Scientific Research Publishing

Journal of High Energy Physics, Gravitation and Cosmology, 2022, 8, 1127-1133
https://www.scirp.org/journal/jhepgc
ISSN Online: 2380-4335
ISSN Print: 2380-4327

How Initial Degrees of Freedom May Contribute to Initial Effective Mass, *i.e.* Effective Mass of the Universe Proportional to (D.O.F.) to the 1/4th Power by an Enormous Initial Degree of Freedom Value

Andrew Walcott Beckwith

Physics Department, College of Physics, Chongqing University Huxi Campus, Chongqing, China
Email: Rwill9955b@gmail.com

How to cite this paper: Beckwith, A.W. (2022) How Initial Degrees of Freedom May Contribute to Initial Effective Mass, *i.e.* Effective Mass of the Universe Proportional to (D.O.F.) to the 1/4th Power by an Enormous Initial Degree of Freedom Value. *Journal of High Energy Physics, Gravitation and Cosmology*, **8**, 1127-1133.
https://doi.org/10.4236/jhepgc.2022.84079

Received: September 24, 2022
Accepted: October 22, 2022
Published: October 25, 2022

Abstract

Using a relationship between Hubble's "parameter", Temperature, Energy and effective mass, from there obtain in 3 + 1 dimensions a relationship between effective mass, and the initial degrees of freedom, to the 1/4th power, we will discuss candidates for entry into this, assuming for a start that initial universe conditions are similar to a black hole, *i.e.* a nearly singular start to inflationary expansion; this would necessitate a HUGE initial degree of freedom value as outlined in our argument.

Keywords

Degrees of Freedom, Effective Mass, Hubbles Parameter

1. First of All the Hubble Parameter Used, and Then the Tie into Energy and Degrees of Freedom

This is the easiest part of the derivation, in some respects extremely simple minded. The inputs into the parameters selected though will be anything but simple.

Begin first with [1], a Hubble parameter

$$H = 1.66\sqrt{g_*} \cdot \frac{T_{\text{temperature}}^2}{m_P} \tag{1}$$

Whereas we have, an assumed temperature dependence which we write as

$$E_{\text{system}} = \frac{k_B}{2} \cdot T_{\text{temperature}} \tag{2}$$

Whereas we use the Sarkar scaling for scale factor, [2] of the form

$$a(t) = a_{\text{initial}} \cdot t^{\gamma} \tag{3}$$

In the first iteration assuming these three equations, there is an extremely simple relationship, as between Temperature and degrees of Freedom initially assumed. We will present it, and then rights afterwards go to the more complex issue of effective mass.

To do so, start with the simplest iteration as to temperature and degrees of freedom, and then from there go to mass issues.

Assume that we have, then a relationship between mass and temperature as of a black hole, namely Hawking's temperature

$$T_{\text{Hawkings}} = \frac{\hbar c^3}{8\pi G k_B M} \tag{4}$$

Then the mass will scale as

$$M = \sqrt{\sqrt{g_*} \cdot \frac{1.66\hbar}{64\pi^2 m_P G^2 k_B^2}} \cdot \sqrt{\frac{t}{\gamma}} \approx \sqrt{N_{\text{Gravitons}}} \cdot m_{\text{Planck}} \tag{5}$$

Having said, that will input in values for the time and that will be the remainder of this document.

2. Input of Time Parameter into Equation (5) and What It Signifies

What we are doing in line with the idea of using an initial black hole configuration is going to a graviton condensate model which would have from [3] the following configuration for an early universe configuration.

$$\begin{aligned} m &\approx \frac{M_P}{\sqrt{N_{\text{gravitons}}}} \\ M_{BH} &\approx \sqrt{N_{\text{gravitons}}} \cdot M_P \\ R_{BH} &\approx \sqrt{N_{\text{gravitons}}} \cdot l_P \\ S_{BH} &\approx k_B \cdot N_{\text{gravitons}} \\ T_{BH} &\approx \frac{T_P}{\sqrt{N_{\text{gravitons}}}} \end{aligned} \tag{6}$$

We would have the value of M so obtained be proportional in this situation to, say, if we were considering modeling the early universe as a "primordial" black hole as setting to first approximation, having [4]-[11]

$$M = \sqrt{\sqrt{g_*} \cdot \frac{1.66\hbar}{64\pi^2 m_P G^2 k_B^2}} \cdot \sqrt{\frac{t}{\gamma}} \approx \sqrt{N_{\text{Gravitons}}} \cdot m_{\text{Planck}} \tag{7}$$

What this is saying is that we can have the following formula for initial gravitons, from a primordial black hole condensate

$$N_{\text{Gravitons}} \approx \sqrt{g_*} \cdot \frac{1.66\hbar}{64\pi^2 \cdot (m_P)^3 G^2 k_B^2} \cdot \frac{t}{\gamma} \tag{8}$$

We have a really weird situation here. Namely consider if we go to Planck units, and we want m in Equation (6) to be commensurate with regards to a massive graviton of about 10^{-65} grams, if so then using normalized Planck units we will have

$$k_B^2 = G^2 = \hbar = m_P = t_P \to 1 \tag{9}$$

Also use the following rescaling of the time, as we could scale it to be

$$t \to \vartheta \cdot t_P \Rightarrow \frac{\vartheta \cdot t_P}{\gamma} \approx o(1) \tag{10}$$

Then:

If Planck mass is about 10^{-5} grams, and the mass of a heavy graviton is about 10^{-65} grams, then

$$m \approx 10^{-60} m_P \Rightarrow N_{\text{Gravitons}} \approx 10^{120} \tag{11}$$

This means that the mass, m, as stated would be that of about a massive graviton, or about 10^{-65} grams.

Whereas the total mass, *M*. would be the actual value of the mass of the universe, provided that

$$\begin{aligned} M &= \sqrt{\sqrt{g_*} \cdot \frac{1.66\hbar}{64\pi^2 m_P G^2 k_B^2}} \cdot \sqrt{\frac{t}{\gamma}} \sqrt{N_{\text{Gravitons}}} \cdot m_{\text{Planck}} \\ &\xrightarrow[\text{Planck Units}]{} \approx \sqrt[4]{g_*} \cdot \sqrt{\frac{1.66}{64\pi^2}} \cdot m_{\text{Planck}} \approx \sqrt{N_{\text{Gravitons}}} \cdot m_{\text{Planck}} \\ &\approx 10^{60} \cdot m_{\text{Planck}} \end{aligned} \tag{12}$$

If so then the strange situation we have would be resolvable if

$$\sqrt[4]{g_*} \cdot \sqrt{\frac{1.66}{64\pi^2}} \approx 10^{60} \tag{13}$$

I.e. the initial degrees of freedom, would be a staggering value of about

$$g_* \approx 10^{240} \cdot \left(\frac{64\pi^2}{1.66}\right)^2 \approx 10^{240} \times 144791 \propto 10^{245} \tag{14}$$

This number is gigantic, and it is in line with the initial mass, *M* as specified being proportional to the mass of the universe today.

On the face of it, this huge initial degrees of freedom argument looks contrived and insane. Where could it come from? We will go back to a version of the multiverse argument and a nonsingular start to the universe which may explain where this gigantic degrees of freedom argument comes from.

3. Tying This into an Early Multiverse Model of the Universe as Specified by the Author Looking Now at the Modification of the Penrose CCC (Cosmology)

We now outline the generalization for Penrose CCC (Cosmology) just before inflation which we state we are extending Penrose's suggestion of cyclic universes, black hole evaporation, and the embedding structure our universe is contained within, this multiverse has BHs and may resolve what appears to be an impossible dichotomy. The text following is largely from [4] [8] and has serious relevance to the final part of the conclusion that there are N universes undergoing Penrose "infinite expansion" (Penrose) [4] [8] contained in a mega universe structure. Furthermore, each of the N universes has black hole evaporation, with Hawking radiation from decaying black holes. If each of the N universes is defined by a partition function, called $\left\{\Xi_i\right\}_{i\equiv N}^{i\equiv 1}$, then there exists an information ensemble of mixed minimum information correlated about 10^7 - 10^8 bits of information per partition function.

In the set $\left.\left\{\Xi_i\right\}_{i\equiv N}^{i\equiv 1}\right|_{\text{before}}$. So minimum information is conserved between a set of partition functions per universe [4] [8]

$$\left.\left\{\Xi_i\right\}_{i\equiv N}^{i\equiv 1}\right|_{\text{before}} \equiv \left.\left\{\Xi_i\right\}_{i\equiv N}^{i\equiv 1}\right|_{\text{after}} \tag{14}$$

However, there is non-uniqueness of information put into partition function $\left\{\Xi_i\right\}_{i\equiv N}^{i\equiv 1}$. Also

$$\left\{\Xi_i\right\}_{i\equiv 1}^{i\equiv N} \propto \left\{\int_0^\infty \mathrm{d}E_i \cdot n\left(E_i\right)\cdot \mathrm{e}^{-E_i}\right\}_{i\equiv 1}^{i\equiv N}. \tag{15}$$

Each of E_i identified with Equation (9) above, are with the iteration for N universes [4] [8] and (Penrose, 2006) [4] [8] Then the following holds, by asserting the following claim to the universe, as a mixed state, with black holes playing a major part, *i.e.*.

<u>**CLAIM 1**</u>

See the below [4] [8] representation of mixing for assorted N partition function per CCC cycle

$$\frac{1}{N}\cdot\sum_{j=1}^{N}\left.\Xi_j\right|_{j\text{ before nucleation regime}} \xrightarrow{\text{vacuum nucleation tranfer}} \left.\Xi_i\right|_{i\text{ fixed after nucleation regime}} \tag{16}$$

For N number of universes, with each $\left.\Xi_j\right|_{j\text{ before nucleation regime}}$ for j = 1 to N being the partition function of each universe just before the blend into the RHS of Equation (16) above for our present universe. Also, each independent universes as given by $\left.\Xi_j\right|_{j\text{ before nucleation regime}}$ is constructed by the absorption of one to ten million black holes taking in energy, ***i.e.* review the following reference (Penrose)** [4]. Furthermore, the main point is done in [4] [8] in terms of general ergodic mixing [4] [8].

Claim 2

$$\left.\Xi_j\right|_{j\text{ before nucleation regime}} \approx \sum_{k=1}^{Max}\left.\tilde{\Xi}_k\right|_{\text{black holes }j\text{th universe}} \tag{17}$$

We argue that this treatment of a multiverse just before the creation of our present universe may allow for the enormous initial degrees of freedom argument given earlier.

4. Conclusion: Do We Have a 1-1 Correspondence via This "Cosmological Constant" Argument in Magnitude with the Mass of a Massive Graviton?

If so, by Novello [12]

$$m_g = \frac{\hbar \cdot \sqrt{\Lambda}}{c} \tag{18}$$

In other documents, the author has tried to come up with a treatment for the cosmological constant. What we are doing here is to come up with, via scaling arguments a value for the left hand side of Equation (18).

In terms of future inquiry, the following references should be ascertained, and reviewed, namely [13]-[22].

The formation of Equation (18) as an example could very well have its genesis by applying Equation (6) to Equation (18) whereas in particular [13] [14] [15] [16] [17] could give us further confirmation as to the Equation (6) as from [3]. Reference [18] would in terms of Equation (6) confirm as alternate mechanisms for how black holes could release gravitons, if they explode or evaporate quickly.

The authors' [19] reference as to initially 100 black holes, can be at least cross checked with assumptions used in the formation of Equation (6), whereas the question of the nature of space-time as neither continuous nor discrete [20], but potentially something else should be revisited especially in lieu with Equation (17) as to the recombination of partition functions of prior universes which may be recombined into our own universe.

Furthermore, the dimensionality arguments are given in [21], Calmet et al., as to what degree of graviton emission occurs from Black holes as a function of the dimensionality of the assumed black hole needs to be reviewed. We ask to review dimensionality of black holes to avoid making mistakes as to the necessity of postulating a necessary number of black holes due to an assumed flux of gravitons from primordial events.

Finally, in terms of [22], any release of gravitons and their contributions to DE needs to be checked as to the voluminous super nova data which has been used to gainsay the rapidity of the expansion of the Universe, *i.e.* is the expansion slowing down or increasing.

Acknowledgements

This work is supported in part by the National Nature Science Foundation of China (Grant No. 11375279).

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

References

[1] Padmanabhan, T. (2005) Understanding Our Universe: Current Status and Open

Issues. In: Ashtekar, A., Ed., 100 *Years of Relativity*: *Space-Time Structure*: *Einstein and Beyond*, World Scientific Publishing Company, Singapore, 175-204. https://doi.org/10.1142/9789812700988_0007

[2] Padmanabhan, T. (2000) Theoretical Astrophysics: Volume 3, Galaxies and Cosmology (Theoretical Astrophysics). Cambridge University Press, Cambridge.

[3] Chavanis, P.H. (2015) Self-Gravitating Bose-Einstein Condensates. In: Calmet, X., Ed., *Quantum Aspects of Black Holes*, Springer, New York, 151-194. https://doi.org/10.1007/978-3-319-10852-0_6

[4] Beckwith, A.W. (2005) Using "Enhanced Quantization" to Bound the Cosmological Constant, (for a Bound-On Graviton Mass), by Comparing Two Action Integrals (One Being from General Relativity) at the Start of Inflation. Chongqing University, Chongqing. http://vixra.org/pdf/1802.0305v1.pdf

[5] Beckwith, A. (2016) Gedanken Experiment for Refining the Unruh Metric Tensor Uncertainty Principle via Schwarzschild Geometry and Planckian Space-Time with Initial Nonzero Entropy and Applying the Riemannian-Penrose Inequality and Initial Kinetic Energy for a Lower Bound to Graviton Mass (Massive Gravity). *Journal of High Energy Physics*, *Gravitation and Cosmology*, **2**, 106-124. https://doi.org/10.4236/jhepgc.2016.21012

[6] Giovannini, M. (2008) A Primer on the Physics of the Cosmic Microwave Background. World Scientific Publishing Company, Singapore. https://doi.org/10.1142/6730

[7] Padmanabhan, T. (2005) An Invitation to Astrophysics. In: *World Scientific Series in Astronomy and Astrophysics*, Vol. 8, World Scientific Publishing Company, Singapore. https://doi.org/10.1142/6010

[8] Beckwith, A.W. (2017) Creating a (Quantum?) Constraint, in Pre Planckian Space-Time Early Universe via the Einstein Cosmological Constant in a One to One and onto Comparison between Two Action Integrals. (Text of Talk for FFP 15, Spain November 30, 11 AM-11:30 AM, Conference). Chongqing University, Chongqing. http://vixra.org/abs/1711.0355

[9] Camara, C.S., de Garcia Maia, M.R., Carvalho, J.C. and Lima, J.A.S. (2004) Nonsingular FRW Cosmology and Nonlinear Electrodynamics. *Physical Review D*, **69**, Article ID: 123504. https://doi.org/10.1103/PhysRevD.69.123504

[10] Dimopoulos, K. (2021) Introduction to Cosmic Inflation and Dark Energy. CRC Press, Boca Raton. https://doi.org/10.1201/9781351174862

[11] Alder, R., Bazin, M. and Schiffer, M. (1965) Introduction to General Relativity. McGraw-Hill Book Company, New York.

[12] Novello, M. (2005) The Mass of the Graviton and the Cosmological Constant Puzzle. ArXiv:astro-ph/0504505. https://arxiv.org/abs/astro-ph/0504505

[13] Haranas, I. and Gkigkitzis, I. (2014) The Mass of Graviton and Its Relation to the Number of Information According to the Holographic Principle. *International Scholarly Research Notices*, **2014**, Article ID: 718251. https://doi.org/10.1155/2014/718251 http://www.hindawi.com/journals/isrn/2014/718251/

[14] Shalyt-Margolin, A.E. (2006) Deformed Density Matrix and Quantum Entropy of the Black Hole. *Entropy*, **8**, 31-43. https://doi.org/10.3390/e8010031

[15] Kieffer, C. (2000) Conceptual Issues in Quantum Cosmology. In: Kowalski-Glikman, J., Ed., *Toward Quantum Cosmology*, Springer, New York, 158-187.

[16] Shalyt-Margolin, A.E. (2005) The Density Matrix Deformation in Physics of the

Early Universe and Some of Its Implications. In: *Quantum Cosmology Research Trends. Horizons in World Physics*, Vol. 246, Nova Science Publishers, Hauppauge, NY, 49-91.

[17] Hajdukovic, D. (2007) Concerning Production and Decay of Mini Black Holes. http://cds.cern.ch/record/1020935/files/0702142.pdf

[18] Hawking, S.W. (1974) Black Hole explosions? *Nature*, **248**, 30-31. https://doi.org/10.1038/248030a0

[19] Beckwith, A.W. (2018) Using "Enhanced Quantization" to Bound the Cosmological Constant, and Computing Quantum Number N for Production of 100 Relic Mini Black Holes in a Spherical Region of Emergent Space-Time. Chongqing University, Chongqing. http://vixra.org/abs/1805.0378

[20] Corda, C. (2018) Space-Time Can Be neither Discrete nor Continuous. *Modern Physics Letters A*, **33**, Article No.1850069.

[21] Calmet, X. (2022) Quantum Black Holes. University of Sussex, Brighton. https://www.mpifr-bonn.mpg.de/1311186/Calmet.pdf

[22] Kirshner, R.P. (1999) Supernovae, an Accelerating Universe and the Cosmological Constant. *Proceedings of the National Academy of Sciences of the United States of America*, **96**, 4224-4227. http://www.pnas.org/content/96/8/4224 https://doi.org/10.1142/S0217732318500694