down quark, amounts to only about 10 MeV [2]. By our model the remaining 928 MeV is used to set the gravitational spring. This is placed into the volume of the proton; dividing the former by the latter gives the pressure from the proton to the gravitational spring, i.e. between the proton and the inner surface of the roughly spherical shell surrounding it (Figure 3(d).) This pressure in N/m$^2$ is

$$^1P = \frac{1E}{1V_p} = 5.30 \times 10^{34}$$

where $^1P$ is the pressure the proton is putting on the space between itself and the inner edge of the nucleus, $^1E$ is the formation energy left over after quark formation in Nm, and $^1V_p$ is the volume of the proton. This is distributed around the surface of the proton (Figure 3(e).) The equal and opposite force on the proton (in Newtons, Figure 3(g)) is the pressure times the surface area:

$$^1S_{Fp} = ^1P \ ^1S_p = 5.10 \times 10^5$$

where $^1S_p$ is the surface area of the proton. $^A_SF_p$ is equivalent to what in the Standard Model is called the strong force holding the quarks together inside the proton. As we generalize to multiple particle nuclei $^A_SF_p$ becomes equivalent to the residual strong force, holding nucleons together in the nucleus. In our model this is equal and opposite to the stress force placed on the inner edge of the nucleus: our single compressive force performs both functions.

Neutrons outside a nucleus normally decay into a proton and electron (and an anti-neutrino) in 14 minutes and 46 seconds [2]. But deuterium, $^2\text{H}$, is stable with one neutron and one proton in the nucleus. This nucleus has the shape of a capsule (roughly two hemispheres joined by a cylinder). Using this surface area gives $^2SF_p = 6.11 \times 10^5$ N, or about 20% higher than for the single proton (15). This we reason is more than enough extra force to hold the neutron together, whereas subject only to the pressure of (15) on its own, the neutron decays.

This is a strong force indeed: the opposing force of two positively charged protons in the spherical nucleus of $^4\text{Helium}$ is only 75.3N, and the strong force $^4SF_p$ on the $^4\text{He}$ nucleons is $9.46 \times 10^5$N. This is 1.86 times (15), because 4 times the energy and 4.64 times the surface area are divided by only 10.0 times the roughly tetrahedral volume.

By definition the formation energy the strong force of the gravitational spring is enough to hold the quarks together inside protons and neutrons. Holding the protons together against their opposing positive charges is then a small matter by comparison. According to our model the
strong force of the Standard Model now has a physical basis: the force of setting the gravitational spring within the nucleus.

The strong force in the case of a nucleus with \( A \) nucleons is

\[
\frac{A}{S} F_p = A P A S_p
\]  

Applying (14) to the element with \( A \) nucleons, where \( A E = A^1 E \) gives us

\[
\frac{A}{S} F_p = \frac{A^1 E}{A V_p} A S_p
\]  

Expanding the volume and surface area in terms of the radius \( A r_p \) and canceling, (17) reduces to

\[
\frac{A}{S} F_p = 3 \frac{A^1 E}{A r_p}
\]  

As the nucleon count rises, the strong force initially increases rapidly, but then tapers off. Our model would suggest that there will be a point where the incremental strong force would be insufficient to hold the nucleus together, and radioactive decay ensues. In contrast the Standard Model tells us the residual strong force retains particles in the nucleus. Beta radioactivity due to decay of a neutron in the nucleus is then due to the weak force. But our model argues that
the compressive force of space is the only force we need consider, and that the weak force of quantum mechanics is really the stress on space becoming too weak to do its job.

The strong force is transmitted to the edge of the nucleus in inverse proportion to its surface area:

\[ \mathcal{A}F_n = \mathcal{A}F_0 \frac{A_{S_p}}{A_{S_0}} \]  

(19)

which likewise applies to the \( n^{th} \) quantum level

\[ \mathcal{A}F_n = \mathcal{A}F_0 \frac{A_{S_0}}{A_{S_n}} \]  

(20)

Substituting Eqs.(19), then (18) and finally (3) rewards us with

\[ \mathcal{A}F_n = \frac{3}{2}E \frac{A_{r_p} A}{n^4} \]  

(21)

Restating (9) using (8)

\[ A_{GU_n} = \frac{1}{2} A_{\Omega} \frac{A}{n^4} = \frac{1}{2} \frac{2Gm_p}{A_{r_p}^2} \frac{A}{n^4} \]  

(22)

The ratio of Eqs.(21) and (22) is

\[ \frac{\mathcal{A}F_n}{A_{GU_n}} = \frac{3}{2}E \frac{A_{r_p}}{Gm_p} \]  

(23)

Applying the approximation from Special Relativity

\[ 1E = m_p c^2 \]  

(24)

we obtain

\[ \frac{\mathcal{A}F_n}{A_{GU_n}} = \frac{3A_{r_p} c^2}{G} \]  

(25)

To distill this relationship let us define the “hardness of space”, \( \Omega \), as the constant

\[ \Omega = \frac{3c^2}{G} \]  

(26)

Then (25) becomes the “fundamental law of nuclear gravitation”:

\[ \mathcal{A}F_n = \frac{\Omega A_{r_p} A_{GU_n}}{G} \]  

(27)

where in kg/m

\[ \Omega = 4.30 \times 10^{27} \]  

(28)

(27) is an expression for the amount of force (originating from the strong force radiating outward) that must be applied to the \( n^{th} \) quantum level to create a unit gravitational acceleration. The quantity \( \Omega A_{r_p} \) is on order of \( 10^{13} \) kg.

Notice that \( A_{r_p} \) is the absolute displacement of the spring. The geometry of the initial condition of the insertion of the mass into space has a fundamental effect on all the outgoing quanta. This is an unexpected geometrical component of more massive objects having a stronger
gravitational field, and complements our hypothesis that space is strained by the insertion of a particle.

The only non-zero eigenvalue of the Cauchy stress tensor is (21), and of the strain tensor is

\[ A\epsilon_n = \frac{A\sigma_n}{A\tau_n} \]  

(29)

The non-zero term of the coefficient of elasticity tensor is the quotient of the strain and the stress:

\[ A\epsilon_n = \frac{3}{1} \frac{E A}{\frac{A\epsilon_n}{n^2}} \]  

(30)

Let us return now to the assertion that gravitation is a side effect of the strain placed on space by insertion of the particle. At first it might seem gravity is simply the effect of the compressive forces in the displaced quantum layers, but that neglects the equal and opposite force of the stress on space at each quantum level. Based on force alone, everything is in equilibrium, and there is no reason for particles to move towards rather than away from one another: the forces at the two ends of a spring—and at each quantum level—are equal and opposite, consistent with Newton’s Third Law. But then, what causes gravitational acceleration?

Consider the two particles in the nucleus of \(^{2}\text{H}\) (deuterium): a proton and a neutron. The nuclear boundary forms a capsule shape around the two particles (analogous to the roughly spherical shell at Figure 3(d) for a single particle). What about the first quantum level? Due to its distance from the nucleus we think of it as a single shell rather than two overlapping shells. Whether this is true or not, certainly there is some quantum level far from the nucleus where we can assume the quantum levels are coincident. Imagine forcing these two particles apart. The nuclear capsule starts to collapse, and finally snaps into the form of two separate particles. To do this one must overcome the inward force of the spring, \(\frac{2}{3}F_p\). But the outer coincident quantum levels are still acting like a capsule-shaped spring and must be forced apart just like the nuclear capsule, albeit at much lower resistance. Gravitation results from the lower energy state achieved as quantum levels of the two particles become aligned; lower, because a capsule has less surface area than the two separate spheres, permitting less force to sustain greater pressure (Figure 4). Kinetic energy is released in the form of acceleration as the alignment is achieved, and is required to undo the alignment. By this model the infinite quantum levels of at least two particles are required to create acceleration due to gravity.

Reversing (26) gives us an elegant expression for Newton’s gravitational constant, G:

\[ G = \frac{3\pi^2}{12} \]  

(31)

2.3. The Fundamental Law of Nature

We turn our attention to that other quantum phenomenon: the production of a photon as an electron transitions down a quantum level. The wavelength of the light emitted is related to the change (\(\Delta\)) in energy required for the transition:

\[ \Delta\nu = \Delta\frac{1}{\lambda} = \frac{\Delta E}{hc} = \frac{R_M Z^2}{hc} \left( \frac{1}{n^2} - \frac{1}{(n-1)^2} \right) \]  

(32)

where \(\nu\) is frequency, \(\lambda\) is wavelength, \(h\) is the Planck Constant, \(c\) is the speed of light in a vacuum, and \(R_M\) is Rydberg’s constant for hydrogen-like (i.e. single electron) atoms of atomic mass \(M\) with \(Z\) nuclear protons[3].

Our model suggests the stress on space within quantum layers is applying a force on electrons that is keeping them in their quantum levels. An indication that this may be the case is the
way electrons are repelled from the heavily compressed space in the nucleus between the proton and quantum level 0 (Figure 3(d).) In fact it seems likely that permittivity and/or permeability are increased as a result of the strain. Call the resulting force on the electron the “quantum force”. As an outward force it would have to overcome the Coulomb force of the nuclear protons attracting the electron, and the gravitational force between the electron and the nucleus. As an inward force it would have to retain the electron in its quantum level until it had enough energy to get to a higher level, and suppress radiation from the moving electron.

The energy change from quantum level \( n \) to quantum level \( n - 1 \) would be the sum of these forces times the distance between the levels (assuming the electron follows a path in line with the centre of the nucleus):

\[
\Delta E = (\frac{Z \cdot Q}{Q} F_n + \frac{Z}{C} F_n + m_e \frac{A}{G} U_n)(r_n - r_{n-1})
\]

where \( \frac{Z}{Q} F_n \) is the quantum force, \( \frac{Z}{C} F_n \) is the Coulomb force of the \( Z \) protons in the nucleus, and \( m_e \) is the mass of the electron. Using (32) and solving for quantum force gives

\[
\frac{Z}{Q} F_n = \frac{R M Z^2}{(r_n - r_{n-1})} \left( \frac{1}{n^2} - \frac{1}{(n-1)^2} \right) \frac{Z}{C} F_n - m_e \frac{A}{G} U_n
\]

To put this in perspective, depending on the size of the nucleus the Coulomb force is a billion to a trillion times smaller than the quantum force; the gravitational force is even smaller. As a first approximation we can safely ignore these terms.

Consider first the ratio of the quantum force in layer \( n \) to the same force in quantum layer 2, the lowest quantum across which a photon can be generated.

\[
\frac{Z}{Q} F_n \frac{Z}{Q} F_2 = \frac{R M Z^2}{(r_n - r_{n-1})} \left( \frac{1}{n^2} - \frac{1}{(n-1)^2} \right) \frac{Z}{C} F_n - m_e \frac{A}{G} U_n
\]

Using (4) this becomes simply

\[
\frac{Z}{Q} F_n \frac{Z}{Q} F_2 = \frac{4}{n^2(n-1)^2}
\]

Similarly comparing the strong force (27) on quantum level \( n \) to the 2\(^{nd} \) level gives

\[
\frac{A}{S} F_n \frac{A}{S} F_2 = \frac{16}{n^4}
\]

The quantum force can be compared to the strong force in each quantum layer by taking a ratio of the (36) and (37):

\[
\frac{Z}{Q} F_n = \frac{n^2}{4(n-1)^2} \frac{Z}{Q} F_2 \frac{A}{S} F_n
\]

The model asserts that the strain on the quantum layer created by the insertion of the particle into space creates stress in that layer which in turn exerts the force an electron must overcome to leap up to the next highest quantum level. In effect the strong force stress on space keeps electrons at their quantum levels. In particular it likely keeps the electron at quantum level 1 from every approaching the nucleus, no matter how many protons it contains. It seems to prevent electromagnetic radiation from the electrons as they accelerate around the nucleus. The most fundamental electromagnetic phenomena are thus tied to the nuclear strong force.

Combining (38) with (27) yields the “fundamental law of nature”: 
\[ Z F_n = \frac{\Omega A r_n n^2 Z F_2}{4(n-1)^2 A F_2} A U_n \]  

(39)

For any atom this is the relationship between the quantum force on the electron (which determines the wavelength of the light photon produced) and the acceleration due to gravity, mediated by the strong force.

2.4. Discussion

No model is causal: it is only descriptive, and its usefulness ultimately depends on its simplicity, elegance and ability to describe and predict reality. Furthermore it cannot be refuted merely by comparison with another model. Many models can be constructed to describe the same phenomena; only experimental evidence can limit a model’s domain.

By our model space displacement creates the strong and weak forces; if correct this finding will have the greatest impact on current theories. The full consequences for quantum mechanics of a compressive force acting on elementary particles and the nucleus must be evaluated.

The scattering of electrons by the strained space in the nucleus is the clearest evidence for this model. And the Standard Model shows no way for neutrons to congregate, while this model explains the existence of tetranuets: clusters of 4 neutrons in a nucleus[6]. Dark matter could simply be gravitationally assembled neutron nuclei. The model holds promise for solving other mysteries. Being only 1% of the mass, quarks may be structures of struts supporting the proton void in space. This implies space has surface tension: light photons may be small voids supported merely by the surface tension of space without the need for supporting struts, leading to a simple explanation of the wave-particle duality.

Our model is intuitively pleasing compared to mysterious gravitational attraction acting at a distance. Finally we can understand why things fall.

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