The Numbers Universe: An Outline of the Dirac/Eddington Numbers as Scaling Factors for Fractal, Black Hole Universes

Ross A. McPherson*

3 Narelle Ct, Laidley, Qld, 4341, Australia

Received 10 February 2008, Accepted 15 June 2008, Published 30 June 2008

Abstract: The large number coincidences that fascinated theorists such as Eddington and Dirac are shown here to be a specific example of a general set of scaling factors defining universes in which fundamental forces are equated. The numbers have prescriptive power and they are therefore correct and exact *a priori*. The universes thus defined exhibit a fractal structure centred on the Planck/Stoney scale with some formal resemblance to black holes and with properties analogous to Hawking radiation. The problematic case of emerging and evaporating universes is briefly considered in the context of quantum gravity. Historically, the large numbers are associated with the mass of a charged particle and the mass of the universe. This paper demonstrates that the numbers are properly understood in the context of four masses including a non-zero mass derived from Hubble‘s Constant and the Planck or Stoney mass.

Keywords: Large Numbers; Planck, Stoney; Fractal; Black Hole; Hawking Radiation; Dirac; Eddington; Linde; Nottale; El Naschie
PACS (2006): 01.70.+w; 03.65.Ud; 04.60.Bc; 04.70.Dy; 05.45.Df; 05.65.+b; 06.20.-f; 98.80.Jk; 12.60.-i; 12.10.-g

1. Introduction

According to Dirac, as reported by Gamow [1], *an elegant theory must be correct.* The large numbers noticed by Dirac, Eddington and others [2,3,4,5,6,7,8], suggest the possibility of an elegant theory that derives physical laws from numerical relations. According to Dirac's particular interpretation of the large numbers, for instance, gravity's strength is inversely proportional to the universe's age. Any such large variation in gravity has since been ruled out by a wealth of carefully analyzed geophysical and astrophysical data

* ssor1@bigpond.com

[9,10,11,12,13] yet such is the elegance of his theory that it continues to inspire theorists even today (as for example [14,15,16,17,18]).

It will be shown in this paper that the 'large' numbers are scaling factors that equate an idealized electromagnetic particle with the Planck/Stoney mass, and the Planck/Stoney mass with the total mass of all the electromagnetic particles in the universe. A *Numbers Universe* (the kind of universe defined by these scaling factors) could comprise as many or as few particles as imagination permits and the numbers therefore are not necessarily large. Irrespective of its size, a Numbers Universe is fractal in structure - the universe and every particle in it are rescaled forms of the Planck/Stoney mass. The fractal structure of the universe is a topic that has excited a considerable amount of interest and speculation recently (e.g. [19]), particularly however in the context of unification physics [20, 21,22,23,24] and even with some explicit reference to the Large Numbers Hypothesis [25][26]. However, in this author's opinion, the fractal quality of a Numbers Universe is not fully understood without reference to a fourth mass that emerges from a triad of larger masses comprising the idealized charged particle, the Planck/Stoney mass and the universe itself. The fourth mass and its associated energy, derived from Hubble's Constant, have found a significant role in a variety of theories, including Hawking's theory of radiating black holes, yet few theorists fully understand the intellectual scaffolding that supports it and which may be dubbed the 'Numbers Universe'. This paper will address that shortcoming.

The paper is divided into three main sections. The Introduction includes subsections dealing with definitions of some key terms, including a revised electrical charge (for convenient comparison of electromagnetic and gravitational quantities), the Stoney scale and the Large Numbers themselves. The middle section is a study of the Numbers Universe, particularly the fractal relations of the four masses. It also considers deflationary and inflationary scenarios associated with the sequencing of numbers. The third and final section is a brief discussion of speculative issues.

1.1 Unified Dimensions

The 'large' numbers of Dirac, Eddington *et al.* are ratios of various electromagnetic and gravitational quantities dimensioned in force, mass, length and time (see section 1.3). There is no ratio of charges except perhaps by implication in the ratio of forces. In a Numbers Universe, therefore, electrical charge might best be understood in electrostatic units (esu), as a compound of dimensions associated with force, rather than in SI, where charge is formally a separate and unique dimension measured in Coulombs. However, there are advantages in retaining the SI context, or at least some key elements of it. A compromise between SI and esu is convenient and it is simply achieved by defining charge according to Ampere's Law while setting the permeability of free space equal to a dimensionless unity [27]. This compromise assigns electric charge a compound of dimensions conventionally associated with force, somewhat in the esu manner, without however sacrificing the general SI context. The SI electrostatic force can then be rephrased thus:

$$\begin{aligned} e^2/4\pi\varepsilon_0 &= c^2 e_R^2, \\ e^2 &= 2.567 \times 10^{-38} C^2, \\ e_R^2 &= 2.567 \times 10^{-45} kg.m, \end{aligned} \tag{1}$$

where e is the elementary charge measured in Coulombs, ε_0 is the permittivity of free space, c is the speed of light in a vacuum and e_R is a revised charge. This revision not only allows for an easier comparison of electromagnetic and gravitational phenomena, it also simplifies calculations for some purely electromagnetic identities. For instance, the electromagnetic radius r_E of any mass (conventionally the 'classical radius' in the case of the electron) is calculated in SI and in revised units thus:

$$r_E = e^2/4\pi\varepsilon_0 m_E c^2 = e_R^2/m_E, \tag{2}$$

where m_E is any charged mass. Moreover, the relativistic nature of the magnetic force is made explicit in revised units:

$$e\vec{v} \times \vec{B} = \frac{c^2 e_R^2}{r^2} \times \frac{e_R^2}{m_E r} = \frac{v^2 e_R^2}{r^2}, \tag{3}$$

where $B$is the magnetic field, m_E is any charged mass, v is its speed as determined by the electrostatic force and r is its distance from another charge. The above three equations will help the reader interpret other equations in this paper.

1.2 Stoney Scale

The Stoney scale equates the electrostatic force with the self-gravitation of the Stoney mass, which may be considered a smaller version of the Planck mass:

$$c^2 e_R^2 = G m_S^2 = \alpha G m_{Pl}^2 = \alpha c\hbar, \tag{4}$$

where $G$is the Gravitational Constant, m_S is the Stoney mass, α is the Fine Structure Constant, m_{Pl} is the Planck mass and the crossed h is the reduced Planck's Constant . Some theorists have interpreted Dirac's and Eddington's large numbers in the context of the Planck scale and indeed some findings in this paper have been anticipated in a purely Planck context by other authors [26]. However, the 'large' numbers known to Dirac, Eddington *et al.* are formally Stoney numbers, being factors that equate electromagnetic and gravitational phenomena, whereas the Planck scale is conventionally the scale of unification for all forces. In this paper, the Stoney scale is retained as the scale of the Numbers Universe, partly because of its historical significance, but also because this limited or specialized form of the Planck scale is still relevant for certain theoretical tasks and deserves to be better recognized. The relative strengths of the electrostatic and gravitational forces can then be expressed simply as a mass ratio:

$$\frac{c^2 e_R^2}{G m_E^2} = \frac{m_S^2}{m_E^2} = N = n^2, \tag{5}$$

where N is not necessarily a large number since it depends on the size of the charged mass m_E.The square root form n is often a more useful quantity.

1.3 'Large' Numbers

The Numbers Universe is defined by ratios representing differences in force, length, time and mass. In the context of the 'real' universe, they are conventionally understood as approximations because exact calculations are beyond the practical capabilities of scientific observation:

$$c^2 e_R^2 / G m_E^2 = N \approx 10^{40}, \tag{6}$$

$$R_U / r_E = N \approx 10^{40}, \tag{7}$$

$$\frac{R_U/c}{r_E/c} = N \approx 10^{40}, \tag{8}$$

$$M_U / m_E = N^2 \approx 10^{80}, \tag{9}$$

where m_E is the mass of a typical electromagnetic particle such as the electron or proton, r_E is its electromagnetic radius as defined in (2), and where R_U and M_U are the radius and mass of the universe. Variations in these identities are often seen, such as substituting a particle's Compton wavelength for its electromagnetic radius and equating m_E with the root mean square of two different charged masses. In fact m_E could even be regarded as an ideal particle that emerges from whatever parameters the theorist considers important.

Expressed as a set of 'rubbery' approximations based at least partly on unmeasured and unmeasurable quantities, the numbers are practically useless. Dirac however identified R_U with the radius of an expanding universe and, by equating (6) and (7), arrived at an interesting conclusion:

$$G = \frac{c^2 e_R^2 r_E}{m_E^2 R_U}. \tag{10}$$

Dirac boldly suggested that gravity weakens as the universe expands since G is inversely proportional to R_U. However, as already noted, the hypothesis is not supported by scientific analysis and, moreover, there are other terms in the equation that could be used to offset changes in R_U - in particular, the mass m_E.

2. The Numbers Universe

If we assume that $N$is the exact same number for all four equations (6)-(9) those equations and all their terms can then be deduced from each other. For example:

$$M_U = N^2 m_E = \frac{c^2 e_R^2}{G m_E^2} \times \frac{c^2 e_R^2}{G m_E^2} \times m_E. \tag{11}$$

Rearranging and cancelling some terms:

$$\frac{G M_U}{c^2} = \frac{c^2 e_R^2}{G m_E^2} \times \frac{e_R^2}{m_E} = N r_E = R_U. \tag{12}$$

Thus R_U is half a Schwarzschild radius (or 'gravitational radius') and we need only know the exact value for one of the variable terms N, M_U, R_U or m_E in order to know the exact values for all of them (uncertainties in the value of G are a different issue and may be considered trivial in the circumstances). The Numbers Universe could thus be the exact size we choose and every adjustment in R_U is simply offset by an adjustment in m_E. Interpreting equations (6)-(9) within the context established by (5):

$$M_U = n^3 m_S = n^4 m_E. \tag{13}$$

According to this relation, the Stoney mass is the whole universe when $N = n$=1. In this context, the Numbers Universe seems to be an enlarged form of the Stoney mass and m_E seems to be a reduced form of the Stoney mass - the more the Stoney mass is subdivided, the greater the universe becomes as a whole, somewhat in the fractal manner of an organism growing by the subdivision of its cells.

Physicists have long wondered why gravity is so weak at the electromagnetic scale. According to some physicists (e.g.[28), the significant fact is not the weakness of gravity but rather the tiny mass of charged particles. According to (13), however, the mass of the universe is equally significant in accounting for the relative strength of gravity and it is relevant to ask - why is the universe so massive? The answer to this question is perhaps best found in the ‘anthropic argument’ [29][20], according to which the large numbers are fairly representative of a universe that is able to support life. Paraphrasing the ‘anthropic argument’, we might say the Numbers Universe is scaled according to the biological needs of numerate beings - or perhaps according to the intellectual needs of beings clever enough to use very big numbers!

While a conventional system of units such as SI is quite appropriate for our universe it would not be appropriate for all Numbers Universes, some of which might comprise only a handful of large particles while others might comprise an almost infinite number of almost zero mass particles. The only appropriate units of measurement for all of these universes are of course the natural units derived from the Stoney scale. In that case, m_S is an invariant unit of mass and any change in n involves a change in mass for M_U and m_E. Thus the factor n^4 is a product of two factors - the factor n, which is the number of particles needed to offset changes in the mass of m_E relative to the mass of m_S, and the factor n^3, which is the number of Stoney masses in the universe. There is however another fundamental mass in the Numbers Universe, and the triad in (13) is in fact better understood as a tetrad.

2.1 Minimum Energy or Non-zero Mass

The Numbers Universe does not make itself known to theorists by means of numbers alone. Some theorists (e.g.[30]) have been intrigued by this relation:

$$\sqrt[3]{\frac{\hbar^2 H_0}{Gc}} \approx m_E, \tag{14}$$

where H_0 is Hubble's constant ($H_0 = c/R_U$). This particular relation emerges from a Planck-scale Numbers Universe and it implicitly derives the electromagnetic mass m_E

from a cubed mass product featuring the squared Planck mass and a minimum mass, here to be denoted m_ω:

$$\sqrt[3]{\frac{\hbar H_0}{c^2}\frac{c\hbar}{G}} = \sqrt[3]{m_\omega m_{Pl}^2} = m_E. \tag{15}$$

Phrased in Stoney terms and with adjusted values for m_E and m_ω:

$$\sqrt[3]{\frac{\alpha\hbar H_0}{c^2}\frac{c^2 e_R^2}{G}} = \sqrt[3]{m_\omega m_S^2} = m_E, \tag{16}$$

$$M_U = n^6 m_\omega, \tag{17}$$

$$m_\omega = \frac{m_E^3}{m_S^2} = \frac{m_S^2}{M_U}, \tag{18}$$

where m_ω is the smallest mass in a Numbers Universe. The mass m_ω can be derived from the following physical relations, one electromagnetic and the other gravitational:

$$m_\omega = \frac{e_R^2}{R_U}, \tag{19}$$

$$\frac{GM_U m_\omega}{R_U} = \alpha\hbar H_0. \tag{20}$$

The mass m_ω however can also be derived from physical relations that seem baffling and paradoxical :

$$m_\omega c^2 = \frac{c^2 e_R^2}{R_U} = \frac{Gm_E^2}{r_E} = m_E v_\omega^2. \tag{21}$$

Here v_ω is the speed of the charged mass m_E at the edge of the universe in an electromagnetic field originating in the centre of the universe, and it is also the speed of the same mass self-gravitating around its own electromagnetic radius. These relations are mathematical ideals based on the paradoxical assumption that m_E/R_U is not affected by the gravitational mass of the universe and that m_E/r_E is not affected by the electrostatic force, since in both these cases the speed of m_E should in fact be the speed of light.

It is possible that there are some real world phenomena that might resemble the mathematical ideals expressed in (21). Since the Numbers universe is predicated on the realistic assumption that the fundamental forces are in fact different manifestations of the same force ($N = n$=1), there is nothing absurd in the additional assumption that those ideals have some parallel or analogous manifestation in the real universe. We might for instance interpret (21) in the context of quantum entanglement, the kind of 'spooky action at a distance' considered by Einstein, Podolsky and Rosen [31]. In that case, the charged mass m_E could be considered a single particle in two different places, responding only to gravity at the electromagnetic boundary r_E and responding only to the electrostatic force at the gravitational boundary R_U . Some such bizarre particle might be necessary for the unification of the fundamental forces.

Rearranging and cancelling terms in (21) leads to another intriguing relation:

$$\frac{Gm_E^2}{R_U^2} = \frac{v_\omega^2 e_R^2}{R_U^2}. \tag{22}$$

The self-gravitation of the charge particle m_E is here equal to the magnetic force at the boundary of the universe. This idealized relation suggests the possibility that a particle's own self gravitational field and its magnetic field might substitute for each other should either be negated or cancelled out. The nearest real-world analogy to the de facto continuation of an excluded magnetic field is the Ahronov-Bohm effect [32] a gravitational analogue of which has in fact already begun to be developed in the context of large number coincidences [33][34][35].

The minimum energy and its associated non-zero mass m_ω have fascinated theorists for many years, usually however without any reference to a Numbers Universe and always in the Plank context. Walter Nernst, for instance, associated the minimum energy with a mechanism for tired light and constant entropy in a steady state universe [36](see also [37]). The non-zero mass of a photon is a feature common to the Einstein, de Broglie and Vigier theories of light, for which an overview and a quite comprehensive list of references is supplied by Vigier [38]. For other identifications, such as with gravitons and the energy associated with the non-zero conductance of the energy vacuum, see for example Kropotkin [39]. The minimum energy has a logical if not necessarily a physical significance and it often features in scientific theories of an 'alternative' or 'fringe' variety. However, it is also familiar to mainstream science, particularly in the form of Hawking radiation, as discussed in the next section.

2.2 Decreasing Numbers Universes

The dynamics and structures of black holes are a focus of ongoing debate among theoretical physicists (e.g.[40][41]). Whether or not black holes exist in physical fact they are a theoretical 'mineshaft' for speculative workers in unification physics. Thus for example Steven Hawking has combined the quantum theory of particle/anti-particle pairs with the gravitational theory of black holes in order to remove the singularity from space-time through evaporation [42] apparently with a view to its ultimate removal from scientific theory as well [43a]. The singularity is inconsistent with the quantum Heisenberg principle of uncertainty and Hawking has sought to replace it with a Planck scaled region where time becomes a fourth spatial dimension [44a]. Any distinction between 'real' and 'imaginary' time is dismissed by Hawking as irrelevant: *"... a scientific theory is just a mathematical model we make to describe our observations: it exists only in our minds. So it is meaningless to ask: Which is real, 'real' or 'imaginary' time? It is simply a matter of which is the more useful description."* [43b] The Numbers Universe would be unthinkable without that sort of rational expediency.

A quantum of Hawking radiation can be defined thus:

$$k_B T_H = \frac{c^3 \hbar}{8\pi G M}, \tag{23}$$

where M is the mass of the black hole, k_B is Boltzmann's constant, T_H is the Hawking temperature and the $k_B T_H$ product is the energy of a particle radiated by the black hole.

The Hawking formula has already appeared implicitly in (14)-(21) but in a Stoney rather than Planck context. It can for example be recovered thus:

$$\frac{Gm_E^2}{r_E} = \frac{c^2e_R^2}{R_U} = \frac{c^4e_R^2}{GM_U} = \frac{\alpha c^3\hbar}{GM_U} = m_\omega c^2 = m_E v_\omega^2. \tag{24}$$

The particle radiated by the black hole is analogous to the non-zero mass that emerges from the electrostatic force at the gravitational boundary of the Numbers Universe, and which also emerges from the self-gravitation of the m_E particle at the electromagnetic radius r_E. In Hawking's theory, a particle/anti-particle pair originating outside the black hole is torn apart such that one particle falls towards the singularity while the other is either radiated away or orbits at the boundary. In an evaporating Numbers Universe, on the other hand, all particles must surely originate internally and we can only speculate about their final destination. As the Numbers Universe diminishes, the numbers that define it also diminish, a process that leads to fewer but larger charged particles, presumably ending with a single Planck/Stoney mass - otherwise the evaporating Numbers Universe would begin radiating particles more massive than itself (which is perhaps a novel definition of the inflationary universe!)

Hawking's work with evaporating black holes allows the Numbers Universe to develop according to physical principles, whether decreasing like a black hole or even in reverse as a kind of inflationary universe. As a mathematical fiction, the changing Numbers Universe can be defined by any sequence of numbers we choose, in either ascending or descending order or even alternately ascending and descending. If there is to be any resemblance to physical reality, however, the numbers must choose themselves and the sequencing of numbers must proceed at some naturally determined rate. The rate of increase/decrease for a Numbers Universe is conceptually tied to the duration of a Hawking black hole, which can be calculated as follows:

$$t = M^3/k, \tag{25}$$

$$k = \hbar c^4/G^2\pi 15360,$$

where t is the duration of the black hole and k is a constant. The time t approximates to Planck/Stoney time when the mass M is the Planck/Stoney mass.

2.3 Increasing Numbers Universes

An increasing Numbers Universe does not increase in volume in the way that our universe is thought to expand from an initial Big Bang. It resembles an inflationary universe, increasing in volume while increasing in total mass and in the total number of charged particles. The standard models of cosmology and particle physics have settled on a set of phase transitions that appears to be supported by observational data (e.g.[45,46,47,48]) and these models are not easily or naturally formulated in the context of a time-reversed Hawking black hole. Indeed, according to the duration given in (25), a Numbers Universe as massive as our universe must be considerably older than conventional scientific estimates allow. Moreover, concepts such as a radiation dominated universe are not easily interpreted in the context of a Numbers model. However, the Numbers Universe could be well suited to some alternative cosmological models, such as Linde's fractal model of 'eternal inflation' [20]. Further more, our universe *today* approximates well to a Numbers Universe and it might serve adequately as a model for any contemporary phase transitions that might be thought to be occurring now (e.g. [47][17]).

In an inflationary Numbers Universe, particles decrease in size even as they increase in number. If the particle is elementary, the decrease in its size might be understood merely as a change in scale or in energy level without any change in internal structure, and yet according to the standard model even elementary particles come in discrete generations. In an inflationary Numbers Universe that resembles reality therefore, the process of change seems to require a set of phase transitions even for elementary particles, as for example:

$$\frac{c^2 e_R^2}{G m_{E0}^2 / i^2} = i^2 n^2, \qquad (26)$$
$$m_{E0}/i = m_E,$$

where m_{E0} is the mass of an early generation particle, i is a factor that represents a continuing increase in the 'large' number n, and m_E is the mass of a later generation particle. The phase transition requires the earlier mass m_{E0} to remain unchanged until i reaches some critical value, at which point m_{E0} suddenly becomes the smaller, more numerous mass m_E. Until that critical value is reached, what physical change is signified by increases in i? If (26) is sufficient to tell the story every trivial increase in i must represent a variation in one or more of the fundamental physical 'constants' G, c and/or e_R . This variation in constants however can only be temporary otherwise m_E would never emerge. The variability of fundamental physical constants (such as the speed of light in a vacuum) is one of the most hotly discussed topics in contemporary physics (e.g.[49][50][51]). It is a curious fact that the topic is implicit and even unavoidable in the concept of an increasing Numbers Universe.

It is possible of course that the conditions allowing for a phase transition are expressed by some other mathematical relation. For example, trivial changes in i (trivial from the viewpoint of a transition from m_{E0} to m_E) might never the less represent significant changes in the energy associated with the minimum mass m_ω. Indeed, in a universe like ours, the minimum energy is so small that any set of stepwise changes in its non-zero energy level is hardly different to a smooth continuum. We can then express the result of a phase transition thus:

$$M_U = m_S i^3 n^3 = m_{E0} i^3 n^4 = m_E i^4 n^4 = m_\omega i^6 n^6. \qquad (27)$$

Such an equation assumes that the universe and its components are elaborately synchronized, an impossibility in a universe as large as ours if communication is limited to the speed of light. However, such synchronization might be explained as the quantum entanglement of a fractal organization.

3. Discussion: The Quantum Numbers Universe

If the universe can be considered a single quantum particle, it might also be thought to have an internal clock that keeps the same time everywhere:

$$T_S = \frac{r_S}{c} = \frac{Gm_S}{c^3} = \frac{e_R^2}{cm_S} = \frac{R_U}{n^3 c}, \tag{28}$$

where T_S is the Stoney time and r_S is the Stoney length. Other times are synchronized with the Stoney time by means of the factor n. In fact, the large number N, equating gravity and electromagnetism, can be understood as a ratio of electromagnetic times:

$$N = \frac{m_S^2}{m_E^2} = \frac{m_E c^2}{\hbar} \times \frac{\hbar}{m_\omega c^2} = \nu_E T_\omega. \tag{29}$$

Here ν_E is the electromagnetic frequency of m_E and T_ω is the electromagnetic time of m_ω. Expressed in Stoney units for time, which are proportional to mass:

$$\nu_E = m_E/m_S = 1/n, \tag{30}$$

$$T_\omega = (m_S/m_E)^3 = m_S/m_\omega = n^3.$$

The phase transition described by (27) requires ongoing changes in T_ω while ν_E is retarded as ν_{E0} (the frequency of m_{E0}). In effect, m_{E0} behaves as if it were subject to a time delay until it is suddenly updated and revised to m_E. In that case, the Stoney mass is completely synchronized with M_U and with m_ω but only imperfectly synchronized with particles like m_{E0}. Whether space and time are absolute or relative might therefore depend on the degree of synchronicity.

In the quantum universe defined here, gravity might be understood entirely in electromagnetic terms:

$$G = \frac{c^2 e_R^2}{m_E^2 \nu_E T_\omega}. \tag{31}$$

However, according to (19)–(21) m_ω can be derived from either electromagnetic or gravitational relations and therefore G could be expressed as a ratio of electromagnetic and gravitational times, which is probably more consistent with the Stoney scale's role as the mediator between two forces. The opposite case, that the electromagnetic force emerges from gravitational principles, is almost never heard, though the occasional attempt is made [27].

3.1 The Mathematical Universe

In the opinion of Arthur Eddington, the large number ratios "*... are not arbitrary but will ultimately be found to have a theoretical explanation, though I have also heard the contrary view expressed.*" [8a] In Eddington's day, the Planck scale did not seem so significant as it does today and the possibilities offered by fractal self-organization had not yet been conceived. Never the less, in spite of the new relevance of a Numbers Universe, most theorists today would probably still maintain 'the contrary view'. The contrary view is understandable partly as a reluctance to submit empirical science to the *a priori* dictates of mere numbers, and partly because the standard models of cosmology and particle physics do not seem consistent with the idealized parameters offered by those numbers. Never the less, many eminent theorists (e.g.[52,53,54,55,20,44]) have marvelled at the mathematical intelligence that our universe seems to demonstrate and even today highly respected theorists such as Hawking scaffold their theories around concepts that happen also to be key aspects of the Numbers Universe. It is difficult therefore to deny that the Numbers Universe could be a useful tool, if only as a signpost to analogous phenomena in the real universe as it exists today. In that case, it could actually inspire theorists like Hawking instead of just deriving its relevance from them.

References

[1] G. Gamow: Does gravity change with time? *Proc.Nat.Acad.Sc.* **57** (1967) 192

[2] G. Gorelik: Hermann Weyl and large numbers in relativistic cosmology. In: Y. Balashov and V. Vizgin (eds) *Einstein Studies In Russia* (Birkhaeuser, Boston, 2002)

[3] E. Harrison: *Cosmology - The Science of the Universe* (Cambridge University Press, Cambridge, 2000)

[4] J. Barrow: The mysterious lore of large numbers. In: B. Bertotti (ed) *Modern Cosmology in Retrospect* (Cambridge University Press, Cambridge, 1990)

[5] M. Abramowicz: Eddington Number and Eddington Mass. *The Observatory* **108** (1988) 19-20

[6] P. Dirac: Cosmological models and the Large Numbers Hypothesis. *Proc.R.Soc.* A **338** (1974) 439-446

[7] R. Dicke: Dirac's cosmology and Mach's Principle. *Nature*, **192** (1961) 440-441

[8] A. Eddington: *New Pathways in Science* (Cambridge University Press, Cambridge,1935) a 233-234

[9] J. Williams, X. Newhall and J. Dickey: Relativity parameters determined from lunar laser ranging, *Phys.Rev.* D **53** (1996) 6730-6739

[10] T. Damour, G. Gibbons and J. Taylor J: Limits on the variability of G using binar pulsar data. *Phys.Rev.Lett.* **61** (1988) 1151-1154

[11] E. Norman: Are fundamental constants really constant? *Am.J.Phys.* **54** (1986) 317-321

[12] I. Shapiro, W. Smith, R. Ingalls and G. Pettengill: Gravitational Constant - experimental bound on its time variation. *Phys.Rev.Lett.* **26** (1971) 27-30

[13] E. Teller: On the change of physical constants. *Phys.Rev.* **73** (1948) 801-802

[14] J. Gilson: A dust solution to the dark energy problem. In: Duffy M. (ed.) *Proceedings of the Conference on Physical Interpretations of Relativity Theory X*, Imperial College, London, 2006

[15] J. Gilson: A sketch for a quantum theory of gravity: rest mass induced by graviton motion. *Galilean Electrodynamics* **17** (2006) 43-49

[16] Cheng-Gang Shao, Jianyong Shen, Bin Wang and Ru-Keng Su: Dirac cosmology and the acceleration of the contemporary universe. *Class.Quant.Grav.* **23** (2006) 3707-3719

[17] R. Matthews: Dirac's coincidences sixty years on. *Astronomy and Geophysics* **39** (1998) 19-20

[18] R. Alpher and G. Gamow: A possible relation between cosmological quantities and the characteristics of elementary particles. *Proc.Nat.Acad.Sc.* **61** (1968) 363-366

[19] P. Teerikorpi and Y. Baryshev: *Discovery of Cosmic Fractals* (World Scientific, London, 2002)

[20] A. Linde: Inflation, quantum cosmology and the anthropic principle. In: J. Barrow, P. Davies and C. Harper (eds.) *Science and Ultimate Reality: Quantum Theory, Cosmology and Complexity* (Cambridge University Press, Cambridge, 2003) 426-458

[21] M. El Naschie: A review of E-Infinity Theory and the mass spectrum of high energy particle physics. *Chaos, Solitons and Fractals* **19** (2004) 209-236

[22] M. El Naschie: Dimensional symmetry breaking and gravity in Cantorian space. *Biosystems* **46** (1998) 41-46

[23] L. Nottale: *Fractal Space-Time and Microphysics - Towards a Theory of Scale Relativity* (World Scientific, London, 1993)

[24] D. Roscoe: A fractal universe with discrete spatial scales. *Apeiron* **3** (1996) 99-107

[25] S. Carneiro: The Large Numbers Hypothesis and quantum mechanics. *Foundation of Physics Letters* **11** (1998) 95-102

[26] E. Recami, P. Ammiraju, H. Hernandez, L. Kretly and W. Rodrigues: Elementary particles as micro-universes - a geometric approach to "Strong Gravity". *Apeiron* **4** (1997) 7-15

[27] R. McPherson: Stoney scale and large number coincidences. *Apeiron* **14** (2007) 243, 258

[28] F. Wilczek : Scaling Mount Planck - a view from the bottom. *Phys.Today* **54** No.6 (2001)12-13

[29] N. Bostrom: *Anthropic Bias - Observation Effects in Science and Philosophy* (Routledge, New York and London, 2002)

[30] S. Weinberg S: *Gravitation and Cosmology - Principles and Applications of the General Theory of Relativity* (John Wiley and Sons, New York, 1972) 620

[31] F. Selleri: *Quantum Mechanics Versus Local Realism - The Einstein-Podolsky-Rosen Paradox* (Plenum Press, New York, 1988)

[32] Y. Aharonov and D. Bohm: Significance of electromagnetic potentials in the quantum theory. *Phys.Rev* **115** (1959) 485-491

[33] Geusa de A Marques and V. Bezerra: On a gravitational analogue of the Aharanov-Bohm Effect. *Phys.Lett.* A **318** (2003) 1-5

[34] Geusa de A Marques, S. Fernandes and V. Bezerra: Some effects on relativistic quantum systems due to a weak gravitational field. *Brazilian Journal of Physics* **35** (2005) DOI 10.1590/S0103-97332005000700025

[35] J. Lawrence and G. Szamosi: Statistical physics, particle masses and the cosmological coincidences. *Nature* **252** (1974) 538-539

[36] P. Huber and T. Jaakkola: The static universe of Walter Nernst. *Apeiron* **2** (1995) 53-57

[37] H. Broberg: Mass, energy, space. *Apeiron* **1** No. 9-10 (1991) 62-75

[38] J. Vigier: Relativistic interpretation (with non-zero photon mass) of the small ether drift velocity detected by Michelson, Morley and Miller. *Apeiron* **4** (1997) 71-76

[39] P. Kropotkin P: The perfect cosmological principle and the Hubble effect. *Apeiron* **1** No.9-10 (1991) 91-96

[40] V. Frolov and I. Novikov: *Black Hole Physics - Basic Concepts and New Developments* (Kluwer Academic Publisher, Dordrecht, 1998)

[41] K. Thorne: *Black Holes and Time Warps - Einstein's Outrageous Legacy* (Norton, New York, 1994)

[42] S. Hawking: Particle creation by black holes. *Commun.Math.Phys.* **43** (1975) 199-220

[43] S. Hawking: *A Brief History of Time - from the Big Bang to Black Holes* (Bantam Books, London, New York, 1996) a 41, b 147-148.

[44] P. Davies: *The Mind of God: Science and the Search for Ultimate Meaning* (Penguin Books, London, New York, 2001) 52-63

[45] L. Lederman and D. Schramm: *From Quarks to the Cosmos - Tools of Discovery* (Scientific American Library, New York, 1989)

[46] E. Kolb and M. Turner: *The Early Universe* (Addison-Wesley, Redwood City CA, 1990)

[47] D. Boyanovsky, H. de Vega and D. Schwarz D: Phase transitions in the early and present universe. *Ann.Rev.Nuclear and Particle Sc.* **56** (2006) 441-500

[48] M. Gleiser: Phase transitions in the universe. *Contemp.Phys.* **39** (1998) 239-253

[49] M. Duff, L. Okun and G. Veneziano: Trialogue on the number of fundamental physical constants. *JHEP 0203 (2002) 023*

[50] J. Barrow: *The Constants of Nature - from Alpha to Omega* (Pantheon Books, New York, 2002)

[51] J. Gribbin and P. Wesson: Fickle constants of physics. *New Scientist* **381** (1992) 30

[52] F. Hoyle: *The Intelligent Universe* (Michael Joseph, London, 1983)

[53] J. Gribbin and M. Rees: *Cosmic Coincidences* (Bantam Books, London , 1989)

[54] J. Jeans: *The Mysterious Universe* (Cambridge University Press, Cambridge, 1931)

[55] R. Penrose: *The Emperor's New Mind: Concerning Computers, Minds and the Laws of Physics* (Oxford University Press, Oxford, 1989)