Fundamental Journal of Modern Physics
ISSN: 2249-9768
Volume 12, Issue 1, 2019, Pages 35-43
This paper is available online at http://www.frdint.com/
Published online September 11, 2019

A BRIEF ANALYSIS OF THE LATEST NEWTONIAN GRAVITATIONAL CONSTANT G RECOMMENDED VALUE BY CODATA 2018

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Abstract

Starting from the latest CODATA 2018 recommended value for the Newtonian gravitational constant G, certain unknown and interesting relationships between the speed of light, gravitational constant, electric charge, and temperature, are established by dimensional analysis. At the base of these relationships is number π which would prove the existence of certain circular shaped physical structures.

Applying dimensional analysis, Ognean established a new value for the Newtonian gravitational constant G equal to $6.67409076 \times 10^{-11}$ $\mathrm{m^3 kg^{-1} s^{-2}}$, [1]. This value was obtained by calculus using a relationship

Keywords and phrases: fundamental constants, gravitational constant, dimensional analysis.

Received July 7, 2019; Accepted July 23, 2019

between the Newtonian gravitational constant G, the square of the fine structure constant $(\alpha^{-1})^2$ and the Planck constant h, having the form: $2X_G = \pi(10X_\alpha / 2X_h)^2$, where X_G, $10X_\alpha$ and X_h are the normalized values (dimensionless) of these three constants [1]. The normalized values were established on the basis of so-called *characteristic lengths* calculated by dimensional analysis, starting from the fundamental constants CODATA 2014 recommended values. [2] The method used and the results obtained are presented in detail in ref. [1].

It has been considered that applying the dimensional analysis for correlating data on the fundamental constants has become much more interesting now after the 26th meeting of the General Conference on Weights and Measures (CGPM) [3] when meter and kilogram were defined in terms of speed of light c and $\Delta\nu Cs$ the transition frequency of the cesium 133 atom.

In the conclusion of his article Ognean wrote [1]: “We can admit that the next very accurate value of the gravitational constant could be different from the calculated value equal to $6.67409076 \times 10^{-11} m^3 kg^{-1}$ s^{-2}. But we consider that this dissimilarity between the measured values and the calculated value, is very important, whereas such difference could reflect a more subtle and unknown “liaisons” existing between the gravitational constant G, the Planck constant and the square of the fine structure constant $(\alpha^{-1})^2$”.

The most recent CODATA 2018 recommended values of the fundamental constants are available on https://physics.nist.gov/cuu/Constants/ [4]. In accordance with [4], the recommended value for the gravitational constant G is 6.6743×10^{-11} $m^3 kg^{-1} s^{-2}$. It is easy to see that between calculated value $6.67409076 \times 10^{-11} m^3 kg^{-1} s^{-2}$ and recommended value 6.6743×10^{-11} $m^3 kg^{-1} s^{-2}$ is a difference. It is further shown that this difference is very important because on its basis more subtle relationships between the fundamental constants can be highlighted. The method used for this purpose is based on characteristic lengths and normalized values detailed in ref. [1] (see Equations 24-32).

If the aforementioned method is applied, the G recommended value can be expressed as 6.6743×10^{-11} $m^3kg^{-1}s^{-2}$ = $(137188.735049\ m)^3$ $(2^{-85}kg^{-1}s^{-2})$ where 137188.735049 m is the characteristic length for G noted x_G. If the characteristic length $x_G = 137188.735049\ m$ is related to the characteristic length x_c for speed of light equal to 146383.03613 m (see Equation 28 in ref. [1]), a normalized value $X_G = 0.937190118973$ is obtained for gravitational constant G. If it is taken into account relationship $2X_G = \pi(10X_\alpha / 2X_h)^2$ results for $10X_\alpha$ the value 1.282864713493 that is slightly larger than 1.282858010144 that is the value for $10X_\alpha$ presented in ref. [1] (see Equation 32). It appears that in the case when CODATA 2018 recommended value G is taken into account, the normalized value $10X_\alpha$ for the square of the fine structure constant $(\alpha^{-1})^2$, has undergone growth similar to an expansion.

It is considered that this expansion could be directly related to the temperature.

Having in view the universal gases law $pV_m = RT$, a normalized value for the temperature is defined. For this aim, the molar gas constant $R = 8.314462618\ Jmol^{-1}\ K^{-1}$ and absolute temperature T = 273.15 K are taken into consideration. In accordance with $pV_m = RT$, we have $pV_m = 8.314462618\ Jmol^{-1}K^{-1} \times 273.15\ K = 2271.0954641067\ Jmol^{-1}$. If it is considered that $Jmol^{-1}$ is equal to $m^2kgs^{-2}mol^{-1}$, the following relationships can be written using characteristic lengths:

$$pV_m = 2271.0954641\,m^2kgs^{-2}mol^{-1} = (138026.55389\,m)^2(2^{-23}kgs^{-2}mol^{-1}),$$

$$R=8.314462618\ m^2kgs^{-2}mol^{-1}K^{-1}=(133623.248404\ m)^2(2^{-31}kgs^{-2}mol^{-1}K^{-1}).$$

If it is considered characteristic length for speed of light $x_c = 46383.03613\,m$ (see above and Equation 28 in [1]), the following normalized values for pV_m and R are obtained:

$$X_{pV_m} = 0.9429135884858 \text{ and } X_R = 0.91283287966117.$$

It is defined a normalized value X_T for the absolute temperature as the difference: $X_{pV_m} - X_R = X_T = 0.9429135884858 - 0.91283287966117 =$ 0.03008070882.

It has been shown above the normalized value $10X_\alpha$ for the square of the fine structure constant $(\alpha^{-1})^2$, has an expansion from 1.28285801014 to 1.282864713493. This expansion could be expressed by the following ratio: 1.282864713493 / 1.282858010144 = 1.000005225324. It is considered the difference 1.000005225324 – 1 = 0.000005225324 reflects the expansion as the temperature T effect.

If 0.000005225324 is related to $1.616255024 \times 10^{-35}\,m$ the Planck length [4] and $X_T = 0.03008070882$ the normalized value for temperature and the result is multiplied by 2^{161} is obtained

$$5.225324 \times 10^{-6} / (1.616255024 \times 10^{-35} \times 0.03008070882) \times 2^{161}$$
$$= 3.1415653 \times 10^{79}, \text{ a value very close to } \pi \times 10^{79}.$$

In the above relationship, the Planck length is considered a dimensionless value obtained when the Planck length is related to a unit of length as follows: $1.616255024 \times 10^{-35}\,m / 1m = 1.616255024 \times 10^{-35}$ (see Equation 15 in ref. [1]).

As a brief conclusion, we can say: the expansion of normalized value $10X_{\alpha}$ is in direct relation with the absolute temperature T = 273.15 K and number π.

A very interesting relationship is obtained if it is taken into consideration elementary electric charge, *e*. In SI electric charge, *e* is expressed in C (coulombs). It is well known when *e* is expressed in C an explicit connection between this dimension and a characteristic length is not possible to be established. But in cgs System, there is an explicit relationship between electric charge, *e*, and cm as a unit for length. In cgs System elementary electric charge, *e* is expressed by statcoulomb (stat C) or franklin (Fr). A statcoulomb is expressed in $g^{1/2}cm^{3/2}s^{-1}$. Between coulombs, C, and statcoulomb, stat C, there is the following conversion relationship [5]: 1 C ↔ 2997924580 stat C.

In this context elementary electric charge $e = 1.602176634 \times 10^{-19}$ C recommended by CODATA 2018 [4] is equal to $4.803204712557 \times 10^{-10}$ $g^{1/2}$ $cm^{3/2}s^{-1}$.

In fact, why is the unit system not so important in this case? In accordance with the dimensional analysis used here, the fundamental constants are expressed by a "*characteristic length*" and a "*global term*" including powers of number 2 and everything else quantities involved (see above). In this context, only the length direct related to the electric charge, *e*, is really important. It is not essential how this relation is performed. The essential idea is we have a relationship between time, space and mass governed by the Coulomb's law on electric charges.

Having in view the above value of $e = 4.803204712557 \times 10^{-10}$ $g^{1/2}cm^{3/2}s^{-1}$, we can write the following relationship using characteristic length:

$$e = 4.803204673 \times 10^{-10}\,\text{cm}^{3/2}\text{g}^{1/2}\ \text{s}^{-1}$$

$$= (17127495.84229\ \text{cm})^{3/2}(2^{-67}\text{g}^{1/2}\text{s}^{-1}).$$

How this characteristic length $x_e = 17127495.84229\ \text{cm}$ for electric charge *e* results? The explanation is the following: in the previous case, the characteristic length for speed of light is 146383.03613 m having the same magnitude as $10(\alpha^{-1})^2\text{m} = 187788.6504486\ \text{m}$ [1]. In the case of electric charge, *e*, the length is expressed in cm so that the magnitude order must be multiplied by 100. Instead of 187788.6504486 m must be 18778865.04486 cm. Similar instead of 299792458 m/s for the speed of light must be 29979245800 cm/s. In this case, a characteristic length for the speed of light very close to 18778865.04486 cm is $29979245800 / 2^{10+2/3} = 18443106.86\ \text{cm}$. It is noted that in this case, the power of number 2 includes the ratio 2/3 whereas in relationship appears $\text{cm}^{3/2}$.

Having in view the ratio between characteristic length for *e* equal to 17127495.84229 cm and the characteristic length for speed of light 18443106.86 cm is obtained the normalized value X_e for electric charge e : $X_e = 17127495.84229\ \text{cm} / 18443106.86\ \text{cm} = 0.928666518878.$

If we taken into consideration the difference between normalized value $X_c = 1$ for speed of light and the normalized value $X_G = 0.9371\ 90118973$ for G and the difference between $X_c = 1$ and $X_e = 0.92866\ 6518878$ for electric charge, *e*, the following relationships are obtained:

$$1 - X_G = 1 - 0.937190118973 = 0.06280988103 = 2 \times 3.14049052 \times 10^{-2},$$

$$1 - X_e = 1 - 0.928666518878 = 7.1333481122 \times 10^{-2}.$$

It appears that the difference $1 - X_G$ equal to $2 \times 3.14049052 \times 10^{-2}$ is very close to 2π. If 2π is related to 2 × 3.14049052 is obtained:

1.000349818236. If the difference $(1.000349818236 - 1) = 3.49818236 \times 10^{-4}$ is divided by 2^{185} is obtained $\dot{7}.133345331 \times 10^{-70}$, a value very close to $1 - X_e = 7.1333481122 \times 10^{-2}$ (see above).

Surely the following legitimate question may arise: how to compare $7.1333481122 \times 10^{-2}$ with $7.133345331 \times 10^{-70}$ or π with $\pi \times 10^{79}$? It must be underlined that in this method only dimensionless ratios - normalized values - are compared. The normalized values are not absolute values but they are universal ratios of the characteristic lengths of the fundamental constants. In these circumstances, these universal ratios can be compared with each other.

It is outlined that normalized values are universal constants they do not depend on the range in which the characteristic lengths are chosen. For example: if the characteristic lengths are chosen in the Planck range $(10^{-35}\,\text{m} = 10^{-33}\,\text{cm})$ is obtained for the speed of light a characteristic length $x_c = 1.34431587523 \times 10^{-33}\,\text{cm}$ whereas the speed of light $c = 2.99792458 \times 10^{10}\,\text{cm s}^{-1}$ can be expressed as $(1.34431587523.10^{-33}\,\text{cm})$ $(2^{144}\,\text{s}^{-1})$. At the same time electric charge, *e*, can be expressed as:

$$e = 4.80320471257 \times 10^{-10}\,\text{cm}^{3/2}\text{g}^{1/2}\text{s}^{-1}$$

$$= (1.248421144128 \times 10^{-33}\,\text{cm})^{3/2}(2^{133}\,\text{g}^{1/2}\text{s}^{-1}).$$

From these results the normalized value for e : $X_e = 1.248421144128 \times 10^{-33}\,\text{cm} / 1.344315875 \times 10^{-33}\,\text{cm} = 0.9286665188$ the exact the same as above.

In the context of this dimensional analysis is important to show that if the difference $1 - X_e = 1 - 0.928666518878 = 7.1333481122 \times 10^{2}$ is divided by 2^{267} is obtained $3.00804672 \times 10^{-84}$ a result very close to the normalized value $X_T = 3.008070882 \times 10^{-2}$ for the temperature absolute which is "responsible" for the expansion of normalized value $10X_\alpha$ (see above). This result reveals a very subtle relationship that exists between the speed of light, electric charge, and the absolute temperature.

Whereas all relationships between normalized values of the constants are based on the powers of number 2, there are also relationships between these powers [1]. For example: if it is considered the power 185 which appears in the above relationship between gravitational constant G and electric charge *e*, this power is media between the powers 243 and 127 or (243 + 127) / 2 = 370 /2 = 185. For more explanations concerning powers 243 and 127 see rel. 7 in table 1 and rel. 8 both presented by the author in ref. [6].

Conclusions

It was established that there is a relationship between the gravitational constant G, the square of the fine structure constant $(\alpha^{-1})^2$ and the Planck constant h, having the form: $2X_G = \pi(10X_\alpha / 2X_h)^2$, where X_G, $10X_\alpha$, and X_h are normalized values (dimensionless) of these constants [1]. On the basis of this relationship, a value very close to the gravitational constant G was calculated. The most recent recommendations from the CODATA show a gravitational constant G little bit larger than the one calculated. Taking into consideration this difference between recommended value and calculated value, new relationships between the speed of light, gravitational constant, electric charge and temperature were established by dimensional analysis. From this analysis appears that between normalized values of these constants there are relationships directly related to number π. Since these relationships are established on the basis of characteristic lengths ultimately results that they reflect in fact the geometrical ratios existing between certain circular physical structures.

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