

# **“Refining black hole physics to obtain Planck’s constant from information shared from cosmological cycle to cycle (avoiding super-radiance)”**

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**Abstract.** Padmanabhan [1] elucidated the concept of super radiance in black hole physics which would lead to loss mass of a black hole, and loss of angular momentum due to infall of material into a black hole. As Padmanabhan explained it, to avoid super radiance, and probable break down of black holes, from infall, one would need infall material frequency, divided by mass of particles undergoing infall in the black hole to be greater than the angular velocity of the black hole event horizon in question. We should keep in mind we bring this model up to improve the chance that Penrose’s conformal cyclic cosmology will allow for retention of enough information for preservation of Planck’s constant from cycle to cycle, as a counterpart to what we view as unacceptable reliance upon the LQG quantum bounce and its tetrad structure to preserve memory . In addition we are presuming that at the time of z=20 in red shift that there would be roughly about the same order of magnitude of entropy as number of operations in the electro weak era, and that the number of operations in the z=20 case is close to the entropy at redshift z=0 . Finally we have changing  $\Lambda$  with the result that after redshift =20 there is a rapid collapse to the present day vacuum energy value. I.e. by z=12 likely  $\Lambda$  the same as today which would be about when Galaxies form.

## **1. Introduction**

We start with the premise that LQG tetrad structure [2] will in itself not be sufficient to preserve cosmological memory from cosmological cycle to cycle. Appendix A gives the rudiments of the GR stress energy tensor while Appendix B outlines how we view the well intentioned LQG memory preservation program and the alternative, a refinement of the conformal cyclic cosmology program of Penrose [3]which will make use of refining the concept of super radiance and how to avoid it, so as to heighten the chance of preserving cosmological ‘memory’ from one cycle of creation to another One of the candidates for memory transfer would be given by data as supplied by Natarajan in GR 20 [4] in pre galactic black holes formed at about z = 20 to z=12 (red shift) times by super massive black holes at least 500 times the mass of our star, Sol. The candidate for information inflow into the initially massive black holes as we choose it would be manifest in relic gravitational waves. To quantify infall into these primordial black holes we will represent GW by massive gravitons, with the mass of a graviton as given by [5]

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$$-3m_{graviton}^2 h = \frac{\kappa}{2} \cdot T \quad (1)$$

Our work uses Visser's [6] analysis of non zero graviton mass for both T and h.

Furthermore, his version of  $g_{uv} = \eta_{uv} + h_{uv}$  can be written as setting

$$h_{uv} \equiv 2 \frac{GM}{r} \cdot \left[ \exp\left(\frac{-m_g r}{\hbar}\right) \right] \cdot (2 \cdot V_\mu V_\nu + \eta_{uv}) \quad (2)$$

If one adds in velocity 'reduction' put in with regards to speed propagation of gravitons[5]

$$v_g = c \cdot \sqrt{1 - \frac{m_g^2 \cdot c^4}{\hbar^2 \omega_g^2}} \quad (3)$$

One can insert all this into Eq. (1) to obtain a real value for the square of frequency  $> 0$ , i.e.

Kim's article [7] is with regards to Gravitons in brane / string theory, but it is likely that the same dynamic for semi classical representations of a graviton with mass.

## **2. Conditions allowing for recycling of Planck's constant in Penrose's cyclic universe model revisited**

The main methodology in the Penrose proposal[3] has been in Eq. (4) evaluating a change in the metric  $g_{ab}$  by a conformal mapping  $\hat{\Omega}$  to

$$\hat{g}_{ab} = \hat{\Omega}^2 g_{ab} \quad (4)$$

Penrose's suggestion has been to utilize the following[3]

$$\hat{\Omega} \xrightarrow{ccc} \hat{\Omega}^{-1} \quad (5)$$

Infall into cosmic black holes has been the main mechanism which the author asserts would be useful for the recycling apparent in Eq.(5) above with the caveat that  $\hbar$  is kept constant from cycle to cycle as represented by

$$\hbar_{old-cosmology-cycle} = \hbar_{present-cosmology-cycle} \quad (6)$$

What would be crucial in doing both Eq. (5) and Eq.(6) would be in specifying how massive black holes as of at least 500 times the mass of the sun, i.e.  $500 M_\odot$ , large mass of a black hole formed between  $z=20$  and  $z=12$  redshifts i.e before galaxy formation, would tend toward conditions for which Eq. (6) could be fulfilled. We do this by looking at details for  $\hat{\Omega}$  satisfied by information gathering which we bring up now.

### **2a. Necessary construction details for the mapping $\hat{\Omega}$**

The procedures for giving linkage to a formulation of  $\hat{\Omega}$  means that one must consider basic constructions given by Penrose as to his ccc proposal which we will outline below, namely that [3]

$$\begin{aligned} E &= 8\pi \cdot T + \Lambda \cdot g \\ E &= \text{source for gravitational field} \\ T &= \text{mass energy density} \\ g &= \text{gravitational metric} \end{aligned} \tag{7}$$

$\Lambda = \text{vacuum energy, rescaled as follows}$

$$\Lambda = c_1 \cdot [\text{Temp}]^\beta \tag{8}$$

For an invariant  $E$  for cycle to cycle no matter what Eq. (8) gives us, this leads to the following statement as to a formulation of  $\hat{\Omega}$  I.e.

$$\begin{aligned} E|_{\text{initial}} = E|_{\text{final}} &\Leftrightarrow \Lambda \cdot g|_{\text{initial}} = \Lambda \cdot g|_{\text{final}} \\ \Lambda \cdot g|_{\text{final}} &= (\Lambda|_{\text{final}}) \cdot \hat{\Omega}^2 \cdot (g_{ab}|_{\text{initial}}) \end{aligned} \tag{9}$$

I.e. is this possible ? Only if there are very small initial wavelengths at/ before the electro weak regime. I.e. a wave length perhaps as small as Planck length. The problem is that in doing so, and this appears to be intuitive and obvious, something which is contradicted by Durrer's [7] treatment of early universe plasma waves generating early universe GW. We then state for hypothesis that if  $N$  is a numerical count which has lead us to hypothesize using

$$\hat{\Omega} \propto S_{\text{entropy}} \sim N \tag{10}$$

### 3. Information infall into early universe black holes and avoiding Super-radiance

Note that Beckwith[8] has used Y. Ng's [9] counting algorithm with regards to entropy, and non zero mass (massive ) gravitons , where  $S \approx N \cdot (\log[V/\lambda^3] + 5/2) \approx N$ . Furthermore, making an initial count of gravitons with  $S \approx N \sim 10^7$  gravitons with Seth Lloyd's[10]  $I = S_{\text{total}} / k_B \ln 2 = [\# \text{operations}]^{3/4} \sim 10^7$  as implying at least one operation per unit graviton, with gravitons being one unit of information, per produced graviton. **Note**, Smoot [11]gave initial values of the operations as

$$[\# \text{operations}]_{\text{initially}} \sim 10^{10} \tag{11}$$

The number of operations, if tied into bits of 'information' may allow for space time linkages of the following value of the fine structure constant, as from a prior to a present universe, once initial conditions of inflation may be examined experimentally, i.e. looking at inputs into[8], i.e. The fine structure constant given in [8], which has presumably the value of

$$\tilde{\alpha} \equiv e^2 / \hbar \cdot c \equiv \frac{e^2}{d} \times \frac{\lambda}{hc} \tag{12}$$

As of the electroweak era

$$\begin{aligned} S_{\text{entropy}}|_{\text{ew}} &\sim N \sim 10^{53}|_{\text{ew}} \propto [\# \text{operations}]^{3/4}|_{\text{ew}} \\ \Leftrightarrow [\# \text{operations}]|_{\text{ew}} &\sim 10^{71} \end{aligned} \tag{13}$$

We are presuming that at the time of z=20 in red shift that there would be roughly about the same order of magnitude of entropy as number of operations in the electro weak era, and that the number of operations in the z=20 case is close to the entropy at redshift z=0

$$\begin{aligned} S_{\text{entropy}} \Big|_{\text{redshift}=20} &\sim N \sim 10^{67} \Big|_{\text{redshift}=20} \\ &\propto [\# \text{operations}]^{3/4} \Big|_{\text{redshift}=20} \\ \Leftrightarrow [\# \text{operations}] \Big|_{\text{redshift}=20} &\sim 10^{89} \end{aligned} \quad (14)$$

After this is done it is useful to note that the number of operations as to the redshift =20 at the formation of the first set of super massive black holes would be about the same as entropy today which the author views as no accident. I.e. the number of super massive black holes is at least 100,000 or more with a mass of at least  $(10^2 - 10^5) \cdot M_\odot$  ~ one hundred to ten thousand times the mass of the sun. Then there could be an infall of less than  $10^{84} - 10^{87}$  operations / black-hole. After this is done, note that the particle infall per black hole is less than  $10^{62}$  value. Interstellar space has 2.73 Kelvin and was only semi hotter at a red shift at z=20. The situation then is that a black hole five times the mass of the sun would have a temperature  $12 \times 10^{-9}$  Kelvin, and that could easily drop to about  $10^{-11}$  Kelvin, which is about the temperature for a black hole 20-50 times the mass of the sun, and that due to[1]

$$T_{BH} = \frac{\hbar c^3}{8\pi kGM} \quad (15)$$

Then the next step would be to look at the resulting temperature differential flowing into the black hole which would be

$$\Delta T \Big|_{\text{near-BH}} = T_{\text{Background}} - T_{BH} \sim 10^\alpha \text{ Kelvin} \geq 2.73 \text{ Kelvin} \quad (16)$$

We look at a black hole of would be mass  $10^{22} \text{ Kg} \propto 10^{58} \text{ eV} / c^2$ , mass of this value would be for a black hole having the temperature given in Eq.(16), leading to if each graviton having  $10^{-29} \text{ eV} / c^2$  number of gravitons of about  $10^{87}$  gravitons; then leading to for 1000 super massive black holes an intake of  $\sim 10^{90} \sim \text{later-entropy}$  value into 100-1000 black holes. This is close to the present value of entropy today and is similar to values given by Lloyd [11] as to the entropy of the present universe, which we do not think is an accident. Therefore, the inflow of heat into 100-1000 pre galactic black holes which is a thermal energy, as given by 100-1000 super massive early black holes is equivalent to  $10^{90} \sim \text{later-entropy}$  equivalent. Also the value of about  $10^{84} - 10^{87}$  operations / black-hole, we look at less than or equal values of the number of operations set up to be processed as given by the electroweak era to be eventually generating approximately a  $10^{90} \sim \text{later-entropy}$  numerical count as created about z=20, which again we think is no accident.

#### **4. A way to create conditions for Planck value from cycle to cycle, while tackling the problem of super radiance [1] and black hole physics as of about z= 20 and making sense of $\hat{\Omega}$**

To do this note that  $\hat{\Omega}$  we write as proportional to entropy, specifically because of  $\Lambda \cdot g \Big|_{\text{final}} = (\Lambda \Big|_{\text{final}}) \cdot \hat{\Omega}^2 \cdot (g_{ab} \Big|_{\text{initial}})$ ; we write entropy as given by first Ng[12] and then also

presented by Cai [13] as , if  $S \sim r_{\oplus}^2$  and  $r_{\oplus}$  is the radius of the black hole horizon, then if M is the mass of a black hole

$$S \leq N = 3\pi G^{-1}/\Lambda \Leftrightarrow \hat{\Omega} \sim 3\pi G^{-1}/\Lambda \Leftrightarrow S_{BH} \approx M^2 \quad (17)$$

Also for the angular velocity, as given by  $\Omega_H \sim 1/r_{\oplus}$

$$\Omega_H \sim 1/r_{\oplus} \propto 1/\sqrt{S} \propto 1/\sqrt{N} \propto 1/\sqrt{Temp^{\beta}} \quad (18)$$

We write the angular velocity as intertwined into Padmanabhan's [1]description of super radiance by noting that for infall into a black hole creating instability and loss of angular momentum for the black hole we would have super radiance for frequency and for mass of an infalling particle into a black hole

$$0 < \omega_{particles}/\tilde{m} < \Omega_H \quad (19)$$

To avoid super radiance, we would have, conversely

$$\omega_{particles}/\tilde{m} > \Omega_H \quad (20)$$

Or

$$\omega_{particles} > \tilde{m}/\sqrt{N} \quad (21)$$

The frequency of incoming particles allowing for stable black holes would be extremely low, ie almost any gravitational radiation and graviton infall into Penrose mandated black holes [3] would do it. If one looks at the contribution of four and five dimensional black holes to entropy, with L being the dimension of a fifth dimension we obtain[14]

$$S_{BH}|_{4D} = 4\pi M^2 \quad (22)$$

$$S_{BH}|_{5D} = 4\pi M^2 \cdot \sqrt{8L/27\pi M} \quad (23)$$

The outcome would be to have for five dimensional black holes [13]no super radiance [1]if

$$\omega_{particles}|_{5D} > (\tilde{m}/\sqrt{N}) \cdot (27\pi M/8L)^{1/4} \quad (24)$$

The frequency goes down as L increases in size.

#### **4. a: black hole physics as of about z= 20 and making sense of $\hat{\Omega}$**

We also can write the following relation as to infall frequency which avoids irradiance, i.e avoiding instability as to black hole behaviour. If the 5<sup>th</sup> dimension, L, grows, the frequency threshold drops

$$\omega_{particles}|_{5D} > (\tilde{m}/\sqrt{\hat{\Omega}}) \cdot (27\pi M/8L)^{1/4} \quad (25)$$

From  $\hat{\Omega} \sim \text{Entropy}$  and using S similar to  $\hat{\Omega}$  and then subsequently  $\hat{\Omega} \sim 3\pi G^{-1}/\Lambda$  [13] and

$\Lambda = c_1 \cdot [\text{Temp}]^{\beta}$  , [15] , and making use of the relations  $T_{BH} = \frac{\hbar c^3}{8\pi kGM}$  [1] ,  $\Delta T|_{near-BH} = T_{Background} - T_{BH}$  , due to  $\hbar$  in the relations we are able to ascertain per black hole

$$\hbar|_{per-BH} \propto \Delta T [background - BH] \cdot (8\pi kGM_{eff}/c^3) \quad (26)$$

Also if at  $z=20$  there is the number of  $N_{z=20BH}$  black holes at  $z=20$ , the contribution to  $\hbar_{old\text{-cosmology}\text{-cycle}} = \hbar_{present\text{-cosmology}\text{-cycle}}$  then can be said to be

$$\hbar|_{z=20} \propto N_{z=20BH} \cdot \Delta T [background - BH] \cdot (8\pi kGM_{eff}/c^3) \quad (27)$$

We also look then at the value of  $\hat{\Omega}$  at  $z=20$  and get from Eq. 27

$$\Omega|_{redshift=20} \sim N \sim 10^{67} \Big|_{redshift=20} \quad (28)$$

And we keep in mind that

$$\left[ \Omega|_{redshift=20} \sim N \sim 10^{67} \Big|_{redshift=20} \right] \cdot \Lambda_{redshift=20} = \left[ \Omega|_{redshift=0} \sim N \sim 10^{89} \Big|_{redshift=0} \right] \cdot \Lambda_{redshift=0} \quad (29)$$

The above hypothesizes changing  $\Lambda$  with the result that after redshift =20 there is a rapid collapse to the present day vacuum energy value. I.e. by  $z=12$  likely  $\Lambda$  the same as today which would be about when Galaxies form.

## 5. Conclusion: black hole physics as of about $z=20$ sets up $\hat{\Omega}$ we write as congruent to Eq.(29)

From Eq. (29) one will have at  $\left[ \Omega|_{redshift=20} \sim N \sim 10^{67} \Big|_{redshift=20} \right]$  an infall of 'information' into many black holes such that the following will be gathered for Planck's constant. Here,  $N_{z=20BH}$  is for the number of super massive black holes at  $z=20$ , namely as given before, we have

$$\hbar|_{z=20} \propto N_{z=20BH} \cdot \Delta T [background - BH] \cdot (8\pi kGM_{eff}/c^3) \quad (27)$$

This is at  $z=20$ . This redshift corresponds to 150 million years after the big bang. The idea being that up to 150 million years after the big bang, there would be enough uploaded information put in to formulate filling in Eq. (27) which would probably be enough to insure resetting  $\hbar_{old\text{-cosmology}\text{-cycle}} = \hbar_{present\text{-cosmology}\text{-cycle}}$  so as to maintain the constancy of physical law from cycle to cycle. The infall as represented by Eq.(27) above tied in with Eq. (29) is the basis of saying that the formula for  $E$  in Eq. (7) remains invariant from the beginning to the end of a cosmological cycle, whereas then afterwards the term  $\hat{\Omega}$  undergoes what is given in Eq.(5), namely[3]

$$\hat{\Omega} \xrightarrow{ccc} \hat{\Omega}^{-1} \quad (5)$$

Keep in mind that after  $z=12$ , one billion years after the big band we have that if we use Park's treatment of quinessence [15], we can get  $\Lambda$  to almost the level it is today, and it drives inflow into BHs.[15]

$$\Lambda = c_1 \cdot [Temp]^\beta \quad (8)$$

If the temperature we call Temp is  $\sim \Delta T|_{near-BH} = T_{Background} - T_{BH}$  we have via the procedure outlined above a way to get entropy and also Eq. (27) filled in as inflow which may be falsifiable procedure.

### Appendix A: The generalized Stress Energy component of GR considered. Which part we evaluate.

To do this we look at, from [17] a GR Einstein stress energy tensor we write as, with  $u_a$  the four vector velocity. Also,  $\rho$  is the relativistic energy density,  $q_a$  the relativistic momentum density, and  $p$  is pressure, and  $\pi_{ab}$  the relativistic anisotropic stress tensor due to viscosity, magnetic fields.  $\rho$  has a gravitational radiation component . Effectively, Eq. (A1) has  $\rho = \rho_{GW} + \rho_{Everything-else}$  such that

$$T_{ab} = \rho u_a u_b + q_a u_b + u_a q_b p h_{ab} + \pi_{ab}$$

$$\Leftrightarrow T_{ab} = T_{GW/Gravitons} + T_{everything-else} \quad (A1)$$

### Appendix B: Preservation of memory in LQG so $\hbar_{old-cosmology-cycle} = \hbar_{present-cosmology-cycle}$

LQG has its non singular quantum bounce as given by Amoros, de Haro , and Odintsov[17 ]. We refer the readers to look at Figure 2, and ask if the tetrad structure as outlined in the article is provable as well as linkable to the necessity of not running afoul of the Tolman restriction on entropy and cyclical models [18]

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