

Precise Ideal Value of the Universal Gravitational Constant G

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Abstract

In this paper, we are going to rely on the first law in physics through which we can obtain a precise ideal value of the universal gravitational constant, a thing which has not happened so far. The significance of this law lies in the fact that, besides determining a precise ideal value of the gravitational constant, it connects three different physical disciplines together, which are mechanics, electromagnetism and thermodynamics. It is what distinguishes this from other law. Through this law, we have created the theoretical value of the gravitational constant G_i and we found it equivalent to $6.674010551359 \times 10^{-11} \text{ m}^3 \cdot \text{kg}^{-1} \cdot \text{s}^{-2}$. In the discussion, the table of measurements of the gravitational constant was divided into three groups, and the average value of the first group G_1 which is the best precision, equals the following sum $6.67401 \times 10^{-11} \text{ m}^3 \cdot \text{kg}^{-1} \cdot \text{s}^{-2}$, and it's the same equal value to the ideal value G_i that results from the law, as shown through our research that any other experimental values must not exceed the relative standard uncertainty which has a certain amount that is equivalent to a value of 5.325×10^{-5} and that's a square value of the fine-structure constant.

Keywords

Gravitational Constant, Newtonian Parameter of Gravitation, Khromatic Theory, CODATA

1. Introduction

Although 3 centuries have elapsed since Newton set forth his gravitational law, physiology has been unable so far to create an exact theoretical value for the universal gravitational constant with no available values of the gravitational constant values except those values concluded by scientific experiments, especially conducted for obtaining the most accurate values of this constant.

We are going, in this research, to surmount this problem by way of setting

forth a universal gravitational constant sole theory value, to be calculated through an index of a law known in the Khromatic theory as “The Law of Gravitational Constant” [1], although another problem yet lies here, which is that all results of experiments relating to determining the value of gravitational constants are confined to two values: a greater value and a lower value.

To overcome this problem, we put forth a supposition that a certain marginal velocity can be a basis for calculating a gravitational greater value acceptable as an ideal value within a certain error rate. And to ascertain the validity of the hypothesis we compared, through discussion, the values we obtained with those on the gravitation **Table 2** of 2014 CODATA, as the comparison showed that in both cases the values were significantly close together, a thing that enabled us to solve the discrepancy between the theoretical and experimental values, consequently modifying **Table 2**, thereby we will have left behind an era of incessant attempts to find out the most accurate value of the gravitational constant.

2. Finding the Accurate and Approximate Value of the Gravitation Constant

2.1. The Precise Ideal Value of G

The law of gravitational constant looks like this:

$$G_i = \infty \left(\frac{k_B c}{e} \right)^2 \text{ m}^3 \text{ kg}^{-1} \text{ s}^{-2}$$

as,

G_i : ideal Universal gravitational constant ($\text{m}^3 \cdot \text{kg}^{-1} \cdot \text{s}^{-2}$)

C : Speed of light in vacuum (m/s)

e : Elementary charge (colum)

k_B : Boltzmann constant (J/K°)

∞ : Complex constant "multiplying more than one constant"

$= 10^{-19} (\text{mC}^2 \cdot \text{K}^2 \cdot \text{J}^{-2} \cdot \text{kg}^{-1})$

We are not going in our discussion, to deal with the method of the inference of this law, because of that it will be through another search that will be published completely, but we will content ourselves by reviewing the law and finds the precise ideal value of gravity through it.

Taking the values of the constants above from an abbreviated list of the 2014 CODATA recommended values of the fundamental constants of physics and chemistry, we get

C : 299792458 (m/s)

e : $1.6021766208(98) \times 10^{-19}$ (colum)

k_B : $1.38064852(79) \times 10^{-23}$ (J/K°)

So, using substitution in the value of constants we get the precise value of the gravitation constant equaling:

$$G_i = 10^{-19} \left(\frac{1.38064852 \times 10^{-23}}{1.6021766208 \times 10^{-19}} \times 299792458 \right)^2 \text{ m}^3 \cdot \text{kg}^{-1} \cdot \text{s}^{-2}$$

$$G_i = 6.674010551359 \times 10^{-11} \text{ m}^3 \cdot \text{kg}^{-1} \cdot \text{s}^{-2}$$

2.2. The Expected Value of the Gravitation Constant

Perhaps the ideal precise value of the gravitation constant is suitable for the static large blocks or those having negligible velocity-induced increment.

As for small masses moving at high speeds, it is more suitable to deal with relativity when calculated, however, we can handle expected values of the gravitational constant for experiments in which the body's velocity is so limited that the block's increment may be overlooked.

And to find such values, we can suppose that the block's laboratory speed limit should not exceed the orbital speed of electron in an atom of hydrogen and consequently the maximum expected gravitational value should not exceed a maximum value of the gravitational constant that is calculable using the equation.

$$G_{\max} = \frac{G_i}{(1-\alpha^2)} \text{ m}^3 \cdot \text{kg}^{-1} \cdot \text{s}^{-2} \text{ as,}$$

$$\alpha : \text{fine - structure constant} = 7.2973525664 \times 10^{-3}$$

And on calculation of this value we get the following:

$$G_{\max} = 6.674365970388 \times 10^{-11} \text{ m}^3 \cdot \text{kg}^{-1} \cdot \text{s}^{-2}$$

Hence we can deduce the ideal standard uncertainty value ΔG from the equation:

$$\Delta G_i = G_{\max} - G_i = 0.000355400102671 \times 10^{-11} \text{ m}^3 \cdot \text{kg}^{-1} \cdot \text{s}^{-2}$$

And the ideal value of the relative standard uncertainty is \bar{u}_r of the equation:

$$\bar{u}_r = \frac{\Delta G_i}{G_i} = 5.325135448 \times 10^{-5}$$

which is a somewhat an acceptable value.

3. Relationship between α and \bar{u}_r

Since

$$\Delta G_i = G_{\max} - G_i \text{ m}^3 \cdot \text{kg}^{-1} \cdot \text{s}^{-2}$$

$$G_{\max} = \frac{G_i}{(1-\alpha^2)} \text{ m}^3 \cdot \text{kg}^{-1} \cdot \text{s}^{-2},$$

Thus

$$\Delta G_i = \frac{G_i}{(1-\alpha^2)} - G_i = \alpha^2 G_i \text{ m}^3 \cdot \text{kg}^{-1} \cdot \text{s}^{-2},$$

and

$$\bar{u}_r = \frac{\Delta G_i}{G_i} = \frac{\alpha^2 G_i}{G_i} = \alpha^2$$

4. Discussion

In this discussion we are going to compare the ideal values we had got by theoretical means and the documented experimental values in CODATA gravitational tables, and we will show that the values are close in both cases.

4.1. Comparison of the Ideal and Results of Measurements of Gravitational Constant

Table 1, borrowed from CODATA Recommended Values of the Fundamental Physical Constants, 2010, summarizes the results of measurements of the Newtonian parameter of gravitation relevant to the 2010 adjustment [2].

In this table there are three groups of measurements [3].

- The first such group consists of six measurements with the average value of

$$G_1 = 6.67401 \times 10^{-11} \text{ m}^3 \cdot \text{kg}^{-1} \cdot \text{s}^{-2}$$

Standard uncertainty 0.00019×10^{-11} and relative standard uncertainty 28.5 ppm;

- The second one consists of four measurements with the average value of

$$G_2 = 6.67250 \times 10^{-11} \text{ m}^3 \cdot \text{kg}^{-1} \cdot \text{s}^{-2}$$

Standard uncertainty 0.00016×10^{-11} and relative standard uncertainty 24 ppm;

- The third one consists of one measurement with the value of

$$G_3 = 6.67559 \times 10^{-11} \text{ m}^3 \cdot \text{kg}^{-1} \cdot \text{s}^{-2}$$

Standard uncertainty 0.00027×10^{-11} and relative standard uncertainty 40 ppm.

Therefore, we conclude that the ideal value of the gravitational constant equals the sum

Table 1. Summary of the results of measurements of the Newtonian constant of gravitation relevant to the 2010 adjustment.

Source	Identification ^a	Method	$10^{-11} \text{ m}^3 \cdot \text{kg}^{-1} \cdot \text{s}^{-2}$	Rel.stand. uncert. ur
Luther and Towler (1982)	NIST-82	Fiber torsion balance, dynamic mode	6.67248 (43)	6.4×10^{-5}
Karagi�oz and Izmailov (1996)	TR&D-96	Fiber torsion balance, dynamic mode	6.6729 (5)	7.5×10^{-5}
Bagley and Luther (1997)	LANL-97	Fiber torsion balance, dynamic mode	6.67398 (70)	1.0×10^{-4}
Gundlach and Merkowitz (2000, 2002)	UWash-00	Fiber torsion balance, Dynamic compensation	6.674255 (92)	1.4×10^{-5}
Quinn <i>et al.</i> (2001)	BIPM-01	Strip torsion balance, Compensation mode, static deflection	6.67559 (27)	4.0×10^{-5}
Kleinevo�s (2002) and Kleinevo�s <i>et al.</i> (2002)	UWup-02	Suspended body, displacement	6.67422 (98)	1.5×10^{-4}
Armstrong and Fitzgerald (2003)	MSL-03	Strip torsion balance, compensation mode	6.67387 (27)	4.0×10^{-5}
Hu, Guo, and Luo (2005)	HUST-05	Fiber torsion balance, dynamic mode	6.67222 (87)	1.3×10^{-4}
Schlamming <i>et al.</i> (2006)	UZur-06	Stationary body, weight change	6.67425 (12)	1.9×10^{-5}
Luo <i>et al.</i> (2009) and Tu <i>et al.</i> (2010)	HUST-09	Fiber torsion balance, dynamic mode	6.67349 (18)	2.7×10^{-5}
Parks and Faller (2010)	JILA-10	Suspended body, displacement	6.67234 (14)	2.1×10^{-5}

$$G_i = 6.674010551359 \times 10^{-11} \text{ m}^3 \cdot \text{kg}^{-1} \cdot \text{s}^{-2}$$

which is extremely close to the average value G_i , that equals the following sum

$$G_1 = 6.67401 \times 10^{-11} \text{ m}^3 \cdot \text{kg}^{-1} \cdot \text{s}^{-2}$$

So we can choose the first group of G measurements as the best precision group of all others.

4.2. Comparison of the Ideal and 2014 CODATA-Recommended Value of the Gravitational Constant [4]

We learn from **Table 2** the recommended values of 2014 CODATA [4] as follows:

That is, based upon the above table, the experimental value of the gravitational constant should range from a maximum value of G_{\max} equaling 6.674390×10^{-11} to a maximum value G_{\min} equaling 6.673770×10^{-11} with G_0 as the arithmetic mean of the two values that equals 6.67408×10^{-11} .

4.2.1. The Ideal Value of the Gravitational Constant Equals the Sum

$$G_i = 6.674010551359 \times 10^{-11} \text{ m}^3 \cdot \text{kg}^{-1} \cdot \text{s}^{-2}$$

which is extremely close to the gravitational experimental value, that equals the following sum

$$G = 6.67408 \times 10^{-11} \text{ m}^3 \cdot \text{kg}^{-1} \cdot \text{s}^{-2}$$

4.2.2. Comparison of the Extent and Rate of Error

When comparing the ideal quantity of standard uncertainty, which equals

$$\Delta G_i = 0.000355400102671 \times 10^{-11} \text{ m}^3 \cdot \text{kg}^{-1} \cdot \text{s}^{-2}$$

To its counterpart mentioned in **Table 2**, which has the value:

$$\Delta G = 0.00031 \times 10^{-11} \text{ m}^3 \cdot \text{kg}^{-1} \cdot \text{s}^{-2}$$

we find great similarity in values.

4.2.3. Comparison of the Relative Error Rate

Likewise, when comparing the ideal value of the relative standard uncertainty, which equals:

$$\bar{u}_r = 5.325135448 \times 10^{-5}$$

To its counterpart contained in **Table 2** which has the value:

$$u_r = 4.7 \times 10^{-5}$$

Table 2. 2014 CODATA- recommended values of gravitation G , ΔG , \bar{u}_r , Concise form.

Newtonian constant of gravitation G	
Value	$6.67408 \times 10^{-11} \text{ m}^3 \cdot \text{kg}^{-1} \cdot \text{s}^{-2}$
Standard uncertainty ΔG	$0.00031 \times 10^{-11} \text{ m}^3 \cdot \text{kg}^{-1} \cdot \text{s}^{-2}$
Relative standard uncertainty u_r	4.7×10^{-5}
Concise form	$6.67408(31) \times 10^{-11} \text{ m}^3 \cdot \text{kg}^{-1} \cdot \text{s}^{-2}$

Table 3. Updated the values of gravitation G , ΔG , \bar{u}_r , Concise form.

ideal Newtonian constant of gravitation G_i	
Value	$6.6740105 \times 10^{-11} \text{ m}^3 \cdot \text{kg}^{-1} \cdot \text{s}^{-2}$
fine-structure constant α	$7.2973525664 \times 10^{-3}$
Standard uncertainty ΔG	$0.0003554 \times 10^{-11} \text{ m}^3 \cdot \text{kg}^{-1} \cdot \text{s}^{-2}$
Relative standard uncertainty \bar{u}_r	$5.325 \times 10^{-5} \alpha^2$
Concise form	$6.6740105 (3554) \times 10^{-11} \text{ m}^3 \cdot \text{kg}^{-1} \cdot \text{s}^{-2}$

we also find great similarity in values.

Therefore, we conclude that all ideal values we have obtained through the theoretical equations are extremely close to their experimental counterparts which we had got from **Table 2**, which shows the recommended values of 2014 CODATA, except that the ideal values are more accurate, having been theoretically concluded, and as such, the data of **Table 2** may be updated and substituted for the ideal values as illustrated below in **Table 3**.

5. Conclusions

There is a precise ideal value of the universal gravitational constant which equals $6.674010551359 \times 10^{-11}$.

That may be calculated through a theoretically concluded equation of its own, and the cause of discrepancy of the gravitation value is attributable to the circumstances of the experiment as well as the sophistication of the nature and speed of particles used to measure the gravitational constant in such experiments.

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