Extended mass relation for seven fundamental masses and new evidences of Large Numbers Hypothesis

[1]Curtis J. Forsythe, [2]Dimitar T. Valev

[1]21204 East 173rd Street, Pleasant Hill, Missouri 64080, USA
[2]Space Research and Technology Institute, Bulgarian Academy of Sciences, 6000 Stara Zagora, Bulgaria

Abstract

A previously derived mass relation has been extended to seven equidistant fundamental masses covering an extremely large mass range from $\sim 10^{-69}$ kg to $\sim 10^{53}$ kg. Six of these masses have been successfully identified as: mass of the observable universe, Eddington mass limit of the most massive stars, mass of hypothetical quantum "Gravity Atom" whose gravitational potential is equal to electrostatic potential e^2/S, Planck mass, Hubble mass and mass dimension constant relating masses of stable particles with coupling constants of fundamental interactions. The seventh mass, $\sim 10^{-48}$ kg remains unidentified and could be considered as a prediction of the suggested mass relation for an unknown fundamental mass, most probably a yet unobserved light particle. First triad of these masses describes macro objects, the other three masses belong to particle physics masses, and the Planck mass appears intermediate in relation to these two groups. Additionally, new evidences of Dirac's Large Numbers Hypothesis (*LNH*) have been found in the form of series of ratios relating cosmological parameters and quantum properties of spacetime. A very large number on the order of 5×10^{60} connects mass, density, age and size of the observable universe with Planck mass, density, time and length, respectively.

Key words: mass relation, fundamental masses, Dirac's Large Numbers Hypothesis, Newtonian Constant of Gravitation, Avogadro's Number

1. Introduction

Discovery of theoretical or empirical mass relations for the many various particles is a great challenge for the recent high energy physics. A few formulae connecting the masses of particles having similar properties are known, for example hadron's multiplets (octets and decuplets of particles having close masses). Because of this, derivation of mass relations covering a very large range of particle masses is most desirable for the recent physics and astrophysics. Though be it rough, one of the first attempts to empirically derive 'Balmer's law' for several particles has been attempted in [1], wherein, $m_n \sim 137 m_e n$ is the mass of the *n*-th particle, m_e is mass of the electron, and n is an integer or half-odd. Based on SU(3) symmetry, the Gell-Mann – Okubo mass formula [2, 3] has been derived for baryon decuplet: $m_{\Delta -} m_{\Sigma} = m_{\Sigma} - m_{\Xi} = m_{\Xi} - m_{\Omega}$, where m_Δ, m_Σ, m_Ξ and m_Ω are the masses of respective hyperons. This formula successfully predicted the mass for the then undiscovered Ω^- hyperon. The mass relations of Georgi-Jarlskog [4] ensue from the SO(10) model and relate masses of charged leptons (e, μ and τ) and down-type quark (d, s and b) $m_e = m_d/3$, $m_\mu = 3m_s$ and $m_\tau = m_b$. However, these mass relations yield results that deviate significantly as compared to experimental data. It is postulated in [5] that a quantized magnetic self-energy of magnitude $3/2\alpha^{-1}n^4M_e$ be added to the rest mass of a lepton to get the next heavy lepton in the chain e, μ, τ,···, with n=1 for μ, n=2 for τ, etc. Here α is the fine structure constant, $M_e \simeq 0.511$ MeV is the rest mass of the electron and n is a new quantum number. Thus it was predicted M_τ=1786.08 MeV, and for the next lepton M_δ=10293.7 MeV. Koide has pointed out [6] that the mass relation $m_e+m_\mu+m_\tau = \frac{2}{3}\left(\sqrt{m_e}+\sqrt{m_\mu}+\sqrt{m_\tau}\right)^2$ is consistent with the measurements of the tau lepton mass. Found in [7] is a simple mass relation $m_i = \frac{m_e}{\propto} \propto_i (0)$, connecting masses of stable particles (p, e, ν_e and graviton) with coupling constants $\propto_i\ (0)$ of the four interactions, where α is fine structure constant and i = 1, 2, 3, 4. This mass relation covers an extremely wide range of values, exceeding 40 orders of magnitude and predicts a graviton mass on the order of 10^{-69} kg. Found in [8] is the mass relation:

$$M_n = m_e(\pi N\sqrt{3})^n\alpha^{(2n-1)} \tag{1}$$

where $N \simeq 6.02\times10^{23}$ is a large pure number and n = 1,2,3,4.

This mass formula produces four equidistant masses covering large range of 61 orders of magnitude. Mass $M_1 \simeq 2.18\times10^{-8}$ kg is apparent Planck mass, $M_2 \simeq 3.80\times10^{12}$ kg, the apparent mass of a hypothetical quantum "Gravity Atom" whose gravitational potential is equal to electrostatic potential e^2/S, $M_3 \simeq 6.63\times10^{32}$ kg has not been identified and $M_4 \simeq 1.16\times10^{53}$ kg is the assumed proper mass of the observable universe. In the present paper, we extend mass relation (1) to now produce seven equidistant fundamental masses covering extremely large mass range of 122 powers of magnitude.

It was noticed in [9] that the ratio of the age of the universe H^{-1} and the atomic unit of time $\tau = \frac{e^2}{m_e c^3} \simeq 10^{-23}\ s$ is a large number $N_D \simeq 4.64\times10^{40}$, where e is electron charge and c is speed of the light in vacuum. Besides, the ratio of mass of the observable universe M_u and nucleon mass is of the order of N_D^2, and the ratio of electrostatic $\frac{e^2}{r^2}$ and gravitational forces $\frac{Gm_em_p}{r^2}$ between proton and electron in a hydrogen atom is 2.27×10^{39}, were G is the Newtonian constant of gravitation and m_e and m_p are electron and proton masses respectively. These "coincidences" hint at a possible connection between macro and micro physical world known as Dirac Large Numbers Hypothesis (*LNH*). Many other interesting ratios have been found approximately relating some cosmological parameters and microscopic properties of matter. For example, Narlikar [10] shows that the ratio of the observable universe radius, cH^{-1}, and the classical electron radius, $\frac{e^2}{m_ec^2}$, is exactly equal to N_D. Besides, the ratio of the electron mass and Hubble (mass) parameter $\frac{\hbar H}{c^2}$ is 3.39×10^{38} [11]. Here $\hbar = \frac{h}{2\pi}$ is the reduced Planck constant and is H is the Hubble constant. Jordan [12] noted that the mass ratio for a typical star and an electron is of the order of 10^{60}. Also, the ratio of observable universe mass and Planck mass is on the order of 10^{61} [13]. Peacock [14] points out that the ratio of Hubble distance and Planck length is on the order of 10^{60}. Finally, the ratio of Planck density ρ_{pl} and recent critical density of the universe ρ_c is found to be on the order of 10^{121} [15]. These ratios between astrophysical parameters and microscopic properties of matter result mostly in large numbers that roughly agree with order of magnitude accuracy. In [16] has been derived a series of ratios relating cosmological parameters (mass M, density ρ_c, age H^{-1} and size cH^{-1} of the observable universe) and Planck mass m_{pl}, density ρ_{pl}, time t_{pl} and length l_{pl} , respectively:

$$\sqrt{\frac{M}{m_H}} = \frac{M}{m_{pl}} = \frac{m_{pl}}{m_H} = \frac{cH^{-1}}{l_{pl}} = \frac{H^{-1}}{t_{pl}} = \sqrt{\frac{\rho_{pl}}{\rho_c}} = \sqrt{\frac{c^5}{2G\hbar H^2}} = N_V \simeq 5.73 \times 10^{60} \quad (2)$$

These exact ratios represent connection between cosmological and quantum parameters of spacetime and thus appear to be a precise formulation and proof of *LHN.* In this paper we have found new evidences in support of *LNH* connecting cosmological parameters and microscopic properties of matter.

2. Brief review of mass relation concerning four fundamental masses.

In Section IIA of paper [8], Newton's law of universal gravitation is derived, based on postulated mass/energy resonance waves, wherein the Newtonian constant of gravitation factors as:

$$G = \frac{c^3\lambda_\Phi^2}{6\pi h N^2} = \frac{hc}{6\pi m_\Phi^2 N^2} = \frac{hc}{6\pi^3(\alpha m_e N)^2} = \frac{\hbar c}{3(\pi\alpha m_e N)^2} \simeq 6.6629 \times 10^{-11}\ \mathrm{m^3kg^{-1}s^{-2}} \quad (3)$$

where m_e is electron rest mass, λ_Φ – the resonance wavelength, m_Φ – the associated particle mass and N is a large pure number, curiously comparably with the 2006 recommended numerical value of Avogadro's number, that in terms of the fine structure constant α, and π, is shown to be given by:

$$N = (4\pi\alpha^5)^2 \times \sqrt{\frac{8}{3}} \simeq 6.022\ 139\ 582 \times 10^{23} \quad (4)$$

and will henceforth be designated as N_F. The Planck mass by convention is $m_p = \sqrt{\hbar c/G}$ [17], it follows, therefore, from Eq. (3) that the apparent Planck mass is given by:

$$m_p = \pi\alpha m_e N_F\sqrt{3} = m_e(\pi N_F\sqrt{3})^1\alpha^1 \simeq 2.178 \times 10^{-8}\ \mathrm{kg} \quad (5)$$

Additionally shown is that the resonance wavelength is equal to twice the first Boar orbit thus leading directly to :

$$m_\Phi = \pi\alpha m_e \simeq 2.088 \times 10^{-32}\ \mathrm{kg} \quad (6)$$

It is known that the fine structure constant α, the coupling constant of electromagnetic interaction, i. e. a measure of its strength, is determined by the formula:

$$\alpha = \frac{e^2}{\hbar c}$$

Taking into consideration this formula, we find from Eq. (3) that:

$$G = \frac{e^2}{3\pi^2 \alpha^3 m_e^2 N_F^2} \tag{7}$$

In Section IIC of paper [8], a hypothetical quantum "Gravity Atom" has been proposed, comprised of an electrically neutral central mass M_G orbited by an electrically neutral particle having electron mass m_e, such that the gravitational potential $GM_G m_e/S$ is equal to an electrostatic potential e^2/S, and S, the orbital radius, is a Bohr orbit. Thus, $GM_G m_e = e^2$, that in conjunction with Eq. (7) results in:

$$M_G = 3\pi^2 \alpha^3 m_e N_F^2 = m_e(\pi N_F \sqrt{3})^2 \alpha^3 \simeq 3.801 \times 10^{12} \text{kg}. \tag{8}$$

It is also of interest to note that this is the mass for which the Schwarzschild radius is equal to twice the classical electron radius.

Examination of Equations (5) and (8) suggests that the masses m_p and M_G are members of the following series:

$$M_n = m_e(\pi N \sqrt{3})^n \alpha^{(2n-1)} \tag{9}$$

where n is the placement within the series, and beginning at $n = 1$ it is found that:

$$M_1 = m_e(\pi N_F \sqrt{3})^1 \alpha^1 \simeq 2.178 \times 10^{-8} \text{ kg} \tag{10}$$
$$M_2 = m_e(\pi N_F \sqrt{3})^2 \alpha^3 \simeq 3.801 \times 10^{12} \text{ kg} \tag{11}$$
$$M_3 = m_e(\pi N_F \sqrt{3})^3 \alpha^5 \simeq 6.632 \times 10^{32} \text{ kg} \tag{12}$$
$$M_4 = m_e(\pi N_F \sqrt{3})^4 \alpha^7 \simeq 1.157 \times 10^{53} \text{ kg} \tag{13}$$

Identified above is the physical significance attributed to masses M_1 and M_2. Mass M_4 appears to be well within the range of estimates for the observable universe proper mass M_u [16, 18, 19] and as such, it represents the upper limit of the series.

3. Extended mass relation for seven fundamental masses

Upon extending the series downwards to n ≦ 0, we obtain:

$$M_0 = m_e(\pi N_F \sqrt{3})^0 \alpha^{-1} = \frac{m_e}{\alpha} \simeq 1.248 \times 10^{-28} \text{ kg} \tag{14}$$

$$M_{(-1)} = m_e(\pi N_F \sqrt{3})^{-1} \alpha^{-3} = \frac{m_e}{\pi N_F \alpha^3 \sqrt{3}} \simeq 7.154 \times 10^{-49} \text{ kg} \tag{15}$$

$$M_{(-2)} = m_e(\pi N_F\sqrt{3})^{-2}\alpha^{-5} = \frac{m_e}{3\pi^2 N_F^2 \alpha^5} \simeq 4.100\ \times 10^{-69}\ \text{kg} \tag{16}$$

Found from Eq. (7), the ratio of any two consecutive masses in the series is a constant, K , wherein:

$$K = M_{(n+1)}/M_n = \pi N_F \alpha^2\sqrt{3}\ \simeq\ 1.774\ \times 10^{20} \tag{17}$$

Therefore:

$$M_n = \frac{m_e}{\alpha}(\pi N_F \alpha^2\sqrt{3})^n = \frac{m_e}{\alpha}K^n = M_0 K^n \tag{18}$$

where $n = -2, -1, 0, \ldots, 4$

We now find that:

$$\frac{2M_1}{\pi K^3} = \frac{2M_4}{\pi K^6} = \frac{2m_p}{\pi K^6} = \frac{2M_u}{\pi K^6} \simeq 2.61 \times 10^{-69}\ \text{kg} \tag{19}$$

The current best estimates of H_o center around about 70 km $\text{s}^{-1}\text{Mps}^{-1}$. Thus, when m_H, the Hubble mass [20, 21], is defined as:

$$m_H = \frac{\hbar H}{c^2} \tag{20}$$

wherein H is the Hubble parameter, we find from Equation (20) an approximate value for m_H of 2.66×10^{-69}kg. This result is close to that from Equation (19). It is close enough in fact that either symbolic member of Equation (19) is assumed to accurately express the value of the Hubble mass concomitant with H. Therefore:

$$\frac{2m_p}{\pi K^3} = m_H \tag{21}$$

and

$$\frac{2M_u}{\pi K^6} = m_H \tag{22}$$

which upon elimination of K between the two results in:

$$m_H = \frac{2m_p^2}{\pi M_u} \tag{23}$$

and the final result upon substituting the right-hand member of Eq. (20) into Eq. (23) for m_H and solving for H, becomes:

$$H = \left(\frac{4c^2}{h}\right)\left(\frac{m_p^2}{M_u}\right) \tag{24}$$

If the Hubble mass is defined as (hH/c^2), as in [8] and [22], the value for m_H would be $\sim 1.64 \times 10^{-68}$ kg, so the left-hand members of Eqs. (21) (22) must then be multiplied by 2π to preserve the equalities, and Eq. (24) is still the final result.

As was proposed in [22], predicated upon the rate of cosmic expansion apparently transitioning from deceleration to acceleration at redshift ~0.5 [23], the deceleration parameter must have passed through a zero null point at transition, as the opposing operatives of cosmic expansion reached a transient state of equilibrium. Intuitively it would seem that the Hubble parameter at that juncture H_{eq}, the tipping point between deceleration and acceleration, must be tied to the mass of the universe via means of a unique relationship that existed at that juncture, as developed through Eqs. (20), (21), (22), and (23), leading to equation and result (24). However, it does not necessarily follow that the Hubble parameter is increasing along with the accelerating rate of cosmic expansion. Some theoretical considerations suggest that the Hubble parameter has now assumed a truly constant value in time and space. Others predict that even as the expansion accelerates, the Hubble parameter will continue to decrease asymptotically, approaching a limiting value of about 62, as the influence of the cosmological constant becomes more and more dominant over the contribution of matter after several billions of years and a several fold increase in the scale factor. It is thus reasonable to propose that H_o, the present day Hubble parameter, and H_{eq} are essentially identical. Thus:

$$H = H_{eq} = \left(\frac{4c^2}{h}\right)\left(\frac{m_p^2}{M_u}\right) \simeq H_o \simeq 68.634 \frac{\text{km}}{\text{s} \times \text{Mpc}} \tag{25}$$

A theoretical value for H_o of 68.658±0.1 km.s^{-1}, obtained via an entirely independent approach [24], is in excellent agreement with the above.

Since by original definition, the square of the Planck mass is:

$$m_p^2 = \frac{hc}{2\pi G}$$

Eq. (24) can be restated as:

$$H_{eq} = \frac{2c^3}{\pi G M_u} \simeq 68.634 \frac{\text{km}}{\text{s} \times \text{Mpc}} \tag{26}$$

and from Eq. (26), we obtain:

$$M_u = \frac{(2/\pi)c^3}{G H_{eq}} \simeq 1.157 \times 10^{53} \text{ kg} \tag{27}$$

the exact same result as that of Eq. (13). Additionally, from Eqs. (13) and (27) another interesting relationship results:

$$M_4 = M_u = \frac{(2/\pi)c^3}{GH_{eq}} = m_o(\pi N_F \sqrt{3})^4 \alpha^7 \simeq 1.157 \times 10^{53}\ \text{kg}$$

Three fundamental masses have been derived by dimensional analysis in [25], namely:

$$m_1 = \frac{\hbar H}{c^2} = m_H \tag{28}$$

$$m_2 = \frac{kc^3}{GH} \simeq M_u \tag{29}$$

$$m_3 = \sqrt[5]{\frac{H\hbar^3}{G^2}} \simeq 1.43 \times 10^{-20}\ \text{kg} \tag{30}$$

In form, Eq. (27) coincides exactly with equation (29) and the two are an identity when the dimensionless parameter *k*, on the order of unity, is identical with $2/\pi$.

The papers [8], [22] do not attribute any physical significance to mass M_3 (6.632×10^{32} kg) in the original n_1 through n_4 series. Recently we have identified this mass with the Eddington stellar mass limit where the outward pressure of the star's radiation balances the inward gravitational force [26, 27]. Besides, we have identified the mass M_0 ($\sim 1.248\ 10^{-28}$ kg) as exactly coinciding with the mass dimension constant in a basic mass equation from paper [7] relating masses of stable particles and coupling constants of the four fundamental interactions. It is interesting that this mass is approximately a half charged pion mass $M_0 = m_e/\alpha \simeq \frac{1}{2} m_{\pi^\pm}$. Mass $M_{(-1)}$ (7.154×10^{-49} kg) is presently unidentified and could feasibly be regarded as a prediction by the suggested model, Eq. (9), for a fundamental, albeit as yet unobserved light particle. Finally, mass $M_{(-2)}$ (4.100×10^{-69} kg) in the extended series is easily identifiable with the Hubble mass Eq. (19) as $0.5\pi m_H$. It is of further interest to note that the extended mass series includes seven equidistant fundamental masses covering a mass interval of 122 orders of magnitude, and that masses $M_{(-2)}$, $M_{(-1)}$, and M_0 are particle physics masses, whereas the masses M_2, M_3, M_4 describe macro objects, and the Planck mass M_1 appears intermediate in relation to these two groups. In fact, it is easily shown that the Planck mass, as given by Eq. (10), is the geometric mean of the extreme masses $M_{(-2)}$ and M_4 as given by equations (16) and (13), as is the geometric mean of masses m_1 and m_2 from equations (28) and (29) when k =1. The physical significance of mass m_3 from Eq. (30), if any, has not yet been identified.

4. New evidences of Dirac's Large Numbers Hypothesis

In [16], a series of ratios is derived relating cosmological parameters (mass, density, age and size of the observable universe) and Planck mass, density, time and length, respectively:

$$\sqrt{\frac{M}{m_H}} = \frac{M}{m_{pl}} = \frac{m_{pl}}{m_H} = \frac{cH^{-1}}{l_{pl}} = \frac{H^{-1}}{t_{pl}} = \sqrt{\frac{\rho_{pl}}{\rho_c}} = \sqrt{\frac{c^5}{2G\hbar H^2}} = N_V \simeq 5.73 \times 10^{60} \tag{31}$$

Where:

$M = \frac{c^3}{2GH} \simeq M_u$ is mass of Hubble sphere.

$m_{pl} = \sqrt{\frac{\hbar c}{2G}}$ is Planck mass defined as the mass whose reduced Compton wavelength and Schwarzschild radius r_s are equal.

$l_{pl} = r_s = \sqrt{\frac{2G\hbar}{c^3}}$ is Planck length and $t_{pl} = l_{pl}/c = \sqrt{\frac{2G\hbar}{c^3}}$

$\rho_{pl} = \frac{3c^5}{16\pi\hbar G^2}$ is Planck density defined as density of sphere of mass m_{pl} and radius l_{pl}

$\rho_c = \frac{3H^2}{8\pi G}$ is recent density of the universe equal to the critical one, H^{-1} – age of the universe and cH^{-1} is Hubble distance.

The ratios (31) appear very important because they relate cosmological parameters and the fundamental microscopic properties of matter. The Planck units imply quantization of spacetime at extremely short range. Thus, the ratios represent connection between cosmological and quantum parameters of spacetime and thus appear to be a precise formulation and proof of *LHN*. In addition, the very large number N_V and Dirac's large number N_D[9] seem connected by the approximate formula:

$$N_D \simeq N_V^{\frac{2}{3}} = \sqrt[3]{\frac{c^5}{2G\hbar H^2}} \simeq 3.2 \times 10^{40} \tag{32}$$

We construct a similar series to (31) involving ratios of the same parameters but using exact values, with the exception of that for the Hubble mass, resulting from papers [8, 22], producing the very large number N_{VF}, as follows:

$$\sqrt{\frac{2}{\pi}\frac{M_u}{m_H}} = \frac{M_u}{m_{pl}} = \frac{2}{\pi}\frac{m_{pl}}{m_H} = \frac{2}{\pi}\frac{cH^{-1}}{l_{pl}} = \frac{2}{\pi}\frac{H^{-1}}{t_{pl}} = \frac{2}{\pi}\sqrt{\frac{\rho_{pl}}{2\rho_c}} = \frac{2}{\pi}\sqrt{\frac{c^5}{G\hbar H^2}} = N_{VF}$$
$$\simeq 5.31 \times 10^{60} \tag{33}$$

Where:

$$M_u = \frac{(2/\pi)c^3}{GH_{eq}}$$

$$m_H = \frac{\hbar H}{c^2}$$

$$m_{pl} = \sqrt{\frac{hc}{2\pi G}}$$

$$H = H_{eq} = \frac{2c^3}{\pi G M_u}$$

$$l_{pl} = \sqrt{\frac{G\hbar}{c^3}}$$

$$t_{pl} = l_{pl}/c = \sqrt{\frac{G\hbar}{c^5}}$$

$$\rho_{pl} = \frac{3m_{pl}}{4\pi l_{pl}^3} = \frac{3c^5}{4\pi\hbar G^2}$$

$$\rho_c = \frac{3H^2}{8\pi G}$$

Thus, the above ratios also represent a connection between cosmological and quantum parameters of spacetime and so also appear to be possible new evidences of *LNH*. Recalling Eq. (17), it is noteworthy that apparently: $N_{VF} = K^3 = (\pi N_F \alpha^2 \sqrt{3})^3 \simeq 5.313 \times 10^{60}$and that N_{VF} and Dirac's large number N_D seem connected by the approximate formula:

$$N_D \simeq N_{VF}^{\frac{2}{3}} = K^2 = (\pi N_F \alpha^2 \sqrt{3})^2 = \sqrt[3]{\frac{4c^5}{\pi^2 G\hbar H^2}} \simeq 3.04 \times 10^{40} \qquad (34)$$

Thus, by independent approaches it is apparent that we obtain very similar results.

From Eq. (28), it follows that:

$$N_F^2 = \frac{(N_{VF})^{\frac{2}{3}}}{3\pi^2\alpha^4} = \frac{K^2}{3\pi^2\alpha^4} \qquad (35)$$

That upon substitution into Eq. (1) for N_F^2 results in:

$$G = \frac{\alpha^2 \hbar c}{m_e^2 K^2} \tag{36}$$

Thus, Eqs. (35) and (36) would indicate a possible relationship connecting $N_{F,}$ as well as N_A to *LNH*, and therefore to *G* through the unique and apparently new fundamental constant *K*.

5. Conclusions

Mass relation (9) obtained in [8] has been extended from n = – 2 to n = 4. The result is seven equidistant fundamental masses M_n, covering a mass interval of 122 orders of magnitude, have been obtained. Six of these masses are successfully identified, namely:

$M_1 \simeq 2.178 \times 10^{-8}$ kg the apparent Planck mass, $\sqrt{(\hbar c/G)}$, that is very important in resent particle physics.

$M_2 \simeq 3.801 \times 10^{12}$ the mass of a hypothetical quantum "Gravity Atom" that gravitational potential $GM_G m_o/S$ is equal to electrostatic potential e^2/S and *S* is a Bohr orbit.

$M_3 \simeq 6.632 \times 10^{32}$ kg is of the order of the Eddington mass limit of the most massive stars.

$M_4 \simeq 1.157 \times 10^{53}$ kg is close to the mass of the Hubble sphere and most probably appears to be mass of the observable universe.

$M_0 \simeq 1.248 \times 10^{-28}$ kg exactly coinciding with a mass dimension constant in a basic mass equation relating masses of stable particles and coupling constants of the four interactions. This mass is approximately a half charged pion mass.

$M_{(-2)} \simeq 4.100 \times 10^{-69}$ kg is easily identifiable with the Hubble mass as $0.5\pi m_H$.

The sixth mass $M_{(-1)} \simeq 7.154 \times 10^{-49}$ kg remains yet unidentified and could be regarded as a prediction by the suggested mass relation for unknown fundamental mass, most probably a yet unobserved light particle. Apparently, masses $M_{(-2)}$, $M_{(-1)}$, and M_0 are particle physics masses, whereas the masses M_2,M_3, M_4 describe macro objects, and the Planck mass M_1 appears intermediate in relation to these two groups.

Finally, new evidences of *LNH* have been found in the form of series of ratios (33) relating cosmological parameters and quantum properties of spacetime. In addition, the very large number $N_{VF} = K^3 = (\pi N_F \alpha^2 \sqrt{3})^3 \simeq N_V = \sqrt{\frac{c^5}{2G\hbar H^2}} \simeq 5.73 \times 10^{60}$ connects mass, density, age and size of the observable universe with Planck mass, density, time and length respectively, where K is a unique and apparently new fundamental constant.

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