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Quantum Gravity at 100TeV for Environmental or Theoretical Errors

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Abstract. An effective field theory approach to gravity suggests that the strength of the gravitational force depends on the scale at which gravitational force is measured by Cavendish type experiments or equivalent in principle gravitational scattering experiments. Based on this equivalence, we show that if the observed harmonic pattern of the laboratory-measured values of $G$ is due to some environmental or theoretical errors, these errors must also affect the true value of momentum $k$ transferred by the graviton in scattering experiments at the LHC. We find that environmental or theoretical errors could shift the scale of quantum gravity at 100TeV. Quantum gravity effects are at energy scales significantly beyond that of the LHC. This proposition may explain the current null results for black holes production at the LHC.

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1. Introduction
Newton's gravitational constant, $G$, has been measured about a dozen times over the last 40 years. Recently, John D. Anderson and coauthors [1] found that the measured $G$ values oscillate over time like a sine wave with a period of 5.9 years. They propose that this oscillation of measured $G$ values does not register variation of $G$ itself, but rather the effect of unknown factors on the measurements [56]. Furthermore, C.S.Unnikrishnan [57] provides a possible explanation to the 5.9-year period oscillation of
Klein (2015[2]) suggests that the observed discrepancies between $G$ values determined in different experiments may be associated with a differential interpretation of Modified Newtonian Dynamics (MOND) theory applied to the galaxy rotation curves. Recent quantitative analysis (Lorenzo Iorio, 2015[3]) rules out the possibility that the observed harmonic pattern of the laboratory-measured values of $G$ is due to some long-range modification of the currently accepted laws of gravitational interaction. As such, this analytical approach may direct future investigations of the systematic uncertainties that plague measurements of $G$.

Based on Symbolic Gauge Theory (SGT), a formalism applied to General Relativity (GR by R. Mignani, E. Pessa and G. Resconi [4,5] and further developed by I. Licata and G. Resconi, Manuel E. Rodrigues and the author [6,10,38]), G. Resconi and the author recently proposed a Non-Conservative Theory of Gravity (NCTG) which can explain the observed variations of $G$ at a 5.9-year scale [9].

The strength of the gravitational force depends on the scale at which the gravitational force is measured by Cavendish-type experiments, where two masses (one of which is a test mass) are precisely known, or by (equivalent in principle) gravitational scattering experiments [11]. At laboratory scales, the strength of gravity is characterized by the reduced Planck mass $M_{pl} = 2.435 \times 10^{18}$ GeV, which determines Newton’s constant $G_N = M_{pl}^{-2}$. The Planck scale $M_{pl}$ is conventionally interpreted as the fundamental scale at which quantum gravitational effects become important in nature. Like all other interactions in nature, however, the effective strength of gravity is affected by quantum corrections. This effect depends on the characteristic energy of the process probing gravitational interactions (see [12,13] for reviews of an effective theory of gravity). Potential problems of running gravitational couplings by focusing only on physically observable quantities (e.g. amplitudes, cross sections) are discussed in [14,15]. New approaches to the physics of particles with masses greater than 1 TeV could offer insights to the problem of the variation of measured $G_N$ values. In such models there is no hierarchy problem [16], whereas quantum gravity can be assessed through experiments at TeV energy levels. That this can be the case in extra-dimensional models is already established [17,18]. Is such modification of gravity also possible in four dimensions [19,39] Current data from the Large Hadron Collider (LHC) experiments at the European Laboratory for Particle Physics (CERN) do not confirm that gravity becomes stronger around 1 TeV [40-44].

In this paper we approach gravity as an effective field theory whereby the strength of the gravitational force depends on the scale at which the latter is measured by Cavendish type experiments or equivalent gravitational scattering experiments. Based on this equivalence, we show that if the observed harmonic pattern of the laboratory-measured values of $G$ is due to some environmental or theoretical errors, then these errors must affect the true value of momentum $k$ transferred by the graviton in the LHC scattering experiments.

2. The sinusoidal variations of Newton’s coupling constant

Measurements of the gravitational constant ($G$) are notoriously difficult due to the gravitational force being by far the weakest of the four known forces. Recent advances, making use of electronically controlled torsion strip balances at the Bureau International des Poids et Mesures (BIPM) in the last 15 years, have improved the accuracy of $G$ measurements (see [20] for details on experimental methods).
These recent measurements have also revealed a peculiar type of oscillatory variation, seemingly following a 5.9 years cycle akin to the so called Length-of-Day (LOD) [1]. Although we recognize that the correlation between G measurements and the 5.9 year LOD cycle could be fortuitous, we think that this is unlikely, given the striking match between these two (Fig. 1).

**Fig. 1:** Comparison of the CODATA set of G measurements with a fitted sine wave (solid curve) and the 5.9 year oscillation in LOD daily measurements (dashed curve), scaled in amplitude to match the fitted G sine wave. Acronyms for the measurements follow the CODATA convention. Also included are a relatively recent BIPM result from Quinn et al. [21] and measurement LENS-14 from the MAGIA collaboration [22] that uses a new technique of laser-cooled atoms and quantum interferometry, rather than the macroscopic masses of all the other experiments. The green filled circle represents the weighted mean of the included measurements, along with its one-sigma error bar, determined by minimizing the L1 norm for all 13 points and taking into account the periodic variation.

The observed correlation cannot be due to centrifugal force acting on the experimental apparatus, since changes in LOD are too small by a factor of about $10^5$ to explain changes in G. This is because the Earth’s angular velocity $\omega_e$ is by definition

$$\omega_e = \omega_0 (1 - LOD),$$

where $\omega_0$ is an adopted sidereal frequency equal to 72921151.467064 prad s$^{-1}$ and the LOD is in ms d$^{-1}$ (www.iers.org). The total centrifugal acceleration is given by

$$a_e = r_e \omega_0^2 \left[ 1 - 2A \sin \left( \frac{2\pi}{P} (t - t_0) \right) \right],$$
where \( A \) is the amplitude of the 5.9 year sinusoidal LOD variation (= 0.000150/86400) and \( r_s \) is the distance of the apparatus from the Earth’s spin axis. The maximum percentage variation of the LOD term is \( 3.47 \times 10^{-9} \) of the steady-state acceleration, while \( \Delta G/G \) is \( 2.4 \times 10^{-4} \). Even the full effect of the acceleration with no experimental compensation changes \( G \) by only \( 10^{-5} \) of the amplitude shown in Fig. 1.

Following Anderson et al. 2015a [1], the shift from the true value of renormalized gravitational constant is given by

\[
G(t)_{\text{shift}} = G_{\text{ren}} + \delta G(t)_{\text{Error}} = G_{\text{ren}} + B_G \sin(a_G t + \varphi) \quad (3)
\]

where

\[
B_G = 2G_{\text{ren}}A_G, \quad (4)
\]

and

\[
A_G = 10^{-4}, \quad \varphi = 80.9 \text{ deg}, a_G = 2\pi / P_G, P_G = 5.899 \text{ yr}. \quad \text{(Anderson et al. 2015a) [1]}
\]

Here, the variation term due to environmental or theoretical errors \( \delta G(t)_{\text{Error}} \) in equation (3) is given by

\[
\delta G(0,t)_{\text{Error}} = G_{\text{ren}} f(t)_{\text{Error}},
\]

\[
f(t)_{\text{Error}} = 2A_G \sin(a_G t + \varphi) \quad (5)
\]

where \( G_{\text{ren}} \) is renormalized gravitational constant, and \( f(t)_{\text{Error}} \) is the environmental or theoretical errors.

3. Quantum gravity and variations of Newton’s Constant due to environmental or theoretical errors

The strength of the gravitational force depends on the scale at which it is measured by Cavendish-type experiments or by equivalent in principle gravitational scattering experiments. Errors, due to some external conditions of the instrument (environmental errors), (inevitable) simplification of the modeled system (theoretical errors), or due to some other cause, can occur in Cavendish-type experiments. Such errors may be systematic: reproduced on every simple repeat of the measurement. Environmental or theoretical errors do not enter into the uncertainty [37]. If not identified and eliminated, these errors lurk in the background and cause a shift from the true value of the measured entity [37].

Here we examine the possibility that the harmonic variation of \( G \) is due to environmental or theoretical errors occurring in Cavendish-type experiments. Since Cavendish-type experiments at low energy scale are equivalent in principle with gravitational scattering experiments, we expect that the type of errors responsible for the variation of the renormalised gravitational constant must also affect the true value of momentum \( k \) transferred by the graviton in scattering experiments at LHC.

It has become a convention to interpret the Planck scale \( M_P \) as a fundamental scale of nature: the scale at which quantum gravitational effects become important. However, Newton’s constant \( G_N = M_P^{-2} \) in natural units \( \hbar = c = 1 \) is measured in very low-energy experiments, and its connection to physics at short distances – in particular, quantum gravity - is tenuous. If the strength of gravitational interactions is scale-dependent, the scale \( \mu_o \) at which quantum gravity effects are significant is one at which:
This condition implies that at length scales $\mu_*^{-1}$ gravity will be unsuppressed. Below we show that condition (6) can be satisfied in models with $\mu_*$ as small as a 100 TeV.

A scalar-tensor theory of gravity (STG), first proposed by Brans and Dicke [60], was inspired by a suggestion of Dirac’s that the gravitational constant $G_N$ varies with time [61]. In the Scalar-tensor theories of gravity, the gravitational action can be written:

$$S = \int d^4x \sqrt{-g} \left(-\frac{R}{16\pi G_N} f(\phi) + \frac{1}{2} g^{\mu\nu} (\partial_{\mu}\phi)(\partial_{\nu}\phi) - V(\phi) + F[\phi, g_{\mu\nu}] \right)$$  \hspace{1cm} [72]$$

What characterizes different STG models is the specific choice of $f(\phi)$, $V(\phi)$ and $F[\phi, g_{\mu\nu}]$, a local scalar function of $\phi$, $g_{\mu\nu}$ and their derivatives. The coefficient of the Ricci scalar $R$ in conventional General Relativity (GR) is proportional to the inverse of Newton’s constant $G_N$ [60–66]. In scalar-tensor theories, then, where this coefficient is replaced by some function of a field which can vary throughout space-time, the “strength” of gravity (as measured by the local value of Newton’s constant $G_N$) will be different from place to place and time to time [60–66].

Here, we propose a scalar-tensor gravity where the scalar field is the environmental or theoretical error $f(t)_{\text{error}}$ given by equation (5). We consider a scalar field $\phi$ coupled to the gravity, in the presence of environmental or theoretical errors $f(t)_{\text{error}}$ and adopt the following notation:

$$S = \int d^4x \sqrt{-g} \left(-\frac{R}{16\pi G_N} f_{\text{error}}(t) f_{\text{error}}^{-1} + \frac{1}{2} g^{00} (\partial_0 f(t)_{\text{error}})(\partial_0 f(t)_{\text{error}}) + \frac{1}{2} g^{\mu\nu} \partial_\mu \phi \partial_\nu \phi \right)$$

$$= \int d^4x \sqrt{-g} \left(-\frac{R}{16\pi \delta G_N(t)^{\text{error}}} + \frac{1}{2} g^{\mu\nu} \partial_\mu \phi \partial_\nu \phi \right), \hspace{1cm} (7)$$

where $(\partial_0 f(t)_{\text{error}})(\partial_0 f(t)_{\text{error}}) = 4a_G^2 A_G^2 \cos^2(a_G t + \phi)$, (vanish by equation.12). Without any loss of generality, we assume that the variation of the gravitational constant $\delta G_N(t)^{\text{error}}$ in the action $(7)$ is defined by equation. (5) for the absolute value of the function $|f(t)_{\text{error}}|$.

Consider the gravitational potential between two heavy, non-relativistic sources, which arises through graviton exchange (Fig. 2. [19]).

Fig. 2: Contributions to the running of Newton’s constant.
The leading term in the gravitational Lagrangian (7) is:

\[ (\delta G(t)^{\text{error}})^{-1} R = (\delta G(t)^{\text{error}})^{-1} h \left( \frac{\partial^2}{\partial t^2} - \nabla^2 \right) h , \]  

(8)

where

\[ g_{\mu\nu} = \eta_{\mu\nu} + h_{\mu\nu} . \]  

(9)

We can interpret quantum corrections to the massless gravitons propagators from the loop (similar to those given in Ref [19]) as a renormalization of \( \delta G(t)^{\text{error}} \). Neglecting the index structure [19], the massless graviton propagator with one-loop correction is:

\[ D(k) \approx \frac{i \delta G(t)^{\text{error}}}{k^2} + \frac{i \delta G(t)^{\text{error}}}{k^2} \sum \frac{i \delta G(t)^{\text{error}}}{k^2} + ...., \]  

(10)

where \( k \) is the momentum carried by the graviton in this model. The term in \( \Sigma \) proportional to \( k^2 \) can be interpreted as a renormalization of \( \delta G(t)^{\text{error}} \), and is easily estimated from the Feynman diagram (see Fig. 2):

\[ \Sigma \approx -ik^2 \int d^4 p D(p)^2 p^2 + ...., \]  

(11)

where \( D(p) \) is the propagator of the particle in the loop. In the case of a scalar field, the loop integral is quadratically divergent. By absorbing equation (11) into a redefinition of \( G \) in the usual way, one obtains an equation of the form:

\[ \delta M_{Pl}^2 = M_{Pl}^2(t) - M_{Pl}^2 = \frac{1}{G(t)^{\text{shift}}_{\text{ren}}} - \frac{1}{G_{\text{ren}}} = \frac{1}{2A_G |\sin a_G t + \phi|} = \frac{1}{\delta G(t)^{\text{error}}_{\text{ren}}} , \]  

(12)

where

\[ \frac{1}{G_{\text{ren}}} = \frac{1}{G_{\text{bar}}} + c \Lambda^2 [19] , \]  

(13)

\( \Lambda \) is the ultraviolet UV cutoff of the loop and \( c = 1/16\pi^2 \). \( G_{\text{ren}} \) is the renormalized Newton constant measured in low-energy experiments, for time scales \( \tau \ll t = 5.9 \text{ year} \). Fermions contribute with the same sign to the running of Newton’s constant, whereas gauge bosons contribute with the opposite sign to scalars.

Taking \( \Lambda_{QG} = \mu_* \) (so that the loop cutoff coincides with the onset of quantum gravity) gives \( G_{\text{bare}} = G(\Lambda_{QG}) = \mu_*^2 \). The requirement that \( G_{\text{ren}} = M_{Pl}^2 \) implies that \( \mu_* \) cannot be very different from the Planck scale \( M_{Pl} \), unless \( c \) is very large. For instance, to have \( \mu_* = 1\text{ TeV} \) requires \( c = 10^{32} \):
$10^{32}$ ordinary scalars or fermions with masses below 1 TeV (which can run in the loop). This observation has already been made by Dvali et al. [23, 24, 25], although in [23] the argument is expressed in terms of a consistency condition from black hole evaporation rather than as a renormalization of group behaviour [19,39]. The number of new degrees of freedom that we are required to introduce may seem high, but it is of the same order as in models with large extra-dimensions [17,18].

For equation (12), the square of reduced Planck mass $M_{Pl}^2(t)$ on Earth is given as follows:

$$M_{Pl}^2(t) = \frac{1}{G(t)_{ren}^{\text{shift}}} = \frac{1}{G_{ren}} \left[ 1 + \frac{1}{2A_G |\sin a_G t + \varphi|} \right]$$

(14)

Substituting equation (13) to equation (14) we obtain:

$$M_{Pl}^2(t) = \frac{1}{G(t)_{ren}^{\text{shift}}} = \frac{1}{G(t)_{bare}^{\text{shift}}} + N \frac{\Lambda(t)_{QG}^{\text{shift}}}{12\pi}$$

(15)

where

$$\Lambda(t)_{QG}^{\text{shift}} = \Lambda_{QG}^{\text{predicted}} \sqrt{1 + \frac{1}{2A_G |\sin a_G t + \varphi|}}$$

(16)

is the time-dependent shift of quantum gravity scale for the theoretically predicted value $\Lambda_{QG}^{\text{predicted}}$ in TeV theories of gravity on Earth due to the environmental or theoretical errors.

For equations (17) and (16), we observe that the possible environmental or theoretical errors that shifts the true value of renormalized gravitational constant $G_{ren}$ in Cavendish-type experiments at low energy scales is also responsible for the shift of the predicted value of the bare gravitational constant $G_{bare}(k)=1/k^2$ in gravitational scattering experiments at high energy scales. Here, $k$ is the bare momentum carried by the graviton. From equation (16), we find that the shift of quantum gravity for predicted value of 1TeV has the global minima:

$$\Lambda(t)_{QG}^{\text{shift}} = \Lambda_{QG}^{\text{predicted}} \min \left\{ \sqrt{1 + \frac{1}{2A_G |\sin a_G t + \varphi|}} \right\} = 100\Lambda_{QG}^{\text{predicted}} = 100\text{TeV}$$

(17)

at $\theta = a_G t + \varphi = 2\pi n + \frac{\pi}{2}$, for integer n,

where $A_G = 10^{-4}$ (Anderson et al. 2015a) [1], and $\Lambda_{QG}^{\text{predicted}} = 1\text{TeV}$ [17,18,19].

Environmental or theoretical errors that is responsible for the variation of the gravitational constant shifts the scale of Quantum gravity at 100TeV. Quantum gravity effects are at energy scales significantly beyond that of the LHC [30]. These effects can thus be investigated by a 100 TeV Proton-Proton Collider [31-33].
Substituting equation (17) to equation (15) we obtain the minimum shift of the square of reduced Planck mass $M^2_{\text{Pl}}(t)$:

$$M^2_{\text{Pl}}(\theta_n^{\text{shift}}) = M^2_{\text{bare}}(\theta_n^{\text{shift}}) + N \Lambda_{QG}(\theta_n^{\text{shift}}) \frac{2^{(\text{shift})}}{12\pi}$$

(19)

at $\theta_n = a_G t + \varphi = 2\pi n + \frac{\pi}{2}$, for integer $n$.

Following X. Calment et al [19], the large number of hidden degrees of freedom $N$ in equation (19), gives a modification of the Einstein-Hilbert action by includes scalars of more than second order in derivatives of the metric. We could imagine an action of the form:

$$S = \int d^4x \sqrt{-g} \left( \frac{R}{16\pi G_N} - f(t)_{\text{error}} |^{-1} + c_1 R^2 + c_2 R_{\mu\nu} R^{\mu\nu} + \ldots \right)$$

$$= \int d^4x \sqrt{-g} \left( \frac{R}{16\pi G_N^+} + c_1 R^2 + c_2 R_{\mu\nu} R^{\mu\nu} + \ldots \right)$$

(20)

where $(\partial_0 f(t)_{\text{error}})(\partial_0 f(t)_{\text{error}}) = 4a_G^2 A_G^2 \cos^2(a_G t + \varphi)$, (vanish by equation 12), and $\delta G_N(t)$ the variation of the gravitational constant given by equation. (5) and, $c_1$, $c_2$ are the coefficients of the curvature-squared terms studied by Stelle [58] and modify gravity at very small scales essentially unconstrained by experimenters. Stelle relates the coefficients in the terms $c_1 R^2$ and $c_2 R_{\mu\nu} R^{\mu\nu}$ to Yukawa-like corrections to the Newtonian potential of a point mass $M$ [19]:

$$\Phi(r) = -\frac{G_N M}{r} \left( 1 + \frac{1}{3} e^{-\tilde{m}_0 r} - \frac{4}{3} e^{-\tilde{m}_2 r} \right)$$

(21)

where

$$\tilde{m}_0^{-1} = \sqrt{32\pi \delta G_N^+(3c_2 - c_3)} , \quad \tilde{m}_2^{-1} = \sqrt{16\pi \delta G_N^+ c_3}$$

(22)

and $G_N$ is the low-energy Newton constant for time scales $\tau << t = 5.9$ year. Substituting equation. (5) to equations. (22) we obtain:

$$\tilde{m}_0^{-1} = m_0^{-1} \sqrt{2A_G |\sin(a_G t + \varphi)|} , \quad \tilde{m}_2^{-1} = m_2^{-1} \sqrt{2A_G |\sin(a_G t + \varphi)|}$$

(23)

with

$$m_0^{-1} = \sqrt{32\pi G_N (3c_2 - c_3)} , \quad m_2^{-1} = \sqrt{16\pi G_N c_3}$$

(24)

Then current bounds [10] from sub-millimeter tests of $\Phi(r)$ give, for both $m_0^{-1}$ and $m_2^{-1}$
yielding safe limits \( c_1, c_2 < 10^{0.1} \) (Calment et al. 2008) [19]. Substituting equation (25) to equations (23), we find that the maximum shift of the current bound [59] due to environmental or theoretical errors for the predicted value of 0.03cm:

\[
(\tilde{m}_0^{-1}, \tilde{m}_2^{-1})_{\text{max-shift}} < \sqrt{2A_G(0.03\text{cm})} = 4.5\mu m
\] (26)

For \(|\sin \theta_n| = 1\), at \( \theta = a_G t + \phi = 2\pi n + \frac{\pi}{2} \), for integer \( n \), where \( A_G = 10^{-4} \) (Anderson et al. 2015a) [1].

From equation (26), we observe that the wide variety of considerations as quantum gravity, extra-dimensions[17-19,39], etc., that suggest that gravitational inverses square law may break down in the experimentally accessible region 4.5\( \mu m \).

4. Production of black holes at the LHC in the presences of environmental or theoretical errors

In this section, we examine the possible effect of environmental or theoretical errors on the production of small black holes at the LHC and describe potential experimental fingerprints of this phenomenon. As long as environmental or theoretical errors are identified and eliminated, it is argued that, depending on the parameters of the model, semi-classical black holes [19,34,35] are potentially observable at the LHC.

The maximum shift to the cross-section at the parton level in the presence of environmental or theoretical errors is given by:

\[
\sigma(ij \rightarrow BH)_{\text{max-shift}} = \frac{M_{BH}^2}{\Lambda_{shift-QG}^4(t)} \bigg|_{\text{min}} = \frac{M_{BH}^2}{10^8 \Lambda_{QG}^4} = \frac{\sigma(ij \rightarrow BH)_{\text{predicted}}}{10^8},
\] (27)

where \( \Lambda_{QG}^{shift}(t)_{\text{min}} \) is given by equation (17), and

\[
\sigma(ij \rightarrow BH)_{\text{predicted}} = \frac{M_{BH}^2}{\Lambda_{QG}^4}
\] (28)

is the predicted cross-section at the parton level [19,24,25,19]. \( M_{BH} \) is the black hole mass.

If we take the predicted scale quantum gravity to be around 1 TeV ([17,18,19,39]), this cross section can be sizable for a semi-classical black hole mass of 3 TeV.

\[
\sigma(ij \rightarrow BH)_{\text{predicted}} = 9TeV^{-2}
\] (29)

Taking into account that not all of the energy of the partons can be used in the formation of the black hole (see, e.g., [36]), the cross-section for the parton level at the LHC should be

\[
\sigma(ij \rightarrow BH + X)_{LHC} = 200fb^{-1}
\] (30)

For a luminosity of 100 fb\(^{-1}\) this would yield \( 2 \times 10^5 \) semi-classical black holes [19].

From equation (27), the maximum shift to the cross-section at the parton level in the presence of systematic errors has the value:
\[
\sigma(ij \rightarrow BH)_{\text{shift}} = 10^{-8} \times \sigma(ij \rightarrow BH)_{\text{predicted}} = 9 \times 10^{-8} \text{TeV}^{-2}
\]

(31)

For LHC cross-section 200fb and luminosity of 100 fb$^{-1}$, environmental or theoretical errors would shift the value of semi-classical black holes to $2 \times 10^{-3}$. The model results are summarized in Table 1.

**Table 1:** Effect of error on experimental black hole production

<table>
<thead>
<tr>
<th>Luminosity (100 fb$^{-1}$)</th>
<th>Predicted by theory</th>
<th>Shift due to error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scale of QG (TeV)</td>
<td>1</td>
<td>100</td>
</tr>
<tr>
<td>Cross-section (TeV$^{-2}$)</td>
<td>9</td>
<td>$9 \times 10^{-8}$</td>
</tr>
<tr>
<td>Number of BH</td>
<td>$2 \times 10^{3}$</td>
<td>$2 \times 10^{-3}$</td>
</tr>
</tbody>
</table>

Black holes produced in experimental conditions, however, can only be observed if environmental or theoretical errors are identified and eliminated. This proposition may explain the current null results for black holes’ production at LHC.

5. Possible source of errors

In 2014, the UK’s Royal society hosted a conference titled “The Newtonian Constant of Gravitation, a constant too difficult to measure?” [67], which was intended to resolve the problem of large discrepancy between recent $G_N$ values. [68]

Another reasonable explanation for the discrepancy of $G_N$ measurements is that there is still some unknown physical cause. [68,46] In 2015, Anderson et al. claimed that the recent values of $G_N$ varied sinusoidally with a period of about 5.9 years by analyzing the measurement results [1], and they proposed that one possible reason for this variation was the activity of the Earth’s core. Then Schlamminger et al. corrected the acquisition time of these measurement results but did not find any remarkable correlation [46]. In 2017, Parra proposed that the temporal variation of $G_N$ was potentially caused by the sun’s dragging effect. [69] These hypotheses can be neither confirmed nor refuted at present, since the precision of $G_N$ measurement is low. $G_N$ measurements of higher precision, obtained by more methods, are, therefore, required.

Our analysis shows that errors, due to some external conditions of the instrument, simplification of the model system, or due to some other cause, occur in Cavendish-type experiments. Such errors could shift the scale of Quantum gravity at 100TeV and explain the current null results for black holes’ production at LHC. What could be a possible source of such errors?

A very interesting extension of scalar-tensor gravity put forward by Mbelek, Lachieze-Rey, T.E. Raptis, and Yang J et al [45-53] could allow electromagnetic (EM) fields to modify the space-time metric far more strongly than predicted by GR and standard TeV-theories of gravity. This model could explain the discordancy in the measurements of Newton gravitational constant as an effect of the Earth’s magnetic field on the measuring instruments.

It is possible that the oscillation of gravitational constant $G_N$ given by equation. (3) is an artifact of unrecognized large systematic errors of the measurement. If this is the case the connection with high energy experiments is improbable.
In future investigations within the framework of NCTG [9], we will show that the observed harmonic pattern of the laboratory measured values of $G$ contributes to the true scale at which quantum gravity effects are large [54]. Furthermore, we will find that the variation of quantum gravity scale over time entails some extreme UV/IR correlations, yields to quantum gravity at 100TeV. They could, therefore, have important repercussions for current early Universe cosmological problems [54].

6. Conclusion

An effective field theory approach to gravity suggests that the strength of the gravitational force depends on the scale at which it is measured by Cavendish-type experiments or equivalent in principle gravitational scattering experiments. Base on this equivalence, we show that if the observed harmonic pattern of the laboratory-measured values of $G$ is due to some environmental or theoretical, these errors must also affect the true value of momentum $k$ transferred by the graviton in scattering experiments at the LHC. We find that environmental or theoretical errors could shift the scale of Quantum gravity at 100TeV. Quantum gravity effects are at energy scales significantly beyond that of the LHC. This proposition may explain the current null results for black holes production at the LHC.

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