SECTION 4

Connecting Newton's G With the Rest of Physics

PART I – BACKGROUND OF THE PROBLEM

The Problem

On October 9-10, 2014, several dozen scientists from around the world gathered at The National Institute of Standards and Technology, NIST, to consider their options.

> "We're all here because we have a problem with *G* - and I mean, boy, do we have a problem with *G*," said Carl Williams, Chief of PML's Quantum Measurement Division, to the assembled group on the first morning of the meeting. "This has become one of the serious issues that physics needs to address."

Surprisingly, physicists still can't agree on the value of the *Big G* constant that features both in Isaac Newton's law of gravitation, which dates back to the year 1687, and in Albert Einstein's General Theory of Relativity. The Newtonian constant of gravitation, fondly known as *Big G*, used to calculate the attractive force of gravity between objects, is more than 300 years old. But although scientists have been trying to measure its value for centuries, *G* is still only known to about 3 significant figures as compared to most of the fundamental constants which are known to 9 significant figures.

Different experimental techniques have found contradictory values for *G*. And, worse yet, the more various experiments researchers conduct to pin down the gravitational constant, the more their results diverge. A plot of all the results from the past 15 years reveals a relatively wide spread in values ranging from about 6.670 to $6.676 \times 10^{-11}\ m^3\ kg^{-1}\ s^{-2}$. CODATA, the International Council for Science Committee on Data for Science and Technology, which analyzes the results of individual experiments and provides an internationally accepted set of values for fundamental physical constants, has had to increase the uncertainty on its latest recommendation for a value of *G* due to the divergence of the experiments.

The problem is aggravated by that, unlike the other fundamental constants, *G* is described in CODATA's "Adjustment of the Fundamental Physical Constants" as follows:

> There is no established relationship between the gravitational constant *G* and other physical quantities; it stands completely uncoupled from the remainder of the adjustment.

and that state of affairs remains unchanged through the most recent adjustment, that of 2018.

The Nature of the Solution

The solution to this set of problems consists of the following steps.

Part II - Demonstration of a fundamental problem in using the General Relativity model of gravitation in addressing the problem of *Big G* because *Big G* arises naturally from the Newtonian model of gravitation. This accounts for the wide range of measurement results that has limited the precision in the value of the constant.

Part III - Definition of what the "correct" value of the constant is a measure of and demonstration that it is practically impossible to measure it and that the correct value lies outside the entire range of the various diverse measured values and is smaller than any of them.

Part IV - Calculating the correct value of the constant by deriving a "relationship between the gravitational constant, G, and other physical quantities" [h, c, q, μ, α, π] contrary to CODATA's report that there is no such established relationship.

Part V – Experimental Testing of the hypothesis and the derivation.

PART II – THE FUNDAMENTAL PROBLEM IN THE CONCEPTION OF BIG G

The fundamental problem in measuring *Big G* is the use of the General Relativity model of gravitation instead of the Newtonian model in which *Big G* arises naturally. That leads to the deeming that in effect the gravitational attraction is as if, for each gravitating body, all of its gravitating mass were concentrated at its center. The [modern] Newtonian understanding is that each of the gravitating bodies is composed of myriad individual gravitating particles. That is demonstrated as follows.

If a gravitating body were cut in half each of the halves would be a gravitating body. If the process were repeated progressively dividing each gravitating body into multiple separate bodies each would be a gravitating body. Carried out down to the atomic level each of the atomic particles of which the original undivided body is composed is an individual gravitating body and so acts whether individual and separate or as part of the original undivided body.

Every individual particle having rest mass interacts gravitationally with every other such particle. In the case of, for example, two separate spherical masses each consisting of a number of individual particles compacted together, each and every one of the individual particles in each sphere interacts gravitationally with each and every one of the particles in the other sphere. The gravitational effect that we experience is the net vector sum of those individual interactions.

Newton's Law of Gravitation, equation 4-1, states the acceleration of mass m resulting from the gravitation of mass M. According to that law that acceleration is independent of the mass of the accelerated body. That mass appears as a factor only in the application of Newton's Second Law of Motion to the gravitational acceleration an action independent of gravitation, of the cause of the acceleration.

Picturing now the set-up for experiments to measure G in which the gravitational effect between spheres is measured, each individual particle in one of the spheres interacts in Newtonian Gravitational fashion paired with each and every one of the individual particles in the other sphere or spheres. That results in two effects on the magnitude of the gravitational action un-accounted for by the General Relativity model of gravitation.

1 - Referring to Newton's Law of Gravitation, equation 4-1, the first effect is that the separation distance, d, for each Particle-to-Particle gravitational action varies depending on the two particles' locations in their overall spheres. The average of those will equal the spheres' center-to-center distance

but, it is the separation distance squared that acts in the gravitational effect. In the Particle-to-Particle interaction it is each individual pair's separation distance squared not the overall average separation that matters. Simply stated, the average separation distance squared as used in Newton's Law of Gravitation is not the same as the average of the squared individual separation distances.

(4-1) $$a_g = G \cdot \frac{M}{d^2} \qquad\qquad F = G \cdot \frac{M \cdot m}{d^2}$$

Because of the form of Newton's Law of Gravitation and the overall gravitational concept of General Relativity, modern physics treats gravitation as depending solely on the gravitationally attract**ing** mass and the center-to-center separation of the bodies, the characteristics of the attract**ed** body being deemed of no significance. But, the independent gravitational action of each particle in the attracting body with each in the attracted body means that the configurations of the attract**ed** body and the attract**ing** body are factors in the overall effect a factor that appears in the interpretation of the d^2 of Newton's Law.

How this works out in practice is illustrated by the example of Figure 1, below. The figure compares two alternative calculations of the Newtonian Gravitational acceleration per Newton's Law of Gravitation between two bodies: [1] a lone single particle and [2] a single body made up of a string of ten such particles connected together.

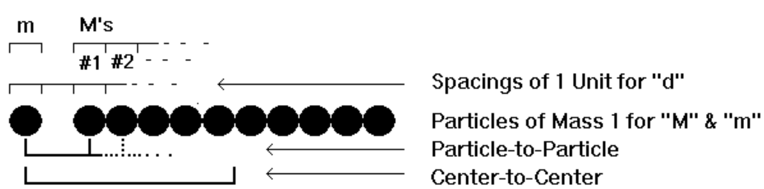
The two alternative calculations are:

[1] Particle-to-Particle

Calculating the action between the lone single particle and each of the single particles of which the second body is composed, one at a time, ten calculations in total, and taking the total acceleration between the two bodies as being the sum of the accelerations for each of the ten particles of which body [2] is composed.

[2] Center-to-Center

Calculating the action between the lone single particle and the second body overall taking the entire mass of the second body as located at its center



Particle-to-Particle

$$a_m = G \cdot \frac{M}{d^2}$$

$$a_1 = G \cdot \frac{M_1}{d^2} = G \cdot \frac{1}{2^2} = 0.250 \cdot G$$

$$a_2 = G \cdot \frac{M_2}{d^2} = G \cdot \frac{1}{3^2} = 0.111 \cdot G$$

. . . .

$$a_{Ptl\text{-}Ptl} = \text{Sum } a_{1-10} = 0.558 \cdot G$$

Center-to-Center

$$a_{Ctr\text{-}Ctr} = G \cdot \frac{1 \cdot 10}{7^2} = 0.204 \cdot G$$

Figure 4- 1

The result is that the effects of the two alternatives are radically different. The Particle-to-Particle calculation result is $a_{Ptl-Ptl} = 0.558 \cdot G$ whereas the Center-to-Center calculation result is $a_{Ctr-Ctr} = 0.204 \cdot G$. The concept of General Relativity Gravitation is that the Center-to-Center method is used. However in actual measurement experiments the acceleration is naturally automatically determined by the Particle-to-Particle method and as a result is larger than it should be for determining Newton's G per the Center-to-Center method. From equation 4-1 G is found by measuring a_g and multiplying it by d^2 divided by m. While the "d^2" and "m" are correct for Newton's Law the a_g is too large and produces a G that is too large. [Adding together the individual Particle-to-Particle accelerations is valid because adding together the corresponding individual forces from $F = m \cdot a$ is valid.]

Furthermore, the difference between the Particle-to-Particle method and the Center-to-Center method varies with the amount of physical separation of the spheres introduced in the measurement set-up and with the diameter of each of the spheres. That, then, is a source of the spread of values obtained in various G measurement attempts.

2 - The second effect is that most of the various Particle-to-Particle pairs' lines of interaction (the line joining any pair of particles) are not parallel to the line joining the centers of the two spheres, the "centerline". [See Figure 4- 2, below.] Thus the total gravitational force of those interactions has two components: one parallel to the centerline and contributing to the overall gravitational attraction and the other at right angles to the centerline and cancelling to null when all of the Particle-to-Particle interactions are considered.

As with the first effect presented above, the various "angles" in Particle-to-Particle interactions vary with the amount of physical separation of the spheres in the set-up and with the diameters of the spheres – a variation that is a second source of the spread of values obtained in various G measurement attempts. This second effect results in a somewhat reduced gravitational action tending to off set to some extent the first effect's enhancing of the gravitational action.

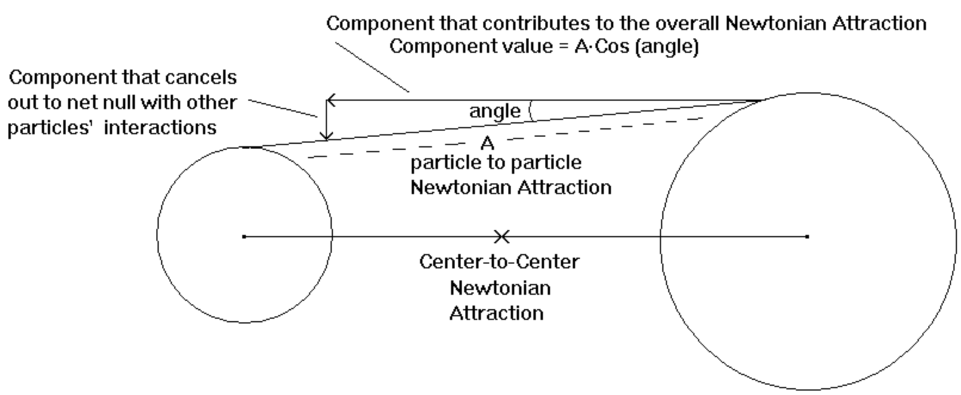


Figure 4- 2

The net result of the two effect's variation from experimental set-up to set-up causes the actual gravitational effect to vary from one experimental set-up to another. The cause of the discrepancies among the various attempts to obtain a precise value for G, the cause of the apparent variations in the value of *Big G*, is not primarily measurement errors; the measurements are probably largely correct for each set-up. The problem is that in the measurement experiments the measured value for a_g is slightly higher than per Newton's Law making the calculated value of *Big G* too large. None of the measurement experiments is measuring the correct, objective *Big G* and certainly the various attempts are not measuring the exact same gravitational effect.

But, what about natural gravitational acceleration ? All bodies near the Earth's surface but free to fall are accelerated by gravity at the same $9.8\ m/s^2$ regardless of the configuration of the particles making up its body. All such falling bodies experience essentially the same acceleration because the effect of the particle-on-particle gravitational interaction acts as the net average of the individual particle pair interactions. That average is dominated by the immensely greater number of particles in the attracting body, the Earth, and their immensely greater particle-to-particle separation distances compared to variation in particle locations in the attracted falling body.

PART III – THE "CORRECT" VALUE OF THE CONSTANT BIG G

Inherent in the conception of Newtonian gravitation operating by deeming that the gravitational attraction is as if all of the mass of the gravitating bodies were concentrated at their centers is that the intended *Big G* constant correspond to that situation. That situation is approximately, and quite close to, the case for gravitating bodies separated by a distance much greater than the diameter of the bodies, such as interplanetary situations. It is not practical to obtain such conditions in a laboratory which means that it is not possible to practically measure a correct *Big G*.

Nevertheless, such a "correct *Big G*" is needed for space age activities and advancing inter-planetary travel and scientific probes and is highly desirable. The only solution to that dilemma is to obtain a relationship between the gravitational constant, G, and other well known physical quantities so that the correct *Big G* can be determined by calculation from the other well known physical quantities, without measurement.

Because the "correct *Big G*" corresponds to all of the mass of the gravitating bodies being concentrated at their centers, the "correct *Big G*" gravitational action experiences none of the distortions of the above effects 1 and 2. Those effects tend to produce a net increase of the associated gravitational attraction so that the gravitational attraction for the "correct *Big G*" is less than in the presence of the distortions. Thus, the "correct *Big G*" is smaller than per any of the measurements performed.

It will shortly be developed that

(4-2) Where:

$$\delta = \tfrac{1}{2}\cdot\left[\frac{1}{4\pi\cdot c}\cdot\frac{1}{c^2}\cdot\frac{\cdot q^2\cdot\mu}{2\cdot\alpha}\right]^{\frac{1}{2}}$$

with: c = the speed of light, q = the elementary charge, μ = the magnetic constant, α = the fine structure constant

$$\delta = 4.039{,}723{,}843\cdot 10^{-35}\ m$$

the value of G is given by

$$G = \frac{c^3\cdot\delta^2}{h}$$

with: h = the Planck constant

$$G = 6.636{,}046{,}823\cdot 10^{-11}\ m^3\ kg^{-1}\ s^{-2}$$

PART IV – THE MODERN NEWTONIAN MODEL OF GRAVITATION AND DERIVING THE VALUE OF THE CONSTANT BIG G

The failure so far to connect *Big G* with the rest of physics is a direct consequence of attempting to do so on the basis of the General Relativity model of gravitation. The following successfully makes the connection by starting with the Newtonian model of gravitation in which *Big G* arises naturally.

The gravitational effect between two gravitating objects is, then, the net combined vector effect of myriad individual gravitating particles of one of the two objects interacting gravitationally in Particle-on-Particle pairs with myriad individual gravitating particles of the other of the two objects.

The following was concluded at the end of, and as a result of, Section 3.

> Two simultaneous flows, one for gravitation and one for electric field and two supporting reservoirs supplying the flows is clearly untenable. There can only be one reservoir in each particle's "core" and one resulting flow producing simultaneously both the gravitational field and the electric field if for no other reason than because two supply reservoirs would mutually interfere with comprehensive spherically outward flow of each.
>
> Therefore the one single reservoir and resulting flow is a flow of gravitation and of light. They are the same flow.

That being the case, the relating of *Big G* to the rest of physics can be pursued via the physics of electric charge and electric field, which proceeds as follows.

Analytic Derivation of G In Terms of Fundamental Physics Constants

"Micro" vs. "Macro" Interpretation of Coulomb's Law

Just as the gravitational effect,

- gravitational attraction, while experienced as a *macro* effect between bodies of significant amounts of mass, actually results from and is the accumulation of the *micro* interactions between pairs of single elementary particles of mass of which the bodies are composed;

so likewise the electric effect,

- electrostatic attraction or repulsion, is generally experienced as a *macro* effect between significant amounts of charge; however, the electric effect actually results from, and is the accumulation of, the *micro* interactions between pairs of single elementary charges.

Consequently it is the elementary charge, q, to which G is to be related.

Coulomb's Law for the electric interaction demonstrates that for the case of two elementary charges the force is proportional to $q_1 \cdot q_2$, or q^2, the product of the magnitude of the two elementary charges. Newton's Third Law of Motion requires an equal magnitude opposite direction "partner" to every force. The transmitting particle, whose flow delivers force to the encountered particle experiences, in reaction to the transmitting particle's spherically symmetrical outward flow, that Newtonian reaction as spherically symmetrical inward force with no net action because of the spherical symmetry.

The encountered particle cannot exert such force on itself. Therefore the electric action produced by the transmitting particle, required by Coulomb's Law to be proportional to q^2 is so produced by its own charge squared, q^2, which force is transmitted by, and imposed on the encountered particle by, the transmitting particle's flow. Of course, both charges participate. Each elementary charge is simultaneously in the role of the transmitting particle and the particle encountered by that transmitted flow. But, the outward flow from the core of the transmitting particle transmits the flow effect of q^2 to act as q^2 on the encountered particle. The two charges in the *macro* statement of Coulomb's Law are counts of the number of elementary charges in each *macro* charge yielding the total amount of charge involved.

Consequently it is the squared elementary charge, q^2, to which G is to be related.

The Particle Core and the Core's Outward Flow

The outward flow is flow of a highly effective substance in that it produces the effects of gravitational field and electric field; yet, it is at the same time a flow of an extremely intangible substance producing only the intangible gravitational field and electric field. But that flow is an integral component of humans' physical world and acts in accordance with well established physical laws dealing with well known physical quantities.

But, the interior of the reservoir supply of medium is entirely foreign to us. We can not really conceive of gravitational plus electric field, stationary in place and so dense and concentrated that it supports outward flow of our world's fields over many billions of years, any more than we can truly conceive of infinity.

The only thing known about the core, the "Core Domain" as compared to our "World Domain" is that as perceived from outside, in terms of the "World Domain" it appears to be a volume of $^4/_3 \cdot \pi \cdot \delta^3$ with a surface of $4 \cdot \pi \cdot \delta^2$. Therefore, volumetrically, i.e. in terms of the core volume, the outward flow through that surface is

(4-3) $4 \cdot \pi \cdot \delta^2 \cdot c$

But, that on-going flow generates potential energy field which in our "World Domain" appears to be static, not flowing. Flowing medium is static potential energy field.

Planck's constant, h, appears as "energy per time" in the form $W = h \cdot f$. That oscillation energy, the equivalent of matter energy as in $h \cdot f = m \cdot c^2$, cannot reside in the "f" nor in its equivalent $^1/_T$; the energy of $W = h \cdot f$ must reside in h.

Then the energy of the medium must result from the flow having the rate of "energy per flow" of $^h/_c$, which is of the fundamental dimensions [Mass × Length], which are also the fundamental dimensions of charge squared, q^2.

The Electric Interaction of Two Elementary Charges and the Value of G

In Section 3 it was stated that, equation, 4-9 [$\Delta v = c \cdot 2\pi \cdot l_P^2 / d^2$ per cycle of f_{source}] clearly implies that it is not possible for a particle having rest mass to be approached closer than the distance $\sqrt{2\pi} \cdot l_P$, defined in equation 4-10 as δ, the radius of such particles' impenetrable "core". However, when two such particles, for example elementary charges, are involved, the minimum approach distance is $2 \cdot \delta$ because each of the two particles cannot individually be approached closer than δ.

The interaction of two elementary charges then develops as follows for each of the two charges. The inconsistency of units here is due to the expressions in equation 4-4, below, covering the transition from the [unknown] "Core Domain" to [our] "World Domain".

(4-4)

[The Flow from the "Core Domain"]	causes and is proportional to	[The Flow in the "World Domain"]
$4 \cdot \pi \cdot (2 \cdot \delta)^2 \cdot c$	$\sim$	$k \cdot \frac{h}{c}$

(4-5)

[The Flow in the "World Domain"]	is the same as	[$^h/_c$ per the Fine Structure Constant $\alpha = ½ \cdot \mu \cdot c \cdot {}^{q^2}/_h$ and The Statcolomb "natural charge" converted by $^1/_{c^2}$ to Coulombs]
$k \cdot \frac{h}{c}$	$=$	$\left[\frac{1}{c^2}\right] \cdot \left[\frac{q^2 \cdot \mu}{2 \cdot \alpha}\right]$

The outward flow from particle's "Core Domain" is the "World Domain" electric field of charge.

The objective here is to obtain the value of δ from which the value of l_P can be calculated and from that the value of G can be calculated, all as follows.

Equating the left side of equation 4-4 to the right side of equation 4-5 via $[\, k \cdot \frac{h}{c} \,]$ and solving for δ the following is obtained.

(4-6) $\delta = \frac{1}{2} \cdot \left[\frac{1}{4\pi \cdot c} \cdot \frac{1}{c^2} \cdot \frac{\cdot q^2 \cdot \mu}{2 \cdot \alpha} \right]^{\frac{1}{2}}$ which simplifies to $\delta = \frac{1}{2 \cdot c^2} \cdot \sqrt{\frac{h}{4\pi}}$

[See "Resolution of the Issue of Units" below page 37.]

Alternatively, from equation 4-4 but with the constant, $k = {}^{1}/{}_{c}2$ from equation 4-5 the solution for δ is also:

(4-7)
$$\delta = \frac{1}{2 \cdot c^2} \cdot \sqrt{\frac{h}{4\pi}}$$

(4-8) $\delta = 4.039{,}723{,}843 \cdot 10^{-35}$ *m* [from either equation 4-6 or (4-7)]

(4-9) From equation 3-10 of section 3, the Planck Length is

$$l_P{}^2 \equiv \frac{\delta^2}{2 \cdot \pi}$$

$$l_P = 1.611{,}616{,}642 \cdot 10^{-35} \; m$$

[The failure of full coordination of l_P with the third significant figure of the 2014 adjustment is due to the two errors in Part II, which errors make their resulting G and therefore l_P somewhat too large.

(4-10) From equation 3-8 of Section 3

$$G = \left[\frac{2\pi \cdot c^3 \cdot l_P{}^2}{h} \right] \quad \text{or} \quad G = \left[\frac{c^3 \cdot \delta^2}{h} \right] \quad \text{from which}$$

$$G = 6.636{,}046{,}823 \cdot 10^{-11} \; m^3 \, kg^{-1} \, s^{-2}$$

which is slightly below the range of the erroneous measurements, 6.670 to 6.676×10^{-11}, as expected per the above Part III, page 33.

From equation 4-11 of Section 3 repeated below

(4-11) $\Delta v = c \cdot \frac{\delta^2}{d^2}$ per cycle of f_{source}

the following is readily developed and validates the result at equation 4-10.:

(4-11) gravitational acceleration = $a_g = \Delta v \cdot f_{Source} = \left[c \cdot \frac{\delta^2}{d^2} \right] \cdot [f_{Source}] = \left[c \cdot \frac{\delta^2}{d^2} \right] \cdot \left[\frac{M \cdot c^2}{h} \right]$

$$= \left[\frac{c^3 \cdot \delta^2}{h} \right] \cdot \left[\frac{M}{d^2} \right] = G \cdot \frac{M}{d^2} = \text{Newton's Law}$$

Resolution of the Issue of Units in Equating Equation 4-4 to 4-5

The units of equation 4-4 which equation is $[4\pi \cdot (2\cdot\delta)^2 \cdot c]$ *are {Length³/Time}*
whereas the units of equation 4-5 which is $\left[\frac{1}{c^2}\right]\cdot\left[\frac{q^2\cdot\mu}{2\cdot\alpha}\right]$ *are {Mass·Length}.*
How can they be equated to each other ?

The core's outer boundary is a surface of area $4\cdot\pi\cdot\delta^2$. It lacks the power to restrain or contain anything. However, the only way the content of the core can leave and flow outward is through the core's surface. That flow is subject to the speed limit of light speed. That sets the flow at $[4\cdot\pi\cdot\delta^2]\cdot c$.

That would appear to be able to fully deplete the core in the time

$$\text{(4-12)}\qquad \frac{\text{Core Volume}}{\text{Outward Flow Rate}} = \frac{{}^4\!/_3\cdot\pi\cdot\delta^3}{4\cdot\pi\cdot\delta^2\cdot c} = \frac{\delta}{3\cdot c}.$$

However, that is an extremely brief amount of time [$4.504\cdot 10^{-44}$ seconds] whereas the universe and the flows have been in existence for billions of years. The resolution of that conflict is that the medium contained within the core is not merely the geometric core volume as we view it from our world; it is "highly concentrated volume", the capability if freed into space outside the core for myriad core physical volumes, the volume of space.

That is the already cited difference between the "Core Domain" and the "World Domain".

The ratio to the core's world view geometrical volume of that "*highly concentrated volume*" as medium to be propagated is designated *F*, the medium magnifying factor, a dimensionless interpretive ratio. The equation 4-12 depletion process then becomes

$$\text{(4-13)}\qquad \frac{\text{"Core Domain" Volume}}{\text{"World Domain" Outward Flow Rate}} = \frac{{}^4\!/_3\cdot\pi\cdot\delta^3\cdot F}{4\cdot\pi\cdot\delta^2\cdot c} = \frac{F\cdot\delta}{3\cdot c}.$$

where *F* is the volume equivalent of the core medium supply relative to the core geometric volume.

$$\text{(4-14)}\quad F = \frac{\text{Volume Equivalent of Core Medium Supply}}{\text{Geometric Core Volume}} = \frac{h/c}{{}^4\!/_3\cdot\pi\cdot\delta^3}\ \frac{\text{Units }\{M\cdot L\}}{\text{Units }\{L^3\}} = 7.938{,}010{,}000\cdot 10^{60}$$

a pure number just as are $^4/_3$, *4*, and π of equation 4-13. Saying the core is medium {M·L} vs. volume {L^3} is like saying a year is {days} vs. {seconds}.

The medium magnifying factor *F* spans two very different regimes of material reality:

1 - The natural world regime in which we exist and function;

2 - The interior of the core of each particle, the supply of highly concentrated medium, minute portions of which are propagated outward in each cycle of the particle's oscillation, gradually depleting the supply.

F spans the relationship between the "Core and World Domains", it expresses the connection of the physical volume of the core and the concentrated-volume medium filling the core. It converts expressing the interior of the core, its substance, between units of volume, [$^4/_3\cdot\pi\cdot\delta^3$] { Length³ }, and units of medium [h/c] { Mass · Length }, as propagated outward.

SUMMARY OF THE LINE OF PROOF

Step 1 – The Problem: Particle-to-Particle Not Center-to-Center

The gravitational effect is not as if all of the mass of the gravitating bodies were concentrated at the center of each body. Each of the gravitating bodies is composed of myriad individual gravitating particles. Each and every one of the individual particles in each body interacts gravitationally with each and every one of the particles in the other bodies. The gravitational effect that we experience is the net vector sum of those individual interactions.

Step 2 – The Nature of the Correct G

Two effects produce the erroneous results in experiments to measure G resulting in values for G that are too high. The correct value of G, unaffected by those errors, corresponding to measuring G with a separation distance, d, very much greater than the size of the gravitating bodies, is thus somewhat smaller than any of the erroneous values.

Step 3 – The Radius δ "Core" in Each Particle

Just as inertial mass, m, has an equivalent frequency $m \cdot c^2/h$, so also does gravitational mass. Following out the implications of that, the result is equation *4-11*, repeated below.

(4-11) $$\Delta v = c \cdot \frac{\delta^2}{d^2} \quad \text{per cycle of } f_{source}$$

The physical significance of this is that it sets a limit on the minimum separation distance in gravitational interactions and thus implies that a "core" of radius δ is at the center of every fundamental particle.

Step 4 – Each Particle Must Transmit Outward Flow

The Particle-to-Particle nature of gravitation creates a need for each gravitationally acting [attract**ing**] particle to communicate to each gravitationally acting [attract**ed**] particle the direction from the attract**ed** particle to the attract**ing** one and the magnitude of the attract**ing** particle's gravitational attraction. Thus, there must be something flowing, continuously, carrying that information, spherically outward, from every gravitating particle.

Step 5 – Each Particle's "Core" – is a Reservoir Supply for the Flow

For the flow of Step 4 to have persisted the billions of years since the "Big Bang" there must be a supply of that flowing substance in every particle. And, that supply must be an extremely concentrated reservoir relative to the outward flow. The only possible such reservoir is the "core" of Step 3.

Step 6 – Definition of δ

The radius of that core relates to the Planck Length as equation *4-12* , repeated below.

(4-10) $$\delta^2 \equiv 2\pi \cdot l_P^{\,2}$$

The value of G can be calculated from δ or from the Planck Length, equation *4-10*, repeated below.

(4-8) $$l_P \equiv \left[\frac{h \cdot G}{2\pi \cdot c^3}\right]^{\frac{1}{2}} \quad \text{so that} \quad G = \left[\frac{2\pi \cdot c^3 \cdot l_P^{\,2}}{h}\right] \quad \text{or} \quad G = \left[\frac{c^3 \cdot \delta^2}{h}\right]$$

Thus, if δ can be related to and calculated from the rest of physics, then likewise can G.

Step 7 – Electric Charge Flow is Like Flow from Mass = Same Sole Flow

Just as in the case of gravitation, every particle having electric charge must communicate its "message" to every other such particle. That flow-communication is the electric field.

Two simultaneous flows, one gravitational and one electric constituting the two fields and with two supporting reservoirs supplying the flows is clearly untenable. There can only be one reservoir in each particle's "core" and one resulting flow producing both the gravitational field and the electric field .

Step 8 – Elementary Charge Coulomb Action is q^2, Not Merely q

Between two elementary charges, the particle encountered by the transmitting particle's electric field flow cannot exert force on itself because of Newton's Third Law. Therefore the electric action produced by the transmitting particle, required by Coulomb's Law to be of magnitude q^2 is so produced by its own elementary charge squared, q^2.

Step 9 – "Core Domain" vs. "World Domain"

The only thing known about the "core", the "Core Domain" as compared to our "World Domain" is that as perceived from outside, in terms of the "World Domain" the "Core Domain" appears to be a volume of $^4/_3 \cdot \pi \cdot \delta^3$ with a surface of $4 \cdot \pi \cdot \delta^2$. Therefore, in terms of the "World Domain", the outward flow through that surface would appear to be $4 \cdot \pi \cdot \delta^2 \cdot c$.

However, equation *4-13,* shortly above, was interpreted to limit to δ the closet possible approach distance to a particle. But, when two such particles, for example two elementary charges, are involved, the minimum approach distance is $2 \cdot \delta$ because each of the two particles cannot individually be approached closer than δ.

Step 10 – The Outward Flow Appears in the "World Domain" Proportional to $^h/_c$

The on-going outward flow generates potential energy field, which in our "World Domain" appears to be static, not flowing. Flowing medium appears to us as static potential energy field.

Planck's constant, h, appears as "energy per time" in the form $W = h \cdot f$. That oscillation energy, the equivalent of matter energy as in $h \cdot f = m \cdot c^2$, cannot reside in the "f" nor its equivalent $^1/_T$. The energy of $W = h \cdot f$ must reside in h.

The energy of the flowing medium, the electric potential energy field, results from the flow having the rate of "energy per flow" proportional to $^h/_c$, which is of the fundamental dimensions [Mass × Length], which are also the fundamental dimensions of charge squared, q^2, charge being that which we associate with electric field.

Step 11 – The Electric Interaction of Two Elementary Charges

The interaction of two elementary charges then develops as follows for each of the two charges. The "Core Domain" flow,

$$4 \cdot \pi \cdot (2 \cdot \delta)^2 \cdot c,$$

causes and is proportional to the "World Domain" flow,

$$k \cdot \frac{h}{c} \qquad [\ k \text{ being the constant of the proportionality }]\ .$$

Further, per the Fine Structure Constant,

$$\alpha = \frac{1}{2} \cdot \mu \cdot c \cdot \frac{q^2}{h}$$

which rearranged is

$$\frac{h}{c} = \frac{q^2 \cdot \mu}{2 \cdot \alpha}$$

and using $k = {}^{1}/_{c^2}$ [to convert "natural" statcoulombs to coulombs], results in

$$4 \cdot \pi \cdot (2 \cdot \delta)^2 \cdot c = k \cdot \frac{h}{c} = \frac{1}{c^2} \cdot \frac{q^2 \cdot \mu}{2 \cdot \alpha}$$

from which

$$\delta = \frac{1}{2} \cdot \left[\frac{1}{4\pi \cdot c} \cdot \frac{1}{c^2} \cdot \frac{\cdot q^2 \cdot \mu}{2 \cdot \alpha} \right]^{\frac{1}{2}} \qquad \text{simplifies to} \qquad \delta = \frac{1}{2 \cdot c^2} \cdot \sqrt{\frac{h}{4\pi}}$$

Or, alternatively, from equation *4-15* but with the constant, $k = {}^{1}/_{c^2}$ from *4-5)*

$$\delta = \frac{1}{2 \bullet c^2} \bullet \sqrt{\frac{h}{4 \bullet \pi}}$$

$\delta = 4.039{,}723{,}843 \cdot 10^{-35}$ *m* [from either form for δ]

$$l_P = \frac{\delta}{\sqrt{2\pi}}$$

$l_P = 1.611{,}616{,}642 \cdot 10^{-35}$ *m*

Final Step – G Calculated from the Planck Length or δ

$$G = \left[\frac{2\pi \cdot c^3 \cdot l_P{}^2}{h} \right] \qquad \text{or} \qquad G = \left[\frac{c^3 \cdot \delta^2}{h} \right]$$

$G = 6.636{,}046{,}823 \cdot 10^{-11}$ $m^3\ kg^{-1}\ s^{-2}$

PART V – TESTING THE HYPOTHESIS AND THE DERIVATION

Testing the hypothesis and the derivation requires having available at hand the specific details and data of one of the numerous *Big G* measurement experiments conducted in recent years. The selected experiment can be any one of that group so long as the confidence that it contains negligible measurement errors is high. Preferably the testing should be conducted independently on several of the recent measurement experiments.

The procedure is to calculate the force, *F* [the force not the medium magnifying factor], per equation *4-1* by two different methods using the parameters of the selected experiment to obtain a comparison ratio that of *Calc1* to *Calc2*, below. For these calculations $G = 1$ can be used because only a ratio is sought.

Calc1 - That of the General Relativity model with the objects' masses concentrated at the objects' centers. This calculation is simple and direct because there is only one value of d, the center to center spacing of the masses, and only one calculation.

Calc2 – That of the Modern Newtonian Gravitation model with each individual particle in each object reacting, one-on-one, with each individual particle of the other object(s), a procedure analogous to the calculation of Figure 4-1 but including the additional effect illustrated in Figure 4-2. This calculation is quite complicated in that there are many values of d, a different one for each particle pair, and the sought value of F is the vector sum of all the individual particle to particle forces.

Because only the ratio of *Calc1* to *Calc2* is sought, the values of M and m can be ignored; the "lump amount" of each in *Calc1* being the same as the sum of all the individual particles of those "lumps" in *Calc2*. However, the dimensions of the physical bodies of M and m are fundamental to the individual particle-on particle interactions for *Calc2*. The calculations deal only with the alternative treatments of d in *Calc1* and *Calc2* plus that in most cases only a partial component of the particle to particle force enters into the overall value of the force, F, in *Calc2* as indicated in Figure 4-2.

The result will be that the F of *Calc2* will be greater than the F of *Calc1* implying a greater G as discussed in Part II.

The ratio, R, of the F of *Calc1* divided by the F of *Calc2* applied to the value of G that the original selected experiment obtained $[R \times G]$ will then yield a G corrected for the problems analyzed in Part II. Subject only to the experimental accuracy of the selected experiment the corrected G will be that of equation *4-10*, $6.636{,}046{,}823 \cdot 10^{-11}\ m^3\ kg^{-1}\ s^{-2}$.

These procedures are implemented in the following Section 5 – "The Experimental Data Validation of Modern Newtonian Gravitation"