A New Large Number Numerical Coincidences

Alexander Kritov
E-mail: alex@kritov.ru

In this article, the author gives a set of new hypothesis wherein he presents new, exact and simple relations between physical constants and numbers. The author briefly analyses the discovered coincidences in terms of their accuracy and confidence, while leaving himself aside any physical explanation of the presented formulas. Important: all the found relations have a common nature of the “power of two”. The exact nature of this remains unknown for yet, so it requires further research. The presented material may also be viewed as a logical continuation and development of Dirac’s and Eddington’s Large Numbers Hypothesis (LNH). However, in contrast to Dirac’s LNH, two of the presented ratios are not approximate but manifest exact equality. This allows a theoretical prediction of the Universe’s radius as well as a calculation of the exact value of Newtonian gravitational constant G, which all fall within the range of the current measurement data and precision. The author formulates these Large Number Numerical (LNN) coincidences by realizing that further discovery of their meaning may lead to a significant change in our understanding of Nature. In this work, SI units are used.

Introduction

Many attempts of bringing together physics and numerology had been done before but a very important step was done in 1938 by Arthur Eddington. According to Eddington’s proposal the number of protons in the entire Universe should be exactly equal to: $N_{Edd} = 136 \times 2^{256} \approx 10^{79}$ [1, 2, 17]. So, it was hypothesised that square root of N_{Edd} should be close to Dirac’s Big number $N \approx \sqrt{136 \times 2^{256}} = \sqrt{136} \times 2^{128}$. Later on, Eddington changed 136 to 137 and insisted that the fine structure constant has to be precisely 1/137, and then his theory seemed to fail at this cornerstone. However, Eddington’s statement also had the number $(2^{128})^2$ which has been left without proper attention. Actually, few years earlier, in 1929, it was German physicist R. Fürth who proposed to use 16^{32} (which is also 2^{128}) in order to connect gravitation to atomic constants [10]. However, all these coincidences have been left unexplained until present time. As G. Gamov said [16]: “Since the works of Sir Arthur Eddington, it has become customary to discuss from time to time the numerical relations between various fundamental constants of nature”. For example, another interesting attempt to use “a log-base-2 relation” between electromagnetic and gravitational coupling constant was made by Saul-Paul Sirag, the researcher from San Francisco in 1979 [12]. Particularly, as noted, power of 2 should have significant role in numerical relations for physics constants according to the author’s idea.

Suggested four Large Number Numerical (LNN) relations or coincidences are presented below. These coincidences are not dependent and related to each other, so prove or disprove of one of them does not mean the same for the others. They all have common number of 2^{128}. First two relations seem to be exact equations, and second two are valid with defined uncertainty. Because of that their nature is more hypothetical, so second two relations are also called “weak”.

1 Cosmological coincidence

The relation is analogous to famous Dirac’s ratio $R_U/r_e \sim 10^{40}$ which relates the Universe radius with classical electron radius. However, Dirac’s ratio is actually valid only approximately (with precision of “the same order of magnitude”), in opposite, the suggested replacement is an exact equation given as follows:

$$\frac{R_U}{\lambda_e} = 2^{128}, \qquad (1)$$

where R_U is value for the radius of the observable Universe and $\lambda_e = \hbar/m_e c \approx 3.86 \times 10^{-13}$ (m) is electron’s reduced Compton wavelength (De Broglie wave). The relation (1) provides us with precise size and age of the observable Universe. So it leads to exact value for the Universe radius of $R_U = 1.314031 \times 10^{26}$ meters corresponding to the Universe age of 13.8896 billion years.

Recently F.M.Sanchez, V.Kotov, C.Bizouard discovered that the use of the reduced electron Compton wavelength is decisive for the compatibility of the Hubble-Lemaitre length with 2^{128} [13–15]. They use this length unit because of proposed holographic relation involving it. Here, the author independently developes this idea suggesting that (1) is an exact relation.

The age of the Universe, according to the Wilkinson Microwave Anisotropy Probe (WMAP) 7-year results, is 13.75 ± 0.13 billion years [9]. Latest NASA observation by Hubble gives the age of the Universe as 13.7 billion years [3]. It is very close to the obtained value and lies in the existing error range. So, the coincidence (1) seems to define the exact Universe elapsed life time as:

$$T_U = \frac{\lambda_e}{c} 2^{128}. \qquad (1.1)$$

Important to note, that having (1.1), initial Dirac's relation may be expressed in the following form:

$$N_1 = \frac{R_U}{r_e} = \alpha^{-1}\, 2^{128}, \qquad (1.2)$$

where $\alpha^{-1} = 137.036$ is inverted fine structure constant and $r_e = ke^2/(m_e c^2)$ — classical electron radius with eliminated numerical factor (i.e. equal to unity) and N_1 is exact value for the large number introduced by Dirac (4.66×10^{40}). As we know for sure that the Universe is expanding and $R_U(t)$ is dependent on time, so the equation (1) suggest that one or few of the fundamental constants (h, c, m_e) should also vary in time. However, current uncertainty in R_U measurement still leaves a room for other alternative ideas and possible coincidences. For example, noting that $m_p/m_e \sim 40/3 \times \alpha^{-1}$, relation (1) can have another form:

$$R_U = \frac{m_p}{m_e}\frac{1}{4}\left(\frac{3}{10}\frac{ke^2}{m_e c^2}\right) 2^{128} \qquad (1.3)$$

which would correspond to 13.95809 Gyr. As this value is currently out of the present WMAP data frame, therefore it is not supported by the author here.

2 Electron-proton radius coincidence

Another interesting idea connects the classical proton radius and gravitational radius of the electron by an exact equation as follows:

$$\frac{r_p}{r_{ge}} = 2^{128}, \qquad (2)$$

where $r_p = \frac{1}{2}\frac{3}{5}ke^2/(m_p c^2)$ — classical proton radius and $r_{gp} = 2Gm_e/c^2$ — gravitational electron radius (i.e. the Schwarzschild radius for the electron mass). Of course some comments are required regarding coefficients $\frac{1}{2}$ and $\frac{3}{5}$. Usually numerical factors are ignored or assumed to be close to unity when defining classical (electron) radius. However, suggested new definition has exact numerical factor $\frac{3}{10} = \frac{3}{5} \times \frac{1}{2}$, so it is obvious to have the following explanations for that one by one:

- Ratio $\frac{3}{5}$ is classical proton radius definition. The only important difference with modern representation of the classical radius is the coefficient $\frac{3}{5}$. It is well known from electrostatics that the energy required to assemble a sphere of constant charge density of radius r and charge r is $E = \frac{3}{5}ke^2/r$. Usually these factors like $\frac{3}{5}$ or $\frac{1}{2}$ are ignored while defining the classical electron radius. Surprisingly, the coincidence advices the use of $\frac{3}{5}$ which means that charge is equally spread within the sphere of the electron (or proton) radius.
- Ratio $\frac{1}{2}$ in classical proton radius definition. Usual definition of the classical radius does not require having $\frac{1}{2}$ because initially one relates total electrostatic energy (E_e) of the electron (or proton) to rest mass energy as following: $E_e = mc^2$. The factor $\frac{1}{2}$ appears if one postulates that electromagnetic energy (E_{em}) of the electron or proton is just a half of particle's rest mass energy as: $E_{em} = \frac{1}{2}\, mc^2$. There are two possible alternative explanations for this:
  1. The Virial Theorem that tells us that the potential energy inside a given volume is balanced by the kinetic energy of matter and equals to half of it. So if one considers electromagnetic energy as kinetic and rest mass as potential energy we would have: $E_{em} = \frac{1}{2}\, mc^2$;
  2. Simply assuming that half of total energy may be magnetic energy or of another nature. One may also propose that there could be no $\frac{1}{2}$ in classical proton radius definition, but there is 2^{129} instead of 2^{129} in formula (2). From the author's point of view this does not correspond to reality, and particularly the number 2^{128} should have strong presence in all numerical expressions of Nature.

It can be easily seen that $r_p = (m_e/m_p)r_e$, so another way to rewrite (2) is:

$$\frac{r_e}{r_{ge}} = \frac{m_p}{m_e}\, 2^{128}. \qquad (2.1)$$

And this leads to another possible representation of the initial formula as:

$$\frac{r_e}{r_{gp}} = 2^{128}, \qquad (2.2)$$

where r_e is classical electron radius, r_{gp} is gravitational (Schwarzschild) radius of the proton. The expression (2.2) is very similar to (2). So, we may actually combine them into another interesting equation:

$$r_p\, r_{gp} = r_e\, r_{ge}. \qquad (2.2a)$$

The precision of the Electron-proton coincidence given by (2) is smaller than 0.02%. From the author's point of view this deviation originates from current uncertainty in gravitational constant (G) measurement. If we consider that the relative G uncertainty nowadays is around and not less than 0.02% then we must accept this amazing and unexplained coincidence that allows us to predict the exact value for the gravitational constant (G). So, this finding suggests that the following possible consequences are valid. Firstly, because of $\frac{3}{5}$ ratio proton or electron still may be considered as classical particle with uniform charge density inside its radius. And secondly, directly from (2) one can express the value of the Newtonian constant of gravitation (G) exactly as follows:

$$G = \frac{3}{20}\frac{ke^2}{m_p m_e}\, 2^{-128}. \qquad (2.3)$$

It leads to exact value for $G = 6.674632 \times 10^{-11}$. This value is within the frame of 2010 CODATA-recommended value with standard uncertainty given by: $6.67384 \pm 0.00080 \times 10^{-11}$ [6] (See also figure). One may compare this expression with the similar one obtained in 1929 by R. Fürth [10]:

$$G = \frac{hc}{\pi(m_p + m_e)^2} = 16^{32}$$

that is read in SI units for G as:

$$G = \frac{2\hbar c}{(m_p + m_e)^2}\, 16^{-32}.$$

It is interesting to compare it to (2.3) to note obvious similarity. However, one may see that the expression is not satisfactory because it leads to the value of ($G = 6.63466 \times 10^{-11}$) which has significant deviation (0.59%) and is far out of 2010 CODATA range. So, the expression 2.3 (which fits well to modern data) is quite challenging because it may be confirmed or disproved by future experimental data for G.

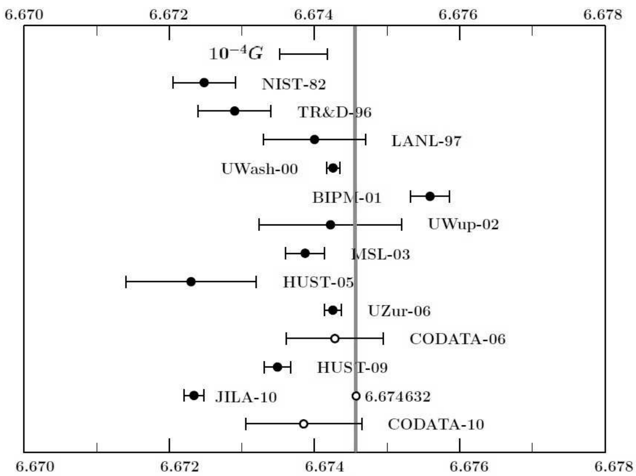

Fig. 1: The figure with recent experimental data for the Newtonian constant of gravitation G. The vertical line corresponds to the value obtained from (2.3).

Though the obtained value fits quite well into current experimental data, the author does not exclude some possible small deviations caused by vacuum polarisation and consequent slight deviation from the uniformity of the charge distribution (like Uehling Potential). So we will look at this in future works.

It is also important to stress that the use of classical proton radius here is very provisional and in principle could be avoided: so the same result for G may be obtained using only the electron's classical radius.

It is easy to note also that Dirac's Large Number N precisely equals to:

$$N = \frac{ke^2}{m_p m_e} = \frac{20}{3}\, 2^{128}. \tag{2.4}$$

This means that variation of Dirac's Large Number (N) in time is hardly possible, because 2^{128} represents simply the constant number. So the ratio of the electromagnetic force to the gravitational one remains always constant during the current epoch.

3 Weak cosmological coincidence

$$\frac{2c^3}{G} \approx \frac{m_p}{t_p}\, 2^{128}, \tag{3}$$

where c is speed of light, G is the gravitational constant, $t_p = \hbar/(m_p c^2)$-period of reduced Compton wave of the proton. This equation may be interpreted as relation of rate of mass growth or the expansion rate of the Universe [4, 5] to harmonic properties of the proton as wave. However the relative precision of (3) is 0.48% (or even 0.49% if we accept definition of G as in 2.3) which is unsatisfactory for modern measurements and it makes the expression valid only approximately. In order to become more precise the expression should have the following representation:

$$\frac{2c^3}{G} \approx \frac{m_p + 9m_e}{t_p}\, 2^{128}. \tag{3.1}$$

Or alternatively (to become exactly precise):

$$\frac{2c^3}{G} = \frac{m_p}{t_p}\frac{20}{3}\,\alpha^{-1}\, 2^{128}. \tag{3.2}$$

But further discussion of this topic will be explored in future works.

4 Weak electron-proton mass ratio

The attempts to explain large numbers by placing inverted fine structure constant in exponential function have been done many times before [11, 12]. Another interesting hypothesis could relate proton to electron mass ratio with fine structure constant and the number 2^{128} in the following manner:

$$\frac{m_p}{m_e} \simeq \frac{7}{2}\, 2^{(\alpha^{-1} - 128)}. \tag{4}$$

However the relative precision is comparably high (0.06%) and is out of the error frame of the current experimental data. However, using this relation as approximation, one can find similar connections of derived formulas to the similar ones in work [12].

Conclusion

The basic meaning of all these relations may be viewed in the form of exact equality for large Dirac's number N (see 2.4). However, all these proposals disprove one of the Dirac's hypothesis regarding the equality of the big numbers [2, see p. 200]. So, the author has shown that the number N, which is the ratio of the electromagnetic force to its gravitational force given by (2.4), is actually not equal to number N_1 which is the ratio of Universe radius to classical electron radius (1.2). However these two differ only by the numerical factor of $20.55 = \alpha^{-1} \times (3/20)$. So, the main conclusions of this study are as follows:

- Current Universe age and radius can be calculated exactly (13.8896 Gyr);
- The value of Newtonian constant of gravitation (G) can be derived exactly (6.674632×10^{-11});
- The number 2^{128} should have a real significance in the constants of Nature.

Generally the concept of "power of two" could be regarded as having two properties in science. Firstly, it is digital (logical) math where power of two has common use. So this may support an idea of holographic concept of the Universe or some of the fractal theories. Secondly, it is used in wave mechanics, and it could be viewed in accordance with wave properties of the elementary particles in quantum physics. In terms of wave concept, the number of 2^{128} corresponds to the tone of 128-th octave or to some higher harmonic ("overtone") of the main tone. It is interesting to mention that a very close idea has been brought few years ago. The idea relates particles mass levels within two sequences that descend in geometric progression from the Plank Mass. Sub-levels are arranged in subsequence of common ratio which uses a power of 2 [7, 8]. The author is also very supportive to the point of view given in [13–15], however it is important to stress that physics should be free from approximate relations and should have only precise equalities and formulas. Some of the exact formulas which may help to support such general ideas have been presented in this work. If new suggested relations for Large Numbers are correct then it should probably lead to new search for its hidden meaning. As always, we must accept the fact that in often cases new findings lead to new questions instead of the answers and that might become a new challenge for new investigations and theories. Assuming that at least one of the discovered relations is correct in the future we may become a bit closer to the true view on physical reality.

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