Journal of Modern Physics, 2016, 7, 1972-1994
http://www.scirp.org/journal/jmp
ISSN Online: 2153-120X
ISSN Print: 2153-1196

Completing Einstein's Spacetime

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How to cite this paper: El Naschie, M.S. (2016) Completing Einstein's Spacetime. *Journal of Modern Physics*, **7**, 1972-1994.
http://dx.doi.org/10.4236/jmp.2016.715175

Received: November 1, 2016
Accepted: November 6, 2016
Published: November 9, 2016

Abstract

The four-dimensional character of Einstein's spacetime is generally accepted in mainstream physics as beyond reasonable doubt correct. However the real problem is when we require scale invariance and that this spacetime be four-dimensional on all scales. It is true that on our classical scale, the 4D decouples into 3D plus one time dimension and that on very large scale only the curvature of spacetime becomes noticeable. However the critical problem is that such spacetime must remain 4D no matter how small the scale we are probing is. This is something of crucial importance for quantum physics. The present work addresses this basic, natural and logical requirement and shows how many contradictory results and shortcomings of relativity and quantum gravity could be eliminated when we "complete" Einstein's spacetime in such a geometrical gauge invariant way. Concurrently the work serves also as a review of the vast Literature on E-Infinity theory used here.

Keywords

E-Infinity, Cantorian Spacetime, Self-Similarity, M-Theory, Kaluza-Klein Space, Fuzzy Kähler Manifolds, Continued Fraction, Isomorphic Length, Geometrical Gauge Invariance

1. Introduction

The present work is a quite comprehensive review of E-Infinity theory [1]-[60] in high energy physics and cosmology which addresses a fundamental question in the very nature of the geometry and topology of spacetime [60]-[402]. Spacetime is four-dimensional manifold with three spatial and one time dimension [403] [404] [405] [406]. There is nothing very surprising nor deviating from our everyday experience in this picture which goes back to the beginning of modern physics [407]-[419]. In other words, Einstein's spacetime is truly conventional except for two minor details, which on closer examination turns out to be truly profound. The deceptively simple twist is that in Einstein's theory space and time are linked together to a spacetime and that at large scales spacetime acquires a curvature linking mass and gravity with the geometry of the Universe [4]-[80] [403]-[410].

The starting point of our criticism of Einstein's preceding conception, which we accept in principle, is again a deceptively simple one. Our point is that Einstein did not dwell on the nature of spacetime at the very small scales [406]. On the other hand at very small scales our inability to give a watertight definition for what a point is becoming critical while the very small scale is also where quantum mechanics becomes very important in fact indispensable for high energy physics let alone quantum gravity [1] [13] [411]. Our solution in the present work is equally disarmingly straightforward. We simply insist that Einstein's spacetime remain self-affine to four-dimensional manifold on all scales down to a point like "infinitesimally" small spacetime "point" which naturally cannot be a classical point but rather a "Cantorian" point. This means a point which upon "magnification" *i.e.* upon increasing the resolution of our "observation" turns ours to be not a point but an entire Cantor set with uncountably infinitely many points and so on ad infinitum [1]-[50]. The analysis to be presented in the next section shows that the requirement of "geometrical" gauge invariance [1]-[80] [406] [412] of Einstein's D - 4 leads to a new fractal-like dimension $D = 4 + \phi^3 = 4.23606007$ where $\phi = \left(\sqrt{5} - 1\right)/2$. From there we proceed to show how this result connects with Witten's M-Theory spacetime [158] [413] as well as explaining the mystery of the Dark Energy and Dark Matter of the Cosmos [4]-[70] [158].

2. Analysis. Geometrical Gauge Invariance

The simple picture of self-similar fractal-like space which we will propose here is all what we need [1]-[10]. Thus to ensure a quasi-geometrical gauge invariance [412], [415] is all what is required to convert Einstein's 4D spacetime to a 4D spacetime on all scales. Our analytical tool to do that is the marvelous classical mathematical "technique" known in the literature as continued fraction. This means that our space should be 4D inside 4D and so on like an infinite arrangement of Russian Dolls [3] each with D = 4 so that at the end we find that our dimension is given by

$$D = 4 + \cfrac{1}{4 + \cfrac{1}{4 + \cfrac{1}{4 + \dots}}} \tag{1}$$

Summing this infinite "series" one finds a little surprise namely that our new total dimension is equal to 4 plus the golden mean to the power of three. In other words D is [1]-[158]

$$\begin{aligned} D &= 4 + \phi^3 \\ &= 4.236067977 \end{aligned} \tag{2}$$

The same neat result could be obtained using the bijection formula of E-Infinity theory [1]-[10] or more conventionally using Von Neumann-Connes' dimensional function of Non-commutative geometry [414].

An important and revealing property of the new spacetime is that union and intersection of "wave" and "particle" lead to the same result which is the quintessence of the wave-particle duality of quantum mechanics [403] [409]. Thus with the wave given by ϕ^2 while the particle is characterized by ϕ one finds the un-normed probability to be [1]-[80] [158]

$$P_1 = \left(\frac{1}{\phi}\right)\left(\frac{1}{\phi^2}\right) = 4+\phi^3 \tag{3}$$

and similarly

$$P_2 = \left(\frac{1}{\phi}\right)+\left(\frac{1}{\phi^2}\right) = 4+\phi^3 \tag{4}$$

In other words we find the classical indistinguishability or fuzziness condition of Cantorian quantum physics to be validated and reflected into the Hausdorff dimension $4+\phi^3$ which fully explains the paradoxical outcome of the famous two-slit experiment with quantum particles. Next we examine the relevance of the present result for Witten's M-Theory [158] [207] [413] as well as the major cosmological riddle of Dark Energy and Dark Matter [10]-[80] [158].

3. Witten's M-Theory, Dark Energy and the Isomorphic Length of Super-Symmetric Penrose Tiling Universe

It may come to some as an unexpected surprise initiating some deep thinking that $4+\phi^3$ can lead to a fractal version of the D = 11 of the wizard of Theoretical Physics E. Witten [413] [416] and particularly his M-theory and the five brane in eleven dimensions model. To find Witten's D from $4+\phi^3$ it needs to be golden mean scaled twice. That way we find [1]-[20] [158]

$$\left(4+\phi^3\right)\left(1+\phi\right)\left(1+\phi\right) = 11+\phi^5 \tag{5}$$

Amazingly this is exactly equivalent to making D = 11 a geometrically gauge invariant spacetime exactly as we did with Einstein's D = 4 spacetime to obtain $D = 4+\phi^3$. Thus using the same continued fraction procedure we find:

$$\begin{aligned} D &= 11+\cfrac{1}{11+\cfrac{1}{11+\dots}} \\ &= 11+\phi^5 \end{aligned} \tag{6}$$

where ϕ^5 is nothing but Hardy's quantum entanglement of two quantum particles [82]. The preceding connection to Hardy's quantum entanglement [41] leads us to speculate on whether $D = 11+\phi^5$ could be used in determining the ordinary and thus the dark energy density of the cosmos [28]-[90]. It turns out that this hunch is correct and we will attempt to explain it in what follows.

4. The Dark Energy Density of the Universe

We recall that a simple $4+\phi^3$ dimension is a basically bosonic space which needs a spin half degree of freedom to accommodate fermions. Consequently $4+\phi^3+1=5+\phi^3$ is the fermionic counterpart of $4+\phi^3$. It just happened to be a dimension identical to the fractal Kaluza-Klein space D = 5 [45] [92]. A few minutes of clear thinking would easily convince us that a space which is super symmetric must possess a dimension which results from the intersection of the bosonic spacetime $4+\phi^3$ with the fermionic space $5+\phi^3$ That means

$$\begin{aligned} D(\text{Super}) &= \left(4+\phi^3\right)\left(5+\phi^3\right) \\ &= 22+k \\ &= (2)\left(11+\phi^5\right) \end{aligned} \quad (7)$$

where $k=\phi^3\left(1-\phi^3\right)=2\phi^5$.

Consequently the isomorphic length of this super symmetric space is exactly equal to that of the fractal version of Witten's M-theory [158].

$$\ell_p = \frac{D(\text{Super})}{2} = 11+\phi^5 \quad (8)$$

Now we know that the Einstein spacetime D = 4 is isotropic and consequently the isomorphic diameter is unity and therefore the isometric radius *i.e.* isomorphic length is one half. Inserting in E (Einstein), one finds [158]

$$\begin{aligned} E &= \frac{(1/2)}{\left(11+\phi^5\right)}\left(mc^2\right) \\ &= mc^2/(22+k) \\ &= E(\text{Ordinary}) \end{aligned} \quad (9)$$

Consequently the Dark Energy density of the Universe must be [22]-[85]:

$$\begin{aligned} E(D) &= 1-E(\text{Ordinary}) \\ &= \left[1-1/(22+k)\right]mc^2 \\ &= \left[(21+k)(22+k)\right]mc^2 \\ &\simeq (21/22)mc^2 \end{aligned} \quad (10)$$

This means the measurable ordinary energy of the Universe is about 4.5% while the corresponding Dark Energy density is a staggering 95.5% in full agreement with cosmic measurements and observations as well as all our previous analyses [4]-[90].

It is remarkable and noteworthy to register in the present context the agreement between the present derivation and the K3-Kähler topology [16] [417] used in deriving the same result namely

$$\begin{aligned} E(O) &= \frac{b_2(\text{Einstein})}{b_2(\text{Kähler})}mc^2 \\ &= \frac{1}{22}mc^2 \end{aligned} \quad (11)$$

and

$$E(D) = \frac{b_2(\text{Kähler}) - b_4(\text{Kähler})}{b_2(\text{Kähler})} mc^2 = \left(\frac{22-1}{22}\right) mc^2 = \frac{21}{22} mc^2 \tag{12}$$

5. Discussion and Conclusion

Again and again the Golden Mean $\left(\phi = \left(\sqrt{5}-1\right)/2 = 0.618033989\right)$ appears unexpectedly in theoretical quantum physics at crucial points [11] such as the probability of quantum entanglement for two particles $\left(P = \phi^5\right)$ as well as the dimensional function of a non-commutative Penrose-Connes Universe [1] [3] [414]. The present work shows that this particular phenomenon is intimately linked to the completion of Einstein's space time via extending it to a gauge invariant manifold with $D = 4 + \phi^3$ rather than D = 4 where ϕ is the said golden mean. The simplest way to calculate this is to use the classical marvelous simple mathematical procedure of continuous fraction. In this way we can neatly show in analogous way that the dimension of the fractal universe of Kaluza-Klein theory is $D = 5 + \phi^3$ rather than D = 5 and similarly D for a fractal M-theory is $D = 11 + \phi^5$ rather than D = 11 [158]. From there we arrive to the accurate ordinary and dark energy density of the universe in a relatively short way indeed. In addition equipped with the preceding insight the remarkable connection of our result to the topology of K3-Kähler and Conway's isomorphic length on one side and our gauge invariant Einstein's spacetime on the other was amply demonstrated and instructively used in the same context namely that of Dark Energy density of the Universe [22]-[90].

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