Holographic Principle derived from Mach's principle and Large Number Numerical Coincidences.

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The author provides the evidence that Holographic principle may be formally derived from Mach's principle and from two Large Number Numerical Coincidences hypothesized in recent author's work. Those, two main paradigms of the physics Holographic principle and Mach's principle may be connected with the use of Large Number Numerical Coincidences – new formal and exact relations for big Dirac's number. This provides new insight to the origin of mass of elementary particles as geometrical area related to its size, as well as formalizes the Whitrow-Randall's relation. Also it allows to calculate exact Eddington's "number of the particles" of the Universe with small correction corresponding to modern cosmological data with a greater extend. Few new conjectures on the nature of the fine structure constant are presented connecting α to proton-electron mass ratio and to Feigenbaum constant.

Introduction

Holographic principle is a new and modest principle in a modern physics. It was first pioneered by Jacob Bekenstein who assessed the informational limits of black holes and made related discovery of upper bounds on the entropy of matter systems. Basically the Holographic principle states that information placed within a certain volume can be encoded by its surrounding area. The holographic principle is also a property of modern string theories and a supposed property of quantum gravity that states that the description of a volume of space can be thought of as encoded by a boundary of the region. We can extend this principle for the mass. If such thing as mass quanta exists then the mass has to be related linearly to the information, so the mass has also to be linear with area.

Holographic principle – the cosmological formulation

Holographic principle can be formulated in different forms. For the purpose of this article we will use so called cosmological formulation of Holographic principle. It connects area of Universe horizon with geometrical property of the containing matter. So, the principle reads that the total area of the boundary of the visible Universe (denoted S_U) equals sum of all the effective areas of all elementary particles – protons and electrons:

$$S_U = N\, S_0$$

where we defined N – total number of electron and proton pairs and the effective area as: $S_0 = 4\pi\, r_{ep} * \lambda_{ep}$ where r_{ep} represents a classical radius of the charge with reduced proton-electron mass and λ_{ep} is De Broigle wave of the reduced proton-electron mass which is just the Compton wavelengths of the electron and the proton added together. Basically this value defines geometrical property of proton-electron pair.

Mach's principle in Whitrow-Randall's formulation

Let us start from recalling Whitrow-Randall's relation:

$$\frac{GM_U}{R_U c^2} \sim 1 \quad (1)$$

where M_U stands for mass of the visible Universe and R_U is the radius of the boundary of the visible Universe. Whitrow-Randall's formulation first suggested in 1946 by Whitrow [3] and in 1950 by P. Jordan who based his approach on A. Haas idea that the total energy of the Universe is zero. In [1] it has been shown that this formulation reflects the nature of Mach's principle.

In order to evaluate Whitrow-Randall's relation precisely we shall use modern experimental data. We can use well known experimental fact that that the density of the visible Universe is very close to critical density. This fact has justified by several means: that Universe geometry is a flat Euclidian and also by the Universe mass estimation via number of the stars and measurement of the Hubble radius. So, the critical density is

$$\rho_{cr} = \frac{3H^2}{8\pi G} = \frac{M_U}{\frac{4}{3}\pi R_U^3} \quad (2)$$

Latest WMAP data [4] confirms the fact that Hubble parameter is currently related to the boundary of the visible Universe as nearly:

$$H = \frac{c}{R_U} \quad (3)$$

Here we accepts that the age of the universe is R_U= 13.88 Gyr, which corresponds to Hubble parameter H= 70.42 km s^{-1} Mpc^{-1} (corresponding to WMAP data the best estimate is 70.4 ± 1.4 (km/sec)/Mpc)

So, (2) and (3) lead to exact relation for Universe radius and Universe mass. It precisely defines the factor in Whitrow-Randall's formulation likely to be equal to 2 rather than unity:

$$R_U = \frac{2GM_U}{c^2} \quad (4)$$

Of course, factor of 2 in Whitrow-Randall's relation leads to the known hypothesis that Universe may have origin as a black hole []. Though this can not be excluded, however it is worth to note that (4) it does not count for hypothetical dark matter.

Large Number Numerical Coincidences.

In 2013 the author formulated two strong Large Number Numerical Coincidences (abbreviated as LNNC). These coincidences are still lays within a good range of experimental data for Gravitational constant and Universe radius.

The first LNNC reads as

$$2^{128} = \frac{R_U}{\lambda_e} \quad (5)$$

This relation of De Broigle length to Universe radius remains a constant as it was first stressed in Schrödinger's work "[7]. However let is assume that this relation should be slightly modified. As Bohr radius of the hydrogen is defined using reduced proton-electron mass, we can also suggest here that we must use De Broigle length of the reduced mass, so the first LNNC also can be of the form:

$$2^{128} = \frac{R_U}{\lambda_{ep}} \quad (6)$$

Where λ_{ep} is De Broigle wave of the reduced proton-electron mass which is just the Compton wavelengths of the electron and the proton added together:

$$\lambda_{ep} = \lambda_e + \lambda_p = \frac{\hbar}{m_e c} + \frac{\hbar}{m_p c} = \frac{\hbar}{m_e c}\left(1 + \frac{m_e}{m_p}\right)$$

So, we may see that the difference between (5) and (6) is relatively small, or order of $1/\mu \sim 10^{-3}$. So (5) or (6) can not be tested as it is still below the precision of R_U measurement. Basically instead of usual electron mass we simply start using reduced electron mass. Interestingly that in this case the radius of the entire Universe can be considered as one of hydrogen's (number 2^{64}-th) orbit radius as per classical atom Bohr model, as Bohr atom model also uses reduced electron mass in its formulation for calculation of the orbit's radiuses.

Then, the second LNNC elaborated in [1] expresses the gravitational constant with good precision

$$G = \frac{3 * ke^2}{20 * m_e m_p} 2^{-128} \qquad (7)$$

In the work [] the author used definition for classical electron radius as $r_e = 3/10 * ke^2/(m_e c^2)$, so using this definition we can rewrite (7) using classical electron radius for reduced mass $r_{ep} = 3/10 * (m_e + m_p) * ke^2/(m_e m_p c^2)$, as:

$$G = \frac{r_{ep} c^2}{2 * (m_e + m_p)} 2^{-128} \quad (8)$$

We must note however that after my work [1] in private discussions I have received few notes where the factor 3/10 in such definition for classical electron radius was however properly criticized. At some extend I may agree that the use of 3/10 instead of 3/5 in the article seemed to be a bit artificial. However we must admit that there are several different ways to derive this alternatively. For example if total energy of the electron is a sum of E_p - positive energy or electrical repulsion within electron's charge and E_n- negative energy of attraction within electron responsible for charge stability as it would be in the classical model:

$$E_p + E_n = mc^2$$

so if these two energies are related as E_p - =2 E_n (which may seem similar to Virial theorem). So then $E_p = 2mc^2$ and we get 3/10 factor instead of 3/5. But while the mechanism underlying the classical electron stability is still not known, using factor of 3/10 instead of 3/5 seems not controversial to the general logic behind fundamentality of factor of 2 in LNNC relations.

The nature of the ratio 2^{128} has a deep meaning and may require further investigation. From author point of view is that it has digital nature and will be elaborated in another coming work. However for the purpose of current work we insert the ratio 2^{128} expressed with a form (6) into (8) to obtain:

$$G = \frac{r_{ep} \lambda_{ep} c^2}{2 * R_U (m_e + m_p)} \quad (9)$$

The most important to note that two variables which characterize the size of the electron and proton are placed into devisor of the expression. So now we have to insert this expression for G into exact Whitrow-Randall's (4):

$$R_U = \frac{2 M_U}{c^2} \frac{r_{ep} \lambda_{ep} c^2}{2 * R_U (m_e + m_p)} \quad (10)$$

So in order to understand the full meaning of the expression we move R_U into left hand side, and after such manipulation there were eliminated factors 2 and c squared, so we finally obtain:

$$\frac{R_U^2}{r_{ep}\lambda_{ep}} = \frac{M_U}{m_e + m_p} \quad (11)$$

As we have defined the effective area: $S_0=4\pi\ r_{ep}*\lambda_{ep}$, and as $N = \frac{M_U}{m_e + m_p}$ (11A) is actual number of the protons and electrons (or *proton electron pairs*) in the Universe then - multiplying both sides of (11) by 4π - we get total area of Universe's horizon as simple sum of all elementary particles effective areas:

$$S_U = N * S_0 \quad (12)$$

which is essential expression of the Holographic Principle. So we have derived exact formulation of Holographic Principle using only LNNC and Mach's principle.

Mass defect included

It is also important to note that $N = \frac{M_U}{m_e + m_p}$ is true only approximately, because it did not count neither for another form of the matter (such as neutrino or photons) nor for neutrons and nucleolus mass defect. To estimate approximate error let's consider the second abundant element in our Galaxy ($^4{}_2He$) which constitutes approximately ¼ of its total mass. The mass defect and neutron within nucleon contributes deviation of $7.4391*10^{-3}$ per proton-electron pair or $1.8598E*10^{-3}$ for total formula defining N, so the correction would be approximately as:

$$N \cong \frac{M_U}{0.99828*(m_e + m_p)} \quad (11B)$$

So the total Universe mass appears to be less because of negative binding energy of nucleons and pair's mass a bit lighter than their simple sum.

Number of particles in Universe

Using obtained result (left hand side of 11) it is possible to calculate exact number of the proton-electron pairs in the Universe - N. As we know that R_U can be found from (6), then we get

$$N = \frac{\lambda_{ep}}{r_{ep}} 2^{256} \quad (13)$$

The ratio of $\frac{\lambda_{ep}}{r_{ep}}$ can be calculated using definitions, and interestingly it does not depend on proton or electron masses but on fine structure constant only and it is equal to: $\alpha^{-1}*10/3$. So, rewriting (13) we can get the total number of electrons and protons in the Universe exactly as:

$$N = \frac{10}{3}\alpha^{-1} 2^{256} \quad (14)$$

Interestingly this result differs from obtained by Eddington number [8] only by ratio (10/3) which has origin as numerical factor in classical electron radius as it has been shown in [1].

Another coincidence for anti-matter

It is important to note that this number N defines total number of electron and protons, so the total number of particles will be 2N. If one includes antimatter also (antiproton and positron) which according to Markov [5] can be created outside the Universe Horizon, than the total number of the particles is 4N and in such case (14) should have a form:

$$N' = \frac{40}{3}\alpha^{-1}2^{256} \quad (15)$$

From my previous work [2] it is known that proton to electron mass ratio can be roughly approximated as:

$$\mu \approx \frac{40}{3}\alpha^{-1} = 1827.15 \quad (16)$$

This expression can become more precise if we take into consideration roughly estimated mass defect deviation (see 11B). As we have shown it to be equal to Δ=0.99828 – only using approximate data for Helium content of the Milky Way. So we can hypothesize that the total number of proton-electron pairs can be precisely equal to:

$$N = \frac{1}{4}\mu * 2^{256} \quad (17)$$

And respectively the factor ¼ in the expression is eliminated if we count the total number of particles including anti-particles in the Universe. This coincidence can have another representation: if we consider 1 proton and 1 electron. Now let's count all De Broglie pulsations that they have performed during Universe life time. Based on presented topics it is easy to calculate that for proton: $N_p=\mu*2^{128}$ and for electron: $N_e=2^{128}$. So, in such case, total number of 4 kinds of particles (proton, electron, antiproton and positron) equals to:

$$N' = N_e N_p \qquad (17A)$$

Having in mind that every De Broglie wave has 2 half-waves (maximum and minimum) every particle can correspond to 4 kind of intersection of proton and electron De Broglie pulsations. Interestingly we can draw such model not only using Universe time line but also on its Horizon sphere, which is another formulation of the Holographic principle. Here proton and electron go into perpendicular directions on a sphere corresponding to azimuth and zenith coordinates, so every particle quartet (proton, electron, antiproton and positron) corresponds to unit cell on the sphere with fixed zenith and azimuth angles.

Counting on dark matter

However, the mainstream of the modern physics suggests that the visible baryonic matter it is not the only matter. It constitutes only 4.9% of total Universe energy []. It is accepted that the rest is represented by dark matter (26.8%) and dark energy respectively. We have to note that 0.048 is 1/22.555 ratio. Such numerical factor is already known from my previous work [1] and it equals to $20.55=\alpha^{-1}*3/20$. So, in case if the total Universe mass including dark matter has baryonic origin than total number of particles N_{Total} can be obtained via multiplication of (14) by this factor and therefore:

$$N_{Total} = \frac{1}{2}*(\alpha^{-1}2^{128})^2 \qquad (18)$$

The equation has much simpler look than (11). However strangely appeared factor ½ must probably be responsible for proton and electron pairs and it will be equal to unity if we count total number of electron and protons. Then this equation also leads to the fact that effective area (see 11) per average proton-electron mass will be now defined as: $S_0=4\pi\ [\ ke^2/(m_e+m_p)c^2\ ]^2$, so it does not depend on fine structure constant neither on geometric factor 3/10 as it was above.

Few notes on fine structure constant nature

First of all the meaning of (14) is that the fine structure constant puzzle can be substituted by Large number (N) puzzle, namely finding the reason why the Universe has N electrons and protons can reveal the reason why the fine structure constant has such value.

The nature of fine structure constant can be also understood as constant which defines Planck constant:

$$\hbar = \alpha^{-1}\frac{ke^2}{c} \qquad (19)$$

The classical limit of quantum theory can be obtained with Planck constant set to zero, or equivalently as α^{-1} set to zero. Such limit should transfer quantum theory equations into their classical Newtonian form. Coming back to (14), we must speculate that classical limit would turn number of electrons and protons in the Universe N to zero. Another alternative explanation would be, if we look at the ratio of electron quantum size (λ_e) to its classical radius (r_e) which defines number of particles. So, in the classical limit the radio becomes unity as quantum size becomes a classical size. In any case this means that (14) has an origin in quantum physics and may appear to be a solution of certain equation for a quantum state.

From (16) we can derive the fine structure constant from proton to electron ration and the ratio which corresponds to mass defect ratio Δ defined by content of nucleons presented in the Universe:

$$\alpha^{-1} = \frac{3}{40}\mu * \Delta \quad (20)$$

In such case the fine structure constant represents simple derivation of the proton to electron mass ratio. For exact equality however it requires that Δ=0.99509517 which a bit less (0.3%) than our above estimate taken from Milky Way data for Helium as in (11B).

Another important conjecture connects the inverse fine structure constant with the Feigenbaum constant δ~4.669201609, discovered by mathematician Mitchel Feigenbaum in 1975. This constant is widely used in informational and fractal theories, so it definitely has a connection to statistics which stresses the statistical character of quantum theory. It also has connection to power of two by its definition.

The inverse fine structure constant can be expressed via Feigenbaum constant as:

$$\alpha^{-1} \sim 2\,\pi\,\delta^2 \qquad (21)$$

It becomes closer to modern value for α^{-1} if one would use Archimedean rational approximation for π=22/7 and Feigenbaum's series with bifurcation parameter with period of 512 where δ=4.66917155537963, see [9]. In such case the inverse fine structure constant would be equal to 137.035882. And, the main expression for Eddington number of particles (14) would look like:

$$N = 4\pi\frac{5}{3}(\delta * 2^{128})^2$$

Or with Archimedean approximation for Pi:

$$N = 8\frac{11*5}{7*3}(\delta * 2^{128})^2$$

The expression has only powers of first 5 prime numbers (2,3,5,7,11) and Feigenbaum constant. These expressions which may reveal the statistical nature of the fine structure constant and correspondingly number of particles in the Universe require further serious investigations.

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