Scientific Research Publishing

Journal of High Energy Physics, Gravitation and Cosmology, 2018, 4, 519-528
http://www.scirp.org/journal/jhepgc
ISSN Online: 2380-4335
ISSN Print: 2380-4327

Calculating the Number of Universes in a Multiverse from First Principles with Linkage to Vacuum Energy and a Relationship with Nonlinear Early Universe B Fields. And the Early Universe B Field Connection to Non-Zero Graviton Mass

Andrew Beckwith

Department of Physics, Chongqing University, Chongqing, China
Email: abeckwith@uh.edu, rwill9955b@gmail.com

How to cite this paper: Beckwith, A. (2018) Calculating the Number of Universes in a Multiverse from First Principles with Linkage to Vacuum Energy and a Relationship with Nonlinear Early Universe B Fields. And the Early Universe B Field Connection to Non-Zero Graviton Mass. *Journal of High Energy Physics, Gravitation and Cosmology*, **4**, 519-528.
https://doi.org/10.4236/jhepgc.2018.43030

Received: April 29, 2018
Accepted: July 22, 2018
Published: July 25, 2018

Abstract

In this document, using a minisuperspace model, in the WdW equation we come up with an evaluation as to an equation which could fit a specialized set of boundary conditions for bounds to early universe vacuum energy. In addition, using the arguments of Golgov, as of a 1989 Moriond Astrophysics meeting of that date we ascertain the probability vacuum energy, as re-written as the cosmological constant, could lead to the production of a "baby" universe. The number, *N*, of that supposition is then analyzed in detail. This in turn has a relationship to a non-linear B field contribution in early universe cosmology whose consequences are explored and delineated. If there is a multiverse, the graviton mass is non-zero. Through arguments given in the document, the scale factor is also then, non-zero, which also portends to having the graviton not equal to zero if there is a corresponding initial non-linear B field, in the set up of the multiverse cosmology. If the Graviton has zero mass, this corresponds to a single repeating universe, with different morphology.

Keywords

Vacuum Energy, Massive Gravitons

1. Introduction

We examine looking at a book by Hambler [1] as to the origins of Quantum gravitation, especially on pages 124-5 as to his treatment of the Wheeler-De Witt equation, for super symmetric models. What the author found most significant was a treatment of how to go from the Classical Friedman equation, to a mini superspace equation which we can then use to identify the vacuum energy relevant to this problem. We for the sake of argument engage in a solution at the nexus of the big bang, paying attention to some of the formalism, also of Kolb and Turner [2], and also [3] whereas in [3], pp 460-462, the Hartle-Hawkings solution is entertained for review. In the end, we first acknowledge the matter version of the WdW equation as given in [1], its similarities to [2] [3] and also delve into the probabilistic interpretation of what a vacuum energy is via [4]. In addition, in the follow up, issues pertaining to [5] [6] will also be alluded to, as to minimum uncertainty relations, and ways to understand uncertainty in time, as part of the time evolution, as far as emergent gravity is concerned. This is important, since if a minimum non-zero scale factor exists, as Beckwith asserts, then by [7] there is from the beginning a balance between variation in time of the energy given in a given three volume, V, and the flux of this energy through the boundary 2 surface, of this volume to consider, which inevitably leads to refining the notion of time and the WdW equation as given in [8]. The author commences speculating upon how this could conceivably affect the topics raised in [9] in the conclusion as to what leads to the perturbations of space time structure brought up in [9]. In doing so, the author is hoping to find falsifiable experimental criteria as to determining if a multiverse exists, which is due to the expansion of topics brought up by [10]. The issues so brought up are crucial to understanding cosmology as a falsifiable experimental science. Also, the probability calculations in [2] [3] [4] if utilized correctly can help indicate the number of separate universes existing in the presumed multiverse. In turn, this also means utilizing the inputs from [11] as to non-linear electrodynamics and cosmology in ways made fully relevant in the last two sections of this paper.

2. Analysis of the WdW Equation as Given in Reference [1], with an Emphasis upon Vacuum Energy. *i.e.* How and Why Vacuum Energy Could Be Unexpectedly Large

What is needed now is to look at the classical Friedman equation in [1] which is transformed (page 124) to (if q is a scaled number frequently set equal to 1)

$$\left\{\alpha\cdot\frac{1}{a^2}\cdot\frac{\partial^2}{\partial a^2}+q\cdot\alpha\cdot\frac{1}{a^3}\cdot\frac{\partial}{\partial a}-\tilde{k}+\frac{8\pi G}{3}\cdot a^2\cdot\rho(a)\right\}\Psi(a)=0 \tag{1}$$

In doing so, the key point is to look at what is called. $\rho(a)$ The generalized expression for it is given in [1] as

$$\rho(a)=M/a^{\sigma} \tag{2}$$

where the coefficient of the denominator is zero leads to the vacuum energy value which we will evaluate, *i.e.*

$$\rho(a)=M \tag{3}$$

In this, we can make the following special solution treatment of the wave function of the universe, in near initial configuration given as, if we use Equation (1) and Equation (3)

$$\Psi(a) = d_0 + d_1 a + d_2 a^2 \Rightarrow d_2 \cdot \left(\frac{4}{a^2} + \frac{8}{3\alpha} \pi G M a^4 - \frac{\tilde{k}}{\alpha} a^2 \right) + d_1 \cdot \left(\frac{1}{a^3} + \frac{8}{3\alpha} \pi G M a^3 - \frac{\tilde{k}}{\alpha} a \right) + d_0 \left(\frac{8}{3\alpha} \pi G M a^2 - \frac{\tilde{k}}{\alpha} \right) = 0 \tag{4}$$

A reasonable assumption is that the wave function given in the first reference, [1], is that we can set the first coefficient in the wave function equal to zero, then, $d_0 \equiv 0$ and if we chose the flat space representation and set $q = 1$, *i.e.* setting $\tilde{k} = 0$ and having $a \sim 0^+ \ll 1$

$$\Psi(a) = a \cdot d_1 \cdot \left\{ 1 - \frac{\left[\alpha + \frac{8\pi G}{3} \cdot M a^6 \right]}{\left[4\alpha + \frac{8\pi G}{3} \cdot M a^6 \right]} \right\} \tag{5}$$

i.e. here, the admissible set of M is then $0 \le M < \infty$, and in the initial phases of evolution cosmologically we can have the following identification made, namely [11]

$$M \sim \Lambda_{\text{Max}} \sim c_2 \cdot T^{\tilde{\beta}} \tag{6}$$

where in fact we are actually using, closer to the point [12] [13]

$$\rho_{VAC} \sim \frac{\Lambda_{\text{observed}}}{8\pi G} \sim \sqrt{\rho_{UV} \cdot \rho_{IR}} \sim \sqrt{l_{\text{Planck}}^{-4} \cdot l_H^{-4}} \sim l_{\text{Planck}}^{-2} \cdot H_{\text{observed}}^2 \tag{7}$$

As well as [12] [13] [14]

$$\frac{\Lambda_{\text{Max}} V_4}{8 \cdot \pi \cdot G} \sim T^{00} V_4 \equiv \rho \cdot V_4 = E_{\text{total}} \tag{8}$$

Combining Equation (7) and Equation (8) as well as scaling E with M, makes the identification.

Note also that initially, we also specify an increase in entropy, due to [15] [16]

$$\left| \frac{\Delta E}{l_P^3} \right| \sim \left| \frac{\Delta P \in 150\pi^2}{l_P^3} \right| \approx |\Delta S| \tag{9}$$

Here, T, in Equation (6) is the temperature, which by Kolb and Turner scales as, if g_{*S} is the degrees of freedom which at times can be $100 < g_{*S} < 1000$ according to [3]

$$T \propto g_{*S}^{-1/3} \cdot a^{-1} \tag{10}$$

Note that if H_{Early}^2 is picked as initially small, it becomes enormous when $\Delta S \sim 10^{10}$ pushes to value a bit later to approaching much later time values of 10^{100}. This shift in value for H_{Early}^2, from a small to a much later value later on, will go to the main issue of initially, with $l_P^2 \propto \left[1.616 \times 10^{-35} \text{meters} \right]^2$ we have huge values for the initial cosmological Hubble parameter, as can be seen through.

$$H_{\text{Early}}^2 \sim \left[\Lambda_{\text{Cosmological}} \cdot l_P^2 / 8\pi G \right] \tag{11}$$

And, also,

$$\frac{l_P^2 \cdot \Delta S}{H_{\text{Early}}^2} \approx \frac{8\pi G \cdot \Delta S}{\Lambda_{\text{Cosmological}}} \sim 10^{-4} - 10^{-5} \tag{12}$$

The implications of this we will reference, in the later part of this document.

3. Visualizing a Probability Expression as to the Likelihood of Synthesis of a Given Universe Due to a Computed Vacuum Energy Value

We will review what was said by [4] as to the probability of having a universe form.

In [3] Dolgov writes the particular GR action with a Λ cosmological "constant term" as given by, if R is part of the Einstein action as given on page 234 of [3]

$$S = \left(m_{\text{Planck}}^2 / 16\pi \right) \cdot \int \mathrm{d}^4 x \sqrt{g} \cdot \left(-R + 2\Lambda \right) \tag{13}$$

We are assuming, according to [3] a "Euclidian sphere" with radii as given in page 235 of [4].

$$\sqrt{3/\Lambda} \tag{14}$$

The above leads to a classical action value which is rendered as

$$S_{\text{classical}} = -3\pi m_{\text{Planck}}^2 / \Lambda \tag{15}$$

This would lead to the probability of the cosmological term being equal to Λ as

$$P_{\text{Given-}\Lambda} \sim \exp\left(3\pi \cdot m_{\text{Planck}}^2 / \Lambda \right) \equiv \exp\left(-S_{\text{classical}} \right) \tag{16}$$

The smaller Λ is, the more likely a universe is created with cosmological term equal to Λ. Our interpretation of what this is saying is, to, for N universes, to write the following, namely have for a Jth universe

$$P_{\text{Given-}\Lambda}\Big|_{\text{jth-universe}} \sim \exp\left(3\pi \cdot m_{\text{Planck}}^2 / \Lambda \right)\Big|_{\text{jth-universe}} \tag{17}$$

We will change this by inverting the exponential factor so we will be getting the probability scaled from 0% to 100%. In doing so, we rewrite Equation (17) as

$$P_{\text{Given-}\Lambda}\Big|_{\text{jth-universe}} \sim \exp\left(-3\pi \cdot m_{\text{Planck}}^2 / \Lambda \right)\Big|_{\text{jth-universe}} \tag{17a}$$

Then, taking the multiverse, we will write a global universal probability as given by

$$\sum_{j=1}^{N} P_{\text{Given-}\Lambda}\Big|_{\text{jth-universe}} = \sum_{j=1}^{N} \exp\left(-3\pi \cdot m_{\text{Planck}}^2 / \Lambda \right)\Big|_{\text{jth-universe}} = 100\% \tag{18}$$

To first order, Equation (18) implies that, if one is looking at different values of Λ at the start of inflation, for each of the N universes, then the value of N so obtained is to good approximation given is the N sub universes, of a multiverse.

Likely, Λ is enormous at the start of each of the N universes inflationary era, meaning that there are, for Planck temperatures, literally billions of such universes. We will examine what each of these universes portends, and the issue of information/entropy per each of these universes.

4. Conclusion, and Implications as Far as Initial Radii of the Universes, Involved. And the Mass of a Graviton

Tiny radii as given by Equation (14), for very large but not infinite Λ values, among other things have a basis, partly in entropy, but also in electromagnetism, and GR. We will examine what that is, and suggest measurement strategies pertinent to confirming our suggestion and model.

Now, if H_{early} is the initial behavior of the Hubble parameter, and one starts with

$$\frac{\left[\Delta E/l_P^3\right]}{\left[H_{\text{early}}^2/l_P^2\right]} \approx \frac{\Delta S}{\left[H_{\text{early}}^2/l_P^2\right]} \sim \frac{l_P^2 \cdot \Delta S}{H_{\text{Early}}^2} \sim \frac{\delta\rho}{\rho} \tag{19}$$

Then we can use a spatial dependence given by Equation (12), *i.e.* by identification of admissible values of Λ, which when combined with Equation (19) yield smallest admissible radii (near singularities) as given by smallest radii of the order of Planck length, l_P, not a perfect singularity, and the connection with E and M is seen in adapting ideas given in [2].

As modified into

$$\rho = \rho_{\text{radiation}} \sim (3/4) \cdot \left[\frac{45}{2\pi^2 g_*}\right]^{1/3} \cdot S^{4/3} \cdot r^{-4} \tag{20}$$

Here, r is of the order of Planck length, l_P, and the entropy, S is of the order of 10^5 to 10^{10} initially as opposed to values of 10^{100} or more today. The radiation density should be reconciled with.

$$\left(\frac{\delta\rho}{\rho}\right)_{\text{Horizon}} \cong \left(1/\sqrt{2\pi}\right) \cdot k^{3\alpha} \sim \frac{H^2}{\dot{\phi}} \propto 10^{-4} - 10^{-5} \tag{21}$$

Having such a relatively small value of $l_P^2 \propto \left[1.616 \times 10^{-35}\,\text{meters}\right]^2$ as placed with $\Delta S \sim 10^{10}$

$$10^{-4} - 10^{-5} \sim \frac{l_P^2 \cdot \Delta S}{H_{\text{Early}}^2} \tag{22}$$

The connection to early universe as given is to make use of the massive graviton mass value [15] of

$$-3m_g^2 h = \frac{\tilde{\kappa}}{2} T \tag{23}$$

We will be examining the import of Equation (23) from first principles. Note that in doing so, the perturbation term *h*, affecting the $g_{u,v}$ metric tensor, is seriously affected by [10], if we use

$$T = 3p - \rho \tag{24}$$

And [10] a minimum value of the density linked to the "cosmological constant" for which

$$\rho_{\Lambda}(t) = \Lambda(t) \cdot c^4 / 8\pi G \tag{25}$$

We claim that Equation (3) can be related in part to [12] [13] [14]

$$\rho_{VAC} \sim \frac{\Lambda_{\text{observed}}}{8\pi G} \sim \sqrt{\rho_{UV} \cdot \rho_{IR}} \sim \sqrt{l_{\text{Planck}}^{-4} \cdot l_H^{-4}} \sim l_{\text{Planck}}^{-2} \cdot H_{\text{observed}}^2 \tag{26}$$

This in part can be related to analyzing if a cosmological background pressure can be negative [11].

$$p = \frac{\rho}{3} - \frac{16}{3}\omega \cdot B^4 \tag{27}$$

There are two time varying values of the cosmological "constant", one of which explicitly depends upon the temperature as was given in Equation (6), as in [11]. Another version of such, is a treatment given by [10] which would lead to writing the cosmological "constant" dominating the universe when

$$\Lambda(t) > 8\pi G\rho / c^4 \tag{28}$$

Looking at what Equation (29) is saying, *i.e.* we can look then at what happens if we look at the Hubble "constant" parameter at the start of the inflationary era [3]

$$\Lambda(t) \sim \left(H_{\text{inflation}}\right)^2 \tag{29}$$

In this case, should the initially created magnetic field, B, be sufficiently large; we will have then negative pressure, leading to a real value to the graviton mass, *i.e.* that the initial magnetic field be huge, so as to initiate having a massive graviton, as specified by

$$m_g^2 = \frac{8\tilde{\kappa}}{9h}\omega \cdot B^4 \tag{30}$$

The link to initial radii, *i.e.* to a non singular expression for the smallest.

What we are asserting is, that the very process of an existent E and M field which contributes to a massive graviton in addition to being a Lorentz violation, also, according to [3] is where we formulate non-zero initial radii to the universe. *i.e.* in [3] there exists a scaled parameter λ, and a parameter a_0 which is paired with α_0. For the sake of argument, we will set the $a_0 \propto \sqrt{t_{\text{Planck}}}$, with $t_{\text{Planck}} \sim 10^{-44}$ seconds. Also,

$$\alpha_0 = \sqrt{\frac{4\pi G}{3\mu_0 c}} B_0 \tag{31}$$

$$\lambda = \Lambda c^2 / 3 \tag{32}$$

Then if, initially, Equation (32) is large, due to a very large cosmological "constant" parameter the time, given in Equation (53) of [10] is such that we can write, most likely, that

$$t_{\min} \approx t_0 \equiv t_{\text{Planck}} \sim 10^{-44}\,\text{s} \tag{33}$$

Whenever one sees the coefficient like the magnetic field, with the small 0 coefficient, for large values of Λ, this should be the initial coefficient at the beginning of space-time which helps us make sense of the non zero but tiny minimum scale factor

$$a_{\min} = a_0 \cdot \left[\frac{\alpha_0}{2\lambda} \left(\sqrt{\alpha_0^2 + 32\lambda\mu_0\omega B_0^2} - \alpha_0 \right) \right]^{1/4} \tag{34}$$

The minimum scale factor has a scaled value of nearly 10 to the minus 55, with $a_0 \propto \sqrt{t_{\text{Planck}}} \sim 10^{-22}$ (35)

In making this approximation, when looking at the number of universes, as given in Equation (17), namely, if each universe is approximately equally probable, then to first order, rounded off, the number of universes, is approximately (assuming that the temperature in the "cosmological constant" expression is at the beginning of inflation)

$$N \sim \exp\left(3\pi \cdot m_{\text{Planck}}^2 / \Lambda\right)\Big|_{\text{jth-universe}} \tag{36}$$

The magnitude of $\Lambda_{\text{Max}} \sim c_2 \cdot T_{\text{temperature}}^{\tilde{\beta}}$ due to a given temperature, in turn will be tied into the minimum scale factor, as given by Equation (34), which in turn is directly affected by the Magnetic field B. If $B \sim$, then this in turn will affect the mass of a graviton.

We can, numerically relate the Λ value to the $B \sim B_0$, and this by making judicious use of Equation (34) and Equation (35), and in doing so get an appropriate range of Λ values which in turn will affect the N value of Equation (36) above.

i.e. all these suppositions need experimental verification which the author hopes is doable in the near future. Finally, given the above, the following should be investigated as consistent with respect to early universe conditions, namely an argument from Kauffman [9].

We follow the recent work of Kauffmann [9], which sets an upper bound to concentrations of energy, in terms of how he formulated the following equation put in below as (53). (53) specifies an inter-relationship between an initial radius R for an expanding universe, and a "gravitationally based energy" expression we will call $T_G(r)$ which lead to a lower bound to the radius of the universe at the start of the Universe's initial expansion, with manipulations. The term $T_G(r)$ is defined via (54) afterwards. We start off with Kauffmann's expression [9]

$$R \cdot \left(\frac{c^4}{G} \right) \geq \int_{|r''|<R} T_G(r + r'') \mathrm{d}^3 r'' \tag{37}$$

Kauffmann [9] calls $\left(\frac{c^4}{G} \right)$ a "Planck force" which is relevant due to the fact we will employ (37) at the initial instant of the universe, in the Planckian regime of space-time. Also, we make full use of setting for small r, especially if we include in ideas, also of, [17] we are then able to utilize the following:

$$T_G\left(r+r''\right)\approx T_{G=0}\left(r\right)\cdot const\sim V\left(r\right)\sim m_{\text{Gravtion}}\cdot n_{\text{Initial-entropy}}\cdot c^2 \tag{38}$$

i.e. what we are doing is to make the expression in the integrand proportional to information leaked by a past universe into our present universe, with Ng [16] style quantum infinite statistics use of

$$n_{\text{Initial-entropy}}\sim S_{\text{Gravtion-count-entropy}} \tag{39}$$

Then Equation (39) will lead to

$$\begin{aligned}
&R\cdot\left(\frac{c^4}{G}\right)\geq\int_{|r''|<R}T_G\left(r+r''\right)\mathrm{d}^3r''\approx\text{const}\cdot m_{\text{Gravtion}}\cdot\left[n_{\text{Initial-entropy}}\sim S_{\text{Gravtion-count-entropy}}\right]\\
&\Rightarrow R\cdot\left(\frac{c^4}{G}\right)\geq\text{const}\cdot m_{\text{Gravtion}}\cdot\left[n_{\text{Initial-entropy}}\sim S_{\text{Gravtion-count-entropy}}\right]\\
&\Rightarrow R\geq\left(\frac{c^4}{G}\right)^{-1}\cdot\left[\text{const}\cdot m_{\text{Gravtion}}\cdot\left[n_{\text{Initial-entropy}}\sim S_{\text{Gravtion-count-entropy}}\right]\right]
\end{aligned} \tag{40}$$

Here, $\left[n_{\text{Initial-entropy}}\sim S_{\text{Gravtion-count-entropy}}\right]\sim 10^5$, $m_{\text{Gravtion}}\sim 10^{-62}\,\text{grams}$, and we set Plank length as:

Planck length = l_{Planck} = 1.616199 × 10^{-35} meters

where we set $l_{\text{Planck}}=\sqrt{\frac{\hbar G}{c^3}}$ with $R\sim l_{\text{Planck}}\cdot 10^{\alpha}$, and $\alpha>0$. Typically $R\sim l_{\text{Planck}}\cdot 10^{\alpha}$ is about $10^3\cdot l_{\text{Planck}}$ at the outset, when the universe is the most compact. The value of *const* is chosen based on common assumptions about contributions from all sources of early universe entropy, and we argue that the above methodology, giving a non zero initial starting point is made especially tendable if one is allowing for the existence of prior recycling universes gravitons to play a role, *i.e.* that in the single universe repeated again and again, there would be real issues as to the survival of the graviton allowing for the conclusion as to (40).

This lower bound to the radii, should be compared to (38) above, and is essential for falsifiable criteria in experimental astrophysics.

The bottom line, is this. If there is a multiverse, the graviton mass is non zero. Through arguments given in the document, the scale factor is also then, non zero, which also portends to having the graviton not equal to zero if there is a corresponding initial non linear B field, in the set up of the cosmology.

Note that *N*, for the number of universes in a multiverse, goes up, if the initial temperature, *T*, as given in Equation (36), goes down, *i.e.* a "cold" universe start, and then a rapid condensation to the unimaginable Planck temperature regime. This, plus the issue of how a real graviton mass value, non imaginary, in Equation (30), puts in real constraints as to the permitted B fields, in the case of the multiverse. The challenge, is, then to have for a real graviton mass, experimental procedures in place to differentiate between a non zero graviton mass, the admitted scale factor value of minimum value, which is affected by both the Planck's "constant" early universe magnitude, and initial B fields, as well as other considerations experimentally. We look forward to falsifiable experimental procedures to investigate this issue experimentally.

The reason why a zero graviton mass has linkage to the lowest number, N, *i.e.* $N = 1$, is due to the initial temperature T, used in Equation (17a) being then extremely high, leading to no condition for which Equation (27) and Equation (30) are satisfied for a non zero initial magnetic field. *I.e.* then as the temperature approaches Plank temperature values, we have

$$\begin{aligned} & p = \frac{\rho}{3} - \frac{16}{3}\omega \cdot B^4 \xrightarrow[N \to 1]{} p = \frac{\rho}{3} \\ & \Leftrightarrow m_g = 0 \,\&\, B = 0 \end{aligned} \tag{41}$$

Equation (41) occurring mean that Equation (40) is bounded below by zero, as well as Equation (34) approaches zero, for an "infinite" (Planck temperature value) as the starting point for the new cosmology. We hope to configure falsifiable tests allowing for such a prediction being confirmed in the near future.

We should discuss and compare finding on the graviton mass with the recent lower bound of $7.7 \times (10^{-23})$ (eV/c^2) which has been recently found by LIGO in Phys. Rev. Lett. 118, 221101 (2017) [18].

This datum, by LIGO [18] suggests that, in Equation (41) that we have a deviation from a zero magnetic field, if so, then

$$\begin{aligned} & \text{if } p = \frac{\rho}{3} - \frac{16}{3}\omega \cdot B^4 \xrightarrow[N \to 1]{} p = \frac{\rho}{3} \\ & \Leftrightarrow m_g = 0 \,\&\, B = 0 \\ & \text{So}, m_g \neq 0 \,\&\, B \neq 0 \\ & \xrightarrow[N \to 1]{} p = \frac{\rho}{3} \pm \varepsilon^{+} \\ & \textit{i.e.} \text{ changing } p \,\&\, \rho \text{ ratios} \end{aligned} \tag{42}$$

This is extremely important and is a testable experimental gravity datum we should investigate the pressure and density ratios via experimental gravity investigations.

Finally, all this investigation should take into account the Corda findings as to how to test for gravity foundations, as given in [19], which would be a way to determine if Scalar-Tensor gravity, is still viable, or if what [18] suggests is true, *i.e.* that gravity is in essence a purely GR construction.

Acknowledgements

This work is supported in part by National Nature Science Foundation of China grant No. 11375279.

References

[1] Hamber, H. (2009) Quantum Gravitation, The Feynman Path Integral Approach. Springer-Verlag Berlin-Heidelberg, Federal Republic of Germany.

[2] Kolb, E. and Turner, M. (1990) The Early Universe, Frontiers in Physics, Lecture Note Series, Volume 69. Addison-Wesley Publishing Company, Menlo Park, California.

[3] Dolgov, A.D. (1989) The Cosmological Constant Problem. In: Audouze, J. and Tran Than Van, J., Eds., *The Quest for the Fundamental Constants in Cosmology*, 227-240, Editions Frontieres, France.

[4] Birrell, N.D. and Davies, P.C.W. (1982) Quantum Fields in Curved Space. Cambridge Monographs on Mathematical Physics. Cambridge University Press, Cambridge. https://doi.org/10.1017/CBO9780511622632

[5] Downes, T.G. and Milburn, G.J. (2011) Optimal Quantum Estimation for Gravitation. arXiv:1108.5220 [gr-qc]

[6] Lapiedra, R. and Morales-Lladosa, J.A. (2013) On the Uniqueness of the Space-Time Energy in General Relativity: The Illuminating Case of the Schwartzshild Metric. *General Relativity and Gravitation*, **45**, 1145-1161. https://doi.org/10.1007/s10714-013-1515-z

[7] Crowell, L.B. (2005) Quantum Fluctuations of Spacetime, World Scientific Series in Contemporary Chemical Physics, Volume 25. World Scientific, Singapore.

[8] Di Dio, E., Durrer, R., Marozzi, G. and Montanari, F. (2014) Galaxy Number Counts to Second Order and Their Bispectrum. http://arxiv.org/pdf/1407.0376v1.pdf

[9] Kauffmann, S.K. (2012) A Self-Gravitational Upper Bound on Localized Energy, Including that of Virtual Particles and Quantum Fields, Which Yields a Passable "Dark Energy" Density Estimate. arXiv:1212.0426 [physics.gen-ph]

[10] Camara, C.S., de Garcia Maia, M.R., Carvalho, J.C. and Lima, J.A.S. (2004) Nonsingular FRW Cosmology and Non Linear Dynamics. Arxiv astro-ph/0402311 Version.

[11] Park, D.K., Kim, H. and Tamarayan, S. (2002) Nonvanishing Cosmological Constant of Flat Universe in Brane World Scenarios. *Physics Letters B*, **535**, 5-10. https://doi.org/10.1016/S0370-2693(02)01729-X

[12] Padmanabhan, T. (2006) An Invitation to Astrophysics. World Scientific Series in Astronomy and Astrophysics, Vol. 8. World Scientific Publishing Company, Singapore. https://doi.org/10.1142/6010

[13] Padmanabhan, T. (2000) Theoretical Astrophysics, Volume 1. Astrophysical Processes. Cambridge University Press, Cambridge.

[14] Padmanabhan, T. (2010) Gravitation, Foundations and Frontiers. Cambridge University Press, Cambridge. https://doi.org/10.1017/CBO9780511807787

[15] Beckwith, A.W. (2009) Entropy Growth in the Early Universe and Confirmation of Initial Big Bang Conditions (Wheeler de Witt Eqn. Results vs. String Theory?). http://vixra.org/abs/0908.0109

[16] Maggiorie, M. (2008) Gravitational Waves, Volume 1, Theory and Experiments. Oxford University Press, Oxford.

[17] Jack, Y. (2008) Spacetime Foam: From Entropy and Holography to Infinite Statistics and Nonlocality. *Entropy*, **10**, 441-461. https://doi.org/10.3390/e10040441

[18] Abbott, P., *et al.* (2017) LIGO Scientific and Virgo Collaboration. *Physical Review Letters*, **118**, Article ID: 221101.

[19] Corda, C. (2009) Interferometric Detection of Gravitational Waves: The Definitive Test for General Relativity. *International Journal of Modern Physics D*, **18**, 2275-2282. https://doi.org/10.1142/S0218271809015904