EXTENDED MASS RELATION FOR SEVEN FUNDAMENTAL MASSES AND NEW EVIDENCE OF LARGE NUMBERS HYPOTHESIS

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ABSTRACT

A previously derived mass relation has been extended to seven equidistant fundamental masses covering an extremely large mass range from ~ 10^{-69} kg to ~ 10^{53} kg. Six of these masses are 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, ~ 10^{-48} kg remains unidentified and could be considered as a prediction of the suggested mass relation for an unknown fundamental mass, potentially 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 Large Numbers Hypothesis (*LNH*) have been found in the form of series of ratios relating cosmological parameters and quantum properties of space-time. 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 Large Numbers Hypothesis, Newtonian Constant of Gravitation

1. INTRODUCTION

Discovery of theoretical or empirical mass relations for the many various particles is a great challenge for the recent high-energy physics and astrophysics, and derivation of mass relations covering a very large range of particle masses is most desirable. Known are a few formulas connecting the masses of particles having similar properties, one such, is Hadron's multiplets (octets and decuplets of particles having close masses).

Though imprecise, one of the first attempts to empirically derive 'Balmer's law' for several particles has been attempted from Nambu (1952), wherein, $m_n \sim 137nm_e$ 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 (Gell-Mann, 1961; Okubo, 1962) 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 (1979) 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 (Barut, 1979) that a quantized magnetic self-energy of magnitude $3m_e n^4/(2\alpha)$ 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, $m_e \approx 0.511$ MeV is the 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 (1993) has pointed out that the mass relation $m_e + m_u + m_\tau = (2/3)(\sqrt{m_e} + \sqrt{m_\mu} + \sqrt{m_\tau})^2$ is consistent with the measurements of the tau lepton mass. Found in

(Valev, 2008) is a simple mass relation $m_i = m_e \alpha_i(0)/\alpha$ connecting masses of stable particles (proton, electron, neutrino ν_e and graviton) with coupling constants $\alpha_i(0)$ of the four interactions, 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 (Forsythe, 2009) is the derived mass relation:

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

where N ~ 6.02×10^{23} is a large pure number and n = 1,2,3,4.

This mass formula produces four equidistant masses covering a large range of 61 orders of magnitude. Mass M_1 ~ 2.18×10^{-8} kg is apparent Planck mass $m_P = (\hbar c/G)^{1/2}$, M_2 ~ 3.80×10^{12} kg is the apparent mass of a hypothetical quantum "Gravity Atom" whose gravitational potential is equal to electrostatic potential e^2/S, M_3 ~ 6.62×10^{32} kg has not been identified and M_4 ~ 1.16×10^{53} kg is the assumed proper mass of the observable universe. Now, in the present paper, we extend mass relation (1) to produce seven equidistant fundamental masses covering extremely large mass range of 122 powers of magnitude.

Dirac (1937) noticed that the ratio of the age of the universe H^{-1}, the inverse of the Hubble parameter, and the atomic unit of time, $\tau = e^2/m_e c^3 \cong 10^{-23} s$, is a large number N_D ~ 4.64×10^{40}, where e is electron charge and c is speed of light in vacuum. Additionally, 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 e^2/r^2 and gravitational forces $Gm_e m_p/r^2$ 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 microphysical world known as Dirac Large Numbers Hypothesis (*LNH*). Many other interesting ratios have been found approximately relating some astrophysical (cosmological) parameters and microscopic properties of the matter. For example Jordan (1947) noted that the mass ratio for a typical star and an electron is of the order of 10^{60}. Narlikar (1977) shows that the ratio of the observable universe radius, cH^{-1}, and the classical electron radius, $e^2/m_e c^2$ is exactly equal to N_D. Additionally, the ratio of the electron mass and Hubble mass parameter $\hbar H/c^2$ is 3.39×10^{38} (Cetto et al., 1986). Here $\hbar = h/(2\pi)$ is the reduced Planck constant and H is the Hubble constant. Peacock (1999) points out that the ratio of Hubble distance cH^{-1} and Planck length l_P is on the order of 10^{60}. Besides, the ratio of Planck density ρ_P and recent critical density of the universe ρ_c is found to be on the order of 10^{121} (Andreev and Komberg, 2000). Further, the ratio of observable universe mass and Planck mass is on the order of 10^{61} (Shemi-zadeh, 2002). These ratios between astrophysical parameters and microscopic properties of matter result mostly in large numbers that roughly agree with order of magnitude accuracy. Valev (2012) 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_P, density ρ_P, time t_P and length l_P) respectively, resulting in a very large number N_V, wherein m_P is defined as the mass whose reduced Compton wavelength and Schwarzschild radius r_s are equal, l_P is identical with r_s, and ρ_P is defined as the density of a sphere having mass m_P and radius l_P.

$$\sqrt{\frac{M}{m_H}} = \frac{M}{m_P} = \frac{m_P}{m_H} = \frac{cH^{-1}}{l_P} = \frac{H^{-1}}{t_P} = \sqrt{\frac{\rho_P}{\bar{\rho}}} = \sqrt{\frac{c^5}{2G\hbar H^2}} = N_V \approx 5.73\times10^{60} \quad (2)$$

These ratios exactly connect cosmological and quantum parameters of space-time and 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. EXTENDED MASS RELATION FOR SEVEN FUNDAMENTAL MASSES

2.1. Review of Mass Relation Concerning Four Fundamental Masses

In the previous paper (Forsythe, 2009), Newton's law of universal gravitation is derived, based on postulated mass/energy resonance waves, wherein the apparent Newtonian constant of gravitation factors as:

$$G = \frac{c^3 \lambda_\phi^2}{6\pi h N^2} = \frac{hc}{6\pi m_\phi^2 N^2} = \frac{\hbar c}{3(\pi \alpha m_e N)^2} \cong 6.663\times 10^{-11} \text{ m}^3 \text{ kg}^{-1} \text{ s}^{-2} \quad (3)$$

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 N_A, the 2006 recommended numerical value of Avogadro's number, and in terms of the fine structure constant α, and π, is shown to be given by:

$$N = \sqrt{8/3}(4\pi\alpha^5)^2 \cong 6.022\times 10^{23} \quad (4)$$

The Planck mass by convention is $m_P = (\hbar c / G)^{1/2}$ (Planck, 1906). Therefore, it follows from Eq. (3) that the apparent Planck mass is given by:

$$m_P = \sqrt{3}\pi\alpha m_e N = m_e(\sqrt{3}\pi N)\alpha \cong 2.18\times 10^{-8} \text{ kg} \quad (5)$$

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

$$m_\phi = \pi\alpha m_e \cong 2.09\times 10^{-32} \text{ kg} \quad (6)$$

It is known that the fine structure constant, the coupling constant of electromagnetic interaction, i. e. a measure of its strength, is determined by the formula $\alpha = e^2/(\hbar c)$. Taking into consideration this formula, we find from Eq. (3) that:

$$G = \frac{e^2}{3\pi^2\alpha^3 m_e^2 N^2} \quad (7)$$

In Section II of paper (Forsythe, 2009), 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:

$$M_G = 3\pi^2\alpha^3 m_e N^2 = m_e(\sqrt{3}\pi N)^2\alpha^3 \cong 3.80\times 10^{12} \text{ kg} \quad (8)$$

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.

Noted in (Forsythe, 2009) is that examination of Eqs. (5) and (8) revels the masses m_P and M_G are members of the series suggested by Eq. (1), that in conjunction with Eq. (6) can also be expressed as $M_n = \pi^{n-1}\alpha^{2n-2} m_\phi(\sqrt{3}N)^n$, where n is the placement within the series. Employing Eq. (1) and beginning at $n = 1$, it is found that:

$$M_1 = m_e(\sqrt{3}\pi N)\alpha \cong 2.18\times 10^{-8} \text{ kg} \quad (9)$$

$$M_2 = m_e(\sqrt{3}\pi N)^2\alpha^3 \cong 3.80\times 10^{12} \text{ kg} \quad (10)$$

$$M_3 = m_e(\sqrt{3}\pi N)^3\alpha^5 \cong 6.63\times 10^{32} \text{ kg} \quad (11)$$

$$M_4 = m_e(\sqrt{3}\pi N)^4 \alpha^7 \cong 1.16\times10^{53} \text{ kg} \tag{12}$$

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 (Carvalho, 1995; Valev, 2014) and as such, it represents the upper limit of the series.

2.2. Extended Mass Relation for Seven Fundamental Masses, a New Fundamental Constant *K* and the Hubble Parameter

Upon extending the series downwards to $n \le 0$, we obtain:

$$M_0 = m_e(\sqrt{3}\pi N)^0 \alpha^{-1} = \frac{m_e}{\alpha} \cong 1.25\times10^{-28} \text{ kg} \tag{13}$$

$$M_{(-1)} = m_e(\sqrt{3}\pi N)^{-1} \alpha^{-3} = \frac{m_e}{\sqrt{3}\pi N\alpha_3} \cong 7.15\times10^{-49} \text{ kg} \tag{14}$$

$$M_{(-2)} = m_e(\sqrt{3}\pi N)^{-2} \alpha^{-5} = \frac{m_e}{3\pi^2 N^2 \alpha^5} \cong 4.10\times10^{-69} \text{ kg} \tag{15}$$

It is found that the ratio of any two consecutive masses in the equations (9-15) is a new fundamental constant K, wherein:

$$\frac{M_{n+1}}{M_n} = K = \sqrt{3}\pi N\alpha^2 \cong 1.77\times10^{20} \tag{16}$$

Therefore:

$$M_n = \frac{m_e}{\alpha}(\sqrt{3}\pi N\alpha^2)^n = \frac{m_e}{\alpha}K^n = M_0 K^n \tag{17}$$

where $n = -2, -1, 0, \ldots, 4$. We now find that:

$$\frac{2M_1}{\pi K^3} = \frac{2M_2}{\pi K^4} = \frac{2M_3}{\pi K^5} = \frac{2M_4}{\pi K^6} \cong 2.61\times10^{-69} \text{ kg} \tag{18}$$

The current best estimates of H_0 center around about 70 km s^{-1} Mps^{-1}. Thus, when m_H, the Hubble mass (Maor and Brustein, 2003; Gazeau and Toppan, 2010), is defined as:

$$m_H = \frac{\hbar H}{c^2} \tag{19}$$

we find from Eq. (19) an approximate value for m_H of 2.66×10^{-69} kg. This result is close to that from Eq. (18). It is close enough in fact that all symbolic members of Eq. (18) are assumed to express accurately the value of the Hubble mass concomitant with *H*. Therefore, regarding the 1st and 4th members:

$$\frac{2m_P}{\pi K^3} = m_H \tag{20}$$

and

$$\frac{2M_u}{\pi K^6} = m_H \tag{21}$$

from which, upon elimination of K, results:

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

and the final result upon substituting the right-hand member of Eq. (22) into Eq. (19) for m_H and solving for H, becomes:

$$H = \frac{2c^2}{\pi\hbar}\frac{m_P^2}{M_u} = \frac{4c^2}{h}\frac{m_P^2}{M_u} \tag{23}$$

If the Hubble mass is defined as hH/c^2, as in (Forsythe, 2009), the value for m_H would be ~ 1.64×10^{-68} kg, so the left-hand members of Eqs. (20) and (21) must then be multiplied by 2π to preserve the equalities, and Eq. (22) is still the final result.

As was proposed in (Forsythe, 2012), predicated upon the rate of cosmic expansion apparently transitioning from deceleration to acceleration at redshift z ~ 0.5 (Perlmutter et al., 1999), 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. (19), (20), (21), and (22), leading to Eq. (23). 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 km s^{-1} Mpc^{-1}, 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_0, the present day Hubble parameter, and H_{eq} are essentially identical. Thus:

$$H = H_{eq} = \frac{4c^2}{h}\frac{m_P^2}{M_u} \cong H_0 \cong 68.63 \text{ km s}^{-1} \text{ Mps}^{-1} \tag{24}$$

A theoretical value for H_0 of 68.66±0.1 km s^{-1} Mps^{-1}, obtained via an entirely independent approach (Bukalov, 2002), is in excellent agreement with the above.

Since by convention, the square of the Planck mass is $hc/(2\pi G)$ Eq. (23) can be restated as:

$$H_{eq} = \frac{2c^3}{\pi G M_u} \cong 68.63 \text{ km s}^{-1} \text{ Mps}^{-1} \tag{25}$$

and from Eq. (25), we obtain:

$$M_u = \frac{2c^3}{\pi G H_{eq}} \cong 1.16\times10^{53} \text{ kg} \tag{26}$$

the exact same result as that of Eq. (12). Additionally, from Eqs. (12) and (26) another interesting relationship results:

$$M_4 = M_u = \frac{2c^3}{\pi G H_{eq}} = m_e(\sqrt{3}\pi N)^4 \alpha^7 \cong 1.16\times 10^{53}\ \text{kg} \tag{27}$$

2.3. Review of Three Fundamental Masses Obtained by Dimensional Analysis

In previous paper (Valev, 2013), three fundamental masses have been derived by dimensional analysis, namely:

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

$$m_2 = k\frac{c^3}{GH} \cong M_u \tag{29}$$

$$m_3 = \left(\frac{H\hbar^3}{G^2}\right)^{1/5} \cong 1.43\times 10^{-20}\ \text{kg} \tag{30}$$

In form, Eq. (26) coincides closely with Eq. (29) and the two are an identity when the dimensionless parameter *k*, on the order of unity, is identical with 2/π.

The papers (Forsythe, 2009; Forsythe, 2012) do not attribute any physical significance to mass $M_3 \sim 6.63\times 10^{32}$ 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 (Vink et al., 2011; Crowther et al., 2011). Additionally, we have identified the mass $M_0 \sim 1.25\times 10^{-28}$ kg as exactly coinciding with the mass dimension constant in a basic mass equation from paper (Valev, 2008) 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 $M_0 = m_e/\alpha \cong 0.5 m_{\pi\pm}$. Mass $M_{(-1)} \sim 7.15\times 10^{-49}$ 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 $M_{(-2)} \sim 4.10\times 10^{-69}$ 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 and 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. (9), is the geometric mean of the extreme masses $M_{(-2)}$ and M_4 as given by Eqs. (15) and (12), as is the geometric mean of masses m_1 and m_2 from Eqs. (28) and (29) when $k=1$. Valev mass m_3 from Eq. (30) has not yet been identified and could be regarded as a prediction for unknown fundamental mass, most likely a yet unobserved very heavy particle.

3. NEW EVIDENCES OF DIRAC LARGE NUMBERS HYPOTHESIS

Recalling Eq. (2) and the definition of terms therein, it is found that $N_V \sim 5.73\times 10^{60}$ when the defined terms are evaluated according to:

$M = c^3/(2GH)$; $m_H = \hbar H/c^2$; $m_P = (\hbar c/2G)^{1/2}$; $l_P = (2G\hbar/c^3)^{1/2}$; $t_P = l_P/c = (2G\hbar/c^5)^{1/2}$; $\rho_P = 3c^5/(16\pi\hbar G^2)$; $\rho_c = 3H^2/(8\pi G)$ is recent density of the universe equal to the critical one; H^{-1}, the age of the universe and cH^{-1} is the Hubble distance.

The Eq. (2) ratios appear very important because they relate cosmological parameters and the fundamental microscopic properties of matter. The Planck units imply quantization of space-time at extremely short range. Thus, the ratios represent connection between cosmological and quantum parameters of space-time and thus appear to be a precise formulation and proof of *LHN*. In addition, the very large number N_V and Dirac large number N_D (Dirac, 1937) seem connected by the approximate formula:

$$N_D \sim N_V^{2/3} = \left(\frac{c^5}{2G\hbar H^2}\right)^{2/3} \cong 3.2\times10^{40} \tag{31}$$

We now construct a similar series to (2) involving ratios of the same parameters producing the very large, number N_{VF}, as follows:

$$\left(\frac{2}{\pi}\frac{M_u}{m_H}\right)^{1/2} = \frac{M_u}{m_P} = \frac{2}{\pi}\frac{m_P}{m_H} = \frac{2}{\pi}\frac{cH^{-1}}{l_P} = \frac{2}{\pi}\frac{H^{-1}}{t_P} = \frac{2}{\pi}\left(\frac{\rho_P}{2\rho_c}\right)^{1/2} = \frac{2}{\pi}\left(\frac{c^5}{G\hbar H^2}\right)^{1/2} = N_{VF} \cong 5.31\times10^{60} \tag{32}$$

Where now:
$H = H_{eq} = 2c^3/(\pi G M_u)$; $M_u = 2c^3/(\pi G H)$ is apparent proper mass of the universe; $m_H = \hbar H/c^2$; $m_P = (hc/2\pi G)^{1/2}$; $l_P = (G\hbar/c^3)^{1/2}$; $t_P = l_P/c = (G\hbar/c^5)^{1/2}$; $\rho_P = 3m_P/(4\pi l_P^3) = 3c^5/(4\pi\hbar G^2)$; $\rho_c = 3H^2/(8\pi G)$, and G is according to Eq. (3). These ratios also represent a connection between cosmological and quantum parameters of space-time and so likewise appear to be possible new evidences of *LNH*. Recalling Eq. (17), it is noteworthy that apparently: $N_{VF} = K^3 = (\sqrt{3}\pi N\alpha^2)^3 \cong 5.31\times10^{60}$ and that N_{VF} and Dirac large number N_D seem connected by the approximate formula:

$$N_D \sim N_{VF}^{2/3} = K^2 = (\sqrt{3}\pi N\alpha^2)^2 = \left(\frac{4c^5}{\pi^2 G\hbar H^2}\right)^{2/3} \cong 3.04\times10^{40} \tag{33}$$

Thus, by independent approaches it is apparent that we obtain very similar results, (31), (33) and (2), (32).
From Eq. (33), it follows that:

$$N^2 = \frac{N_{VF}^{2/3}}{3\pi^2\alpha^4} = \frac{K^2}{3\pi^2\alpha^4} \tag{34}$$

that upon substitution into Eq. (3) for the square of N results in:

$$G = \frac{\alpha^2\hbar c}{m_e^2 N_{VF}^{2/3}} = \frac{\alpha^2\hbar c}{m_e^2 K^2} \tag{35}$$

Thus, Eqs. (34) and (35) connect *N* to *LNH* and therefore to *G* through the unique and apparently new fundamental constant *K*, as given by Eq. (16).

4. CONCLUSIONS

Mass relation (1) obtained in (Forsythe, 2009) 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 $M_1 \sim 2.18\times10^{-8}$ kg the apparent Planck mass $m_P = (\hbar c/G)^{1/2}$, that is very important in resent particle physics. The mass $M_2 \sim 3.80\times10^{12}$ kg is the central mass of a hypothetical quantum "Gravity Atom" whose gravitational potential $GM_G m_e/S$ is equal to electrostatic potential e^2/S and S is a Bohr orbit radius and the mass $M_3 \sim 6.63\times10^{32}$ kg is of the order of the Eddington mass limit of the most massive stars. The mass $M_4 \sim 1.16\times10^{53}$ kg is close to the mass of the Hubble sphere and most probably appears to be mass of the observable universe. The mass $M_0 \sim 1.25\times10^{-28}$ kg coincides with a mass dimension constant in a basic mass equation relating masses of stable particles and coupling constants of the four interactions; approximately a half charged pion mass. The mass $M_{(-2)} \sim 4.10\times10^{-69}$ kg is easily identifiable with the Hubble mass as $0.5\pi m_H$. The mass $M_{(-1)} \sim 7.15\times10^{-49}$ kg remains yet unidentified and could be regarded as a prediction by the suggested mass relation for unknown fundamental mass, most likely 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 and 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 relating cosmological parameters and quantum properties of space-time. In addition, the very large number $N_{VF} = K^3 = (\sqrt{3}\pi N\alpha^2)^3 \cong N_V = \sqrt{c^5/(2G\hbar H^2)} \cong 5.31\times10^{60}$ connects mass, density, age and size of the observable universe with Planck mass, density, time and length respectively, and K is apparently a unique and new fundamental constant.

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