The Connection between Electric Charge, Gravitation, and the Feynman Sum over All Histories View of Quantum Electrodynamics

D.T. Froedge
Formerly Auburn University
dtfroedge@glasgow-ky.com

V041120
@ http://www.arxdtf.org

Abstract

In the introduction to Feynman's *Six Easy Pieces* it was said: "You could not imagine the sum-over-histories picture being true for a part of nature and untrue for another part. You could not imagine it being true for electrons and untrue for gravity" The purpose of this paper is to show that Gravitation and Electric Charge are the result of the interaction of the Feynman path photons. Feynman proposed that for a photon, or any particle, going from one point to another [1], there is a probability of the particle has traveled every possible path, and by very accurate measurements of quantum effects there is every reason to believe that this is true. It is shown that the interaction of these Feynman path photons generated by mass particles change the index of refraction of space, and can constitutes the effects of gravitation and electric charge.

It is proposed that a photon moving through probability density amplitude of approaching Feynman photons experiences an alteration in the index of refraction. This alteration of photon dynamics can be shown to be the causation of gravitation, and, electric charge

It is remarkable that this relationship allows calculating the value of the **Gravitational Constant** to at least **eleven significant digits**. It is further remarkable that the value is **within the error bars** of all the measurements published by the by the **International Bureau of Weights and Measures, (BIPM),** since 2000 (Appendix I)

This paper uses selected parts of several of the authors papers, [2],[3],[4],[5].

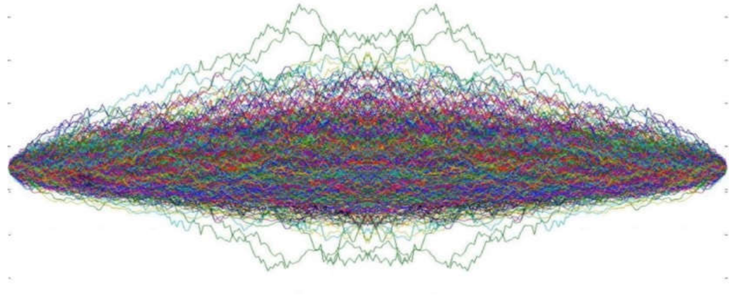

Fig.1, A subset of the infinite set of Feynman action path trajectories

For photons on repetitious tracts such as a standing wave or oscillation in a particle, there is a continuous regeneration of an infinite number of external paths each time the internal paths repeat.

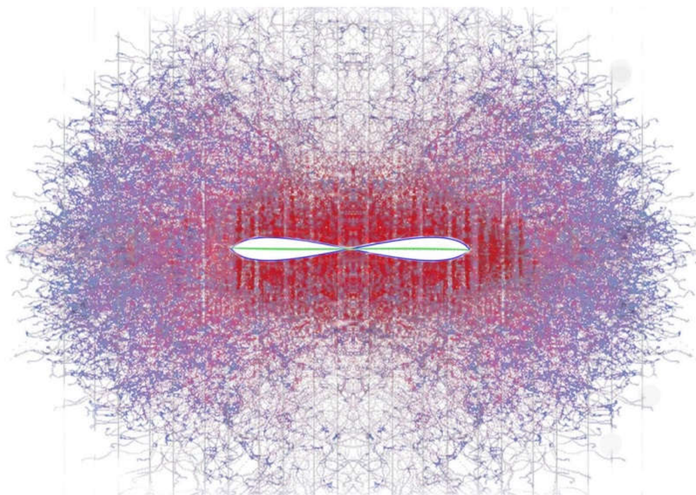

Fig. 2 The probable path density, which is infinite is not the same as the location probability density.

Although the probability of a Feynman action path for a photon can be anywhere, the probability density is not infinite everywhere, but is a function of the distance form the most probable path Fig, 2.

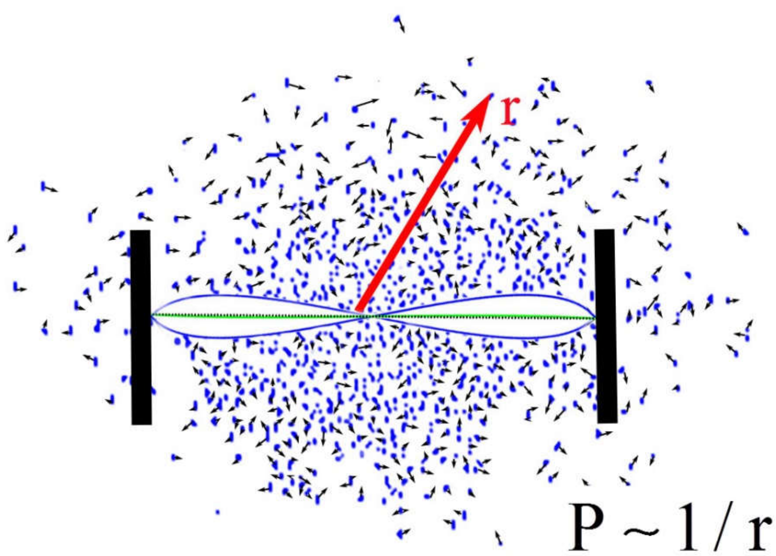

Fig. 2, probability of Feynman photons exterior to the minimum path

The probability density of the photons form the most probable paths has been investigated by a number of researchers and summarized in [4]

$$P \sim 1/r \tag{1}$$

Sakoda and Omote [6] and others found the scattering amplitudes finding the asymptotic probability distribution $r >> \lambda\!\!\!^{-}$ to be proportional to:

$$\mathbf{P}(r_{\perp}) = \psi^{*}\psi \sim \frac{\lambda\!\!\!^{-}}{r} \tag{1.2}$$

For the consideration of a trapped photon oscillating between two points or in a bound repetitious motion Fig. 2 , the time average probability density of the Feynman photons being at a position at a distance r from the classical tract is found to be:

$$P_F = \frac{2\lambda\!\!\!^{-}_C}{r} \tag{3}$$

P is the probability density $\lambda\!\!\!^{-}_c$ is the Compton radius and r is the radial distance from the minimum path.

Photons orbiting inside mass particles are not necessarily axially aligned with other particles and do not have a common rotation axis, thus this expression is the time average density of all random directed photons and constitutes the probability density of photons generated by a mass. Fig.4

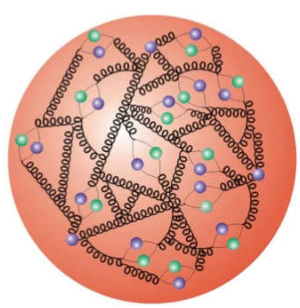

Fig. 4, Random constituents of a mass particle including gluons bosons leptons quarks etc.

The presumption is made that at the subatomic level the mass of any particle is composed of bound light speed particles that travel repetitive paths and producing action paths that exist outside the particle. The probability of these particles is responsible for producing both gravitational and electrical interactions. It is presumed that this probability density is a general property of matter and applies to all mass particles.

Postulate Regarding Feynman photons interact by altering the velocity of light

Postulate:

The change in the speed of light, on passing through the Compton volume of a second photon is proportional to the ratio of the Planck particle area $\left(\bar{\lambda}_{PL}^2\right)$ *to the Compton area* $\bar{\lambda}_c^2$

$$\frac{\Delta c}{c_0} = \frac{\bar{\lambda}_{PL}^2}{\bar{\lambda}_c^2} \tag{1.4}$$

The related index of refraction, η , and Planck constant $\bar{\lambda}_{PL}$ are:

$$\frac{\Delta c}{c_0} = \frac{c_0 - c}{c_0} = \left(1 - \frac{c}{c_0}\right) = \left(1 - \eta^{-1}\right) \qquad \bar{\lambda}_{PL} = \sqrt{\mu\lambda} = \sqrt{\frac{G\hbar}{c^3}} \tag{5}$$

Eq.(1.4), presumes the photon is the size of the Planck particle its probability density located within the Compton radius and the change in c is just the probability of a direct hit of the Planck particle.(Fig. 5)

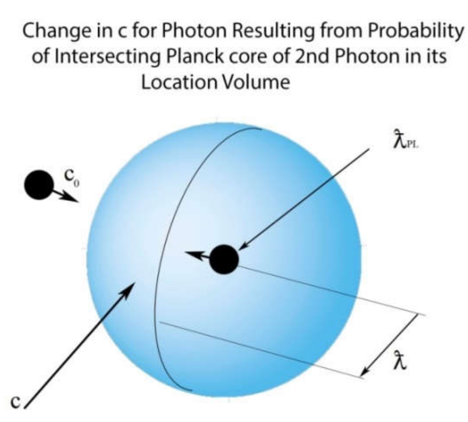

Fig.5 , Photon delay passing through probability distribution of another photon.

Multiplying the change in the speed of light per photon times the probability density of Feynman photons, Eq.(3), Eq.(1.4), gives:

$$\frac{\Delta c}{c_0} = \text{Change per photon} \times \text{photon probability denstiy}$$

$$\frac{\Delta c}{c_0} = \frac{\lambda\!\!\!^{-}{}_{PL}^2}{\lambda\!\!\!^{-}{}_c^2} \times \frac{2\lambda\!\!\!^{-}{}_C}{r} \tag{6}$$

Or

$$\frac{\Delta c}{c_0} = \frac{\text{Target area}}{\text{Total area}} \text{density}$$

This fundamental relation which defines the change in the velocity of light induced by Feynman photons is the source of both gravitational and electric interaction. This has connection to the work of M. Urban et.al.in regard to the vacuum background [7], [8].

From Eq.(6), this immediately gives the speed of light in the presence of mass to be the gravitational relation.

$$\frac{\Delta c}{c_0} = \frac{2\mu}{r} \tag{7}$$

or

$$c = c_0\left(1 - \frac{2\mu}{r}\right) \tag{8}$$

This is the exact change in the index of refraction of light in the presence of a mass as predicted by General Relativity when projected on flat Minkowski space, and confirmed by the radar measurements of the Shapiro effect. [9],[10],[11].

Restating in terms of potential which is taken as universal:

$$\frac{\Delta c}{2c_0} = \frac{GM}{c^2 r} = \frac{GMm_1}{\left(m_1 c^2\right) r} = \frac{\text{Gravitational potential energy}}{\text{Total energy}} \text{per unit mass}$$

$$\frac{\Delta c}{2c_0} = \frac{\Delta\varepsilon}{\varepsilon} \tag{9}$$

The velocity ratio term in Eq., $\Delta c / 2c_0$ is equal to the ratio of the potential to total energy of interacting particles, and the same for both electric and gravitational interactions. In a conservative system it is just equal to the ratio of the kinetic to rest energy.

Electric Interaction

Using the same postulates and presumptions on the Feynman the electric charge interaction can be found.

The difference between gravitation and electric interaction is that the probability of Feynman photons from an electron does not move in random directions, but due to spin polarization, move as the core particles of the electron in a circular path around the particle [2].

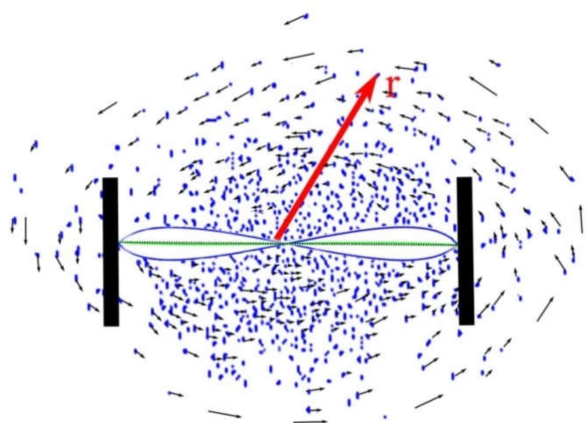

Fig. 5, Circular directions of Feynman Photons for polarized charged mass particles

This constitutes an increase in probability density for an oncoming photon by a factor of the repetition rate. An oncoming photon experiences the static density Eq.(10), times the repetition rate of that value (Fig.4 & Fig.5).

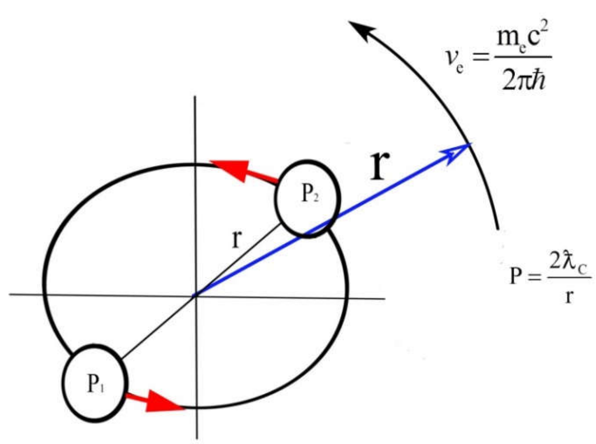

Fig. 4, Shows the time average probability density for a Feynman photon on an action path and the repetition frequency an any point.

This means that at each cycle of the internal photons at the Compton frequency there is a path repetition making another contribution to the probability density as illustrated in Fig. 7:

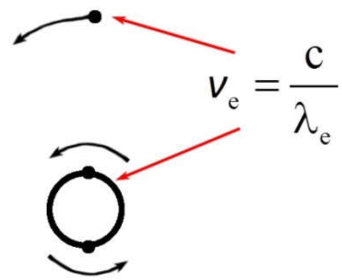

Fig. 7, Frequency of probable photon passing a point equal to cycle of the internal photons. .

Thus the probability density of the location of a Feynman photon interacting with an oncoming photon from another electrical charge Eq.(3), is then multiplied by the frequency:

$$P_F = \frac{2\bar{\lambda}_C}{r}\,\nu_e \qquad (10)$$

ν_e is the Compton frequency of the electron, $\nu_e = c/\lambda = c/2\pi\bar{\lambda}$, and the expression for the change in the speed of light in the presence of an electron (Eq.(6)) becomes:

$$\frac{\Delta c}{c_0} = \text{Change per photon} \times \left[\text{Photon probability denstiy} \times \text{Frequencyp of path repetition}\right]$$

$$\frac{\Delta c}{c_0} = \left(\frac{\bar{\lambda}_{PL}^2}{\bar{\lambda}_c^2} \times \frac{2\bar{\lambda}_C}{r} \times \nu\right) \qquad (11)$$

Compare this with the expression for Gravitation Eq.(6), $\frac{\Delta c}{c_0} = \frac{\bar{\lambda}_{PL}^2}{\bar{\lambda}_c^2} \times \frac{2\bar{\lambda}_C}{r}$

Eq.(11), is the change in c as the result of the electron photon probability density, but the interaction of the photons between electrons requires the probability of the coincidence thus the product of the probabilities. It is the interaction between the particles that determines the coupling constant for the electrons (see Fine Structure Constant Appendix I).

Multiplying interactions of two particles in proximity gives:

$$\frac{\Delta c}{2c_0} = \left(\frac{\sqrt{2}\bar{\lambda}_{PL}^2}{\bar{\lambda}_c^2}\frac{c}{\lambda_e}\right)\left(\frac{\sqrt{2}\bar{\lambda}_{PL}^2}{\bar{\lambda}_c^2}\frac{c}{\lambda_e}\right)\frac{\bar{\lambda}_e}{r_1}\frac{\bar{\lambda}_e}{r_2}$$

For this to be correct as the change in the velocity of light in the presence of two electrons, the quantities in parenthesis must be the fine structure constant α, or:

$$\frac{\Delta c}{2c_0} = \frac{\alpha\bar{\lambda}_e}{r_1}\frac{\alpha\bar{\lambda}_e}{r_2} \tag{12}$$

The value of alpha α can be then written as:

$$\alpha = \frac{\sqrt{2}\,\bar{\lambda}_{PL}}{\bar{\lambda}_e}\nu_e \;\rightarrow\; \alpha = \nu_e\sqrt{\frac{2\mu_e}{\bar{\lambda}_e}} \rightarrow \nu_e m_e\sqrt{\frac{2G}{c\hbar}} \tag{13}$$

$$\alpha = 0.00729735253596$$

Appendix I shows proper inclusion of the gyromagnetic ratio and the value of G in the calculations to obtain accurate values. Only the error in the experimental value of G limits the accuracy of the calculation. By calculating the value of G from the other constants its precise value can be found to at least eleven significant digits.

The value of the index of refraction in this expression, Eq.(12), is at the position r_1 from the first particle thus valuating the index of refraction at the classical radius $r_1 = \alpha\bar{\lambda}_e$ of the first particle gives, the value function of the distance to the second particle. This is then the ratio of the potential energy to the total to the total energy of the particle, or the energy ratio of the potential to the total energy of the electron.

$$\frac{\Delta c_I}{2c} = \frac{1}{m_e c^2}\frac{Q^2}{\Delta r_{12}} \tag{1.1}$$

The interaction of two mass particles by gravitation

The gravitational interaction of two masses can be found using the same procedure for gravitation as charge, and Eq.(7).

The combined effect of the two particles at a point at a distance r from the fist point and that point being Δr_{12} from that point is:

$$\frac{\Delta c}{c_0} = \frac{\Delta c_1}{c_0}\frac{\Delta c_2}{c_0}, \tag{1.2}$$

The total index of refraction at change at is then:

$$\frac{\Delta c_T}{c_0} = \frac{2\mu_1}{r_1}\frac{2\mu_2}{\Delta r_{21}} \tag{1.3}$$

Since the value of the index of refraction is valid at any point it is convenient to pick a point a constant relative point independent of the relative motion

For the same reason as for the electric evaluation the evaluation point is set at the sum of the Schwarzschild radius.

$$|\vec{r}| = (2\mu_1 + 2\mu_2) \tag{1.4}$$

then

$$\frac{\Delta c}{c_0} = \frac{2\mu_1}{2(\mu_1 + \mu_2)}\frac{2\mu_2}{\Delta r_{12}} \tag{1.5}$$

Writing this out explicitly gives the index of refraction in terms of the particle separation thus:

$$\frac{\Delta c}{2c_0} = \frac{1}{(m_1 + m_2)c^2}\frac{Gm_1m_2}{\Delta r_{12}} \tag{1.6}$$

This is the proper value of the ratio of the potential energy to total energy of two gravitating particles or the energy extractable by a change in relative position.

Energy and the Index of Refraction

The first point is to note that the gravitation and electric potentials for an electron in Eq.(1.6), and Eq.(1.1), are identical accept for the factor of the Compton frequency ν

$$\text{Gravitation} \qquad \frac{\Delta c_e}{c} = \frac{\mu_e}{\lambda\!\!\!^{-}_e}\frac{2\lambda\!\!\!^{-}_e}{r_1} \qquad (1.7)$$

$$\text{Charge} \qquad \frac{\Delta c_e}{c} = \frac{\mu_e}{\lambda\!\!\!^{-}_e}\frac{2\lambda\!\!\!^{-}_e}{r_1}\nu_e \qquad (1.8)$$

The Δc term appears a factor in both potentials and is related to:

$$\begin{aligned} \frac{\Delta c}{2c_0} &= \frac{1}{mc^2}\frac{Q^2}{\Delta r_{12}} = \frac{\varepsilon_E}{\varepsilon} \\ \frac{\Delta c}{2c_0} &= \frac{1}{(m_1+m_2)c^2}\frac{Gm_1m_2}{\Delta r_{12}} = \frac{\varepsilon_G}{\varepsilon} \end{aligned} \qquad (1.9)$$

The left side of all these expressions is the ratio of the extractable potential energy for two particles to the total energy of the mass.

The relativistic change in energy to the total energy can be expressed the same form.

$$\frac{(m_0-m)c^2}{m^2c^2} = -\frac{1}{2}\frac{v^2}{c^2} = \frac{\Delta\varepsilon_K}{\varepsilon} \qquad (10)$$

The difference of the kinetic energy and the potential energy are the Lagrangian in conservative system so we can write the Lagrangian for both Gravitation and charge as:

$$\mathcal{L} = \frac{1}{2}\frac{v^2}{c^2} = \frac{\Delta c}{2c_0}, \qquad (11)$$

or a fundamental particle Lagrangian can be written:

$$\mathcal{L} = -\frac{1}{2}\left(1 - \frac{v^2}{c_0^2} - \frac{cc_0}{c_0^2}\right) \qquad (12)$$

Conclusion

Presented has been a plausible causation of gravitation and electrical charge interaction within the confines Quantum Theory in Minkowski four-space. The connection between the Gravitational constant and the Fine Structure constant presented here is unprecedented.

It has to be regarded as a new approach to physics, and as such, a degree of speculation has been incorporated, many parts lack mathematical rigor, but fit well with known physical parameters. How the postulates and speculation impact or elucidate the understanding of QM will be left to future clarification.

Hopefully the ideas presented here will lead to a better understand between Quantum Mechanics and Gravitation

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Appendix I

The calculation of the relation between the Gravitational constant and the Fne Structure Constant to eleven significant sigits

The interaction of the Feynman path photons resulting from the internal particle paths defines both gravitational and electrical forces [1],[2],[3]. As a result, the value of the fine structure constant is found expressed in terms of fundamental constants as:

$$\alpha^2 = \frac{2\lambda_{PL}^2}{\lambda_e^{\ 2}} \nu_e^{\ 2} \tag{13}$$

The constants are the Planck radius, $\lambda_{PL} = \sqrt{\mu\lambda} = \sqrt{G\hbar / c^3}$, the Compton radius λ_e, the anomalous gyromagnetic ratio $g_A = g_e/2$,and the electron Compton frequency $\nu_e \to m_e c^2 / 2\pi\hbar$. The Feynman photons of two interacting particles represent the first order quantum loop, and thus the wavelength and the reciprocal of the frequency of the electron must be corrected by the higher order perturbations included in the anomalous gyromagnetic ratio, $g_A = g_e/2$, and $\nu_e \to \nu_e / g_A$. The values of the constants are included in Table [1].

All of the constants in the expression are known to at least eleven significant digits, except the gravitational constant. The maximum number of digits for the gravitational constant known with experimental certainty is about three.

By solving for the gravitational constant (G) in Eq.(1), the expression becomes:

$$G = \frac{\alpha^2 2\pi^2 c\left(\lambda_e g_A\right)^4}{\hbar} \tag{14}$$

From these values the gravitational constant can be calculated to an accuracy of about eleven significant digits:

$\underline{G = 6.}6755053318 \text{ x } 10\text{-}8 \ cm^3 gm^{-1} s^{-2}$

This value is slightly higher (0.02%) than the current Codata consensus recommended value of 6.67430(15) x10- 11m3kg-1s-2, but it is not outside the scatter of measurements used in forming that consensus. It is within the error bars of all the experimental measurements conducted by the International Bureau of Weights and Measures, (BIPM), published since 2000, [4][5][6[[7]. Comparison with those values is presented below, Table [2].

The merit of this theory requires this relation to be correct. If it is wrong the theory is flawed.

Table 1

Constants and sources used in calculation, CGS units.

c = 2.9979245800E+10*	$g_A = g_e/2$ = 1.00115965218 †
$\hbar$ = 1.054571817646E -27 *	$\lambda\!\!\!^{-}_e = \hbar / m_e c$ = 3.8616633678E-11
a = 1/137.035999084 †	m_e = 9.1093837015(28)E -28 ⊕

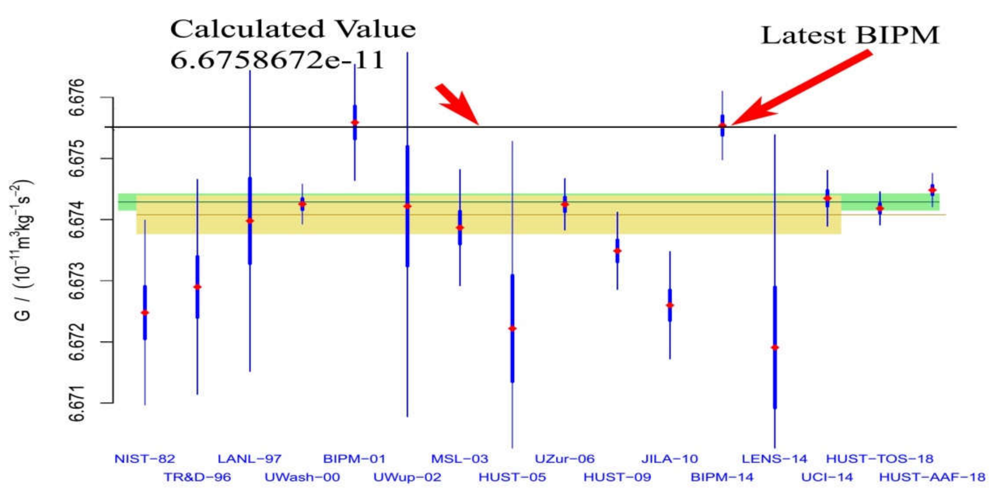
* Definition † Gabrielse et. al. [12][13] . ⊕2018 Codata Recommended Values

Table 2

Comparing calculated value of G with BIPM and Codata consensus values

Calculated value	G = 6.6755053318 x 10-11
BIPM weighted mean 2014	G = 6.67554(16) x 10-11
BIPM Sep, 2015	G = 6.67545(18)) x 10-11
BIPM 01-32-2001	G = 6.67559(27) x 10-11
Codata Consensus Value	G = 6.67430(15) x 10-11

[14],[15],[16],[17]18],[19].



Experimental values used for statistical calculation of Codata consensus value of G, [13]