How to determine a jump in energy prior to a causal barrier, with an attendant current, for an effective initial magnetic field. In the Pre Planckian to Planckian space-time

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Abstract

We start where we use an inflaton value due to use of a scale factor $a \sim a_{\min} t^{\gamma}$ .Also we use $\delta g_{tt} \sim a_{\min}^{2} \cdot \phi_{initial}$ as the variation of the time component of the metric tensor g_{tt} in Pre-Planckian Space-time. Our objective is to find an effective magnetic field, to obtain the minimum scale factor in line with Non Linear Electrodynamics as given by Camara, et.al, 2004. Our suggestion is based upon a new procedure for an effective current based upon an inflaton time exp (i times frequency times time) factor as a new rescaled inflaton which is then placed right into a Noether Current scalar field expression as given by Peskins, 1995. This is before the Causal surface with which is , right next to a quantum bounce, determined by $H_{causal-structure-quantum-bounce} = 0$, with the next shift in the Hubble parameter as set up to be then $H_{initial} \sim 1/\Delta t \sim 1.66\sqrt{g_*} \cdot T^2 / M_{mass-scale}$. And g_* is an initial degrees of freedom value of about 110. Upon calculation of the current, and a resulting magnetic field, for the space time bubble, we then next obtain a shift in energy, leading to a transition from $H_{causal-structure-quantum-bounce} = 0$ to. We argue then that the delineation of the $\delta g_{tt} \sim a_{\min}^{2} \cdot \phi_{initial}$ term is a precursor to filling in information as to the Weyl Tensor for near a singularity measurements of starting space-time. Furthermore, as evidenced in Eq. (26) and Eq. (27) of this document, we focus upon a "first order" check into if a cosmological "constant" would be invariant in time, or would be along the trajectory of the time varying Quinessence models.

Key words Inflaton physics, Causal structure, Penrose Weyl tensor conjecture, Quinessence.

1. Outlining an inflaton model, which is pertinent, to the physics just in the vicinity of a Quantum bounce

We wish to state that our paper is an extension of the initial manuscript, as given by the author, in [1] and is to answer a question which has vexed the author repeatedly. If magnetic fields exist at the start of the universe, then what creates them?

Our solution is to base a current, for the magnetic field, as created by a Noether current [2] , as a starting point, with the Noether current created as partly derived from an inflaton field, times exponential of the imaginary number, frequency, and time interval. In doing so, our derived Noether current is real valued, which is astonishing, and is part of the reason we call this effective current as the actual current of an initial relic gravitational field.

We will now commence introducing the scalar field we will use over and over again, as far as the physics, our document.

We will begin using the physics outlined in [3] as to

$$\phi \equiv \sqrt{\langle \phi^2 \rangle} = \frac{H^{3/2}}{2\pi} \cdot \sqrt{\Delta t} \tag{1}$$

Our starting point in this Linde result [3], is to utilize the Beckwith- Moskaliuk, result that [4]

$$\delta t \Delta E \geq \frac{\hbar}{\delta g_{tt}} \neq \frac{\hbar}{2} \tag{2}$$

$$Unless \quad \delta g_{tt} \sim O(1)$$

Utilizing here that, [4,5]

$$\left|\delta g^{00}\right| \sim a^2 \left|\phi(\text{inf})\right| << 1 \tag{3}$$

If so then we have, approximately a use of, by results of Sarkar, as in [6]

$$H_{Early-Universe} \sim 1.66 \cdot \sqrt{g^*} \cdot \frac{T_{Early-Universe}}{M_{mass-scale}} \tag{4}$$

in terms of early universe Hubble expansion behavior which we incorporate into our uncertainty principle, to obtain

$$\Delta E \sim \frac{\left(1.66 \cdot \sqrt{g^*} \cdot \frac{T_{Early-Universe}}{M_{mass-scale}}\right)^3 \cdot \hbar}{\left(2\pi a_{\min}\right)^2 \phi^3} \tag{5}$$

And by Padmanabhan [7] for the interior of the bubble of space-time we will have, here that

$$
\begin{aligned}
& a \approx a_{\min} t^{\gamma} \\
& \Leftrightarrow \phi \approx \sqrt{\frac{\gamma}{4\pi G}} \cdot \ln\left\{ \sqrt{\frac{8\pi G V_0}{\gamma \cdot (3\gamma - 1)}} \cdot t \right\} \\
& \Leftrightarrow V \approx V_0 \cdot \exp\left\{ -\sqrt{\frac{16\pi G}{\gamma}} \cdot \phi(t) \right\}
\end{aligned} \tag{6}
$$

From here, we will explain the behavior of a change in energy about the structure of a Causal boundary of the bounce bubble in space-time defined by Beckwith, in [1] so that

$$
\begin{aligned}
& g_{tt} \sim \delta g_{tt} \approx a_{\min}^2 \phi_{initial} << 1 \\
& \xrightarrow[\Pr e-Planck \to Planck]{} \delta g_{tt} \approx a_{\min}^2 \phi_{Planck} \sim 1 \\
& \Leftrightarrow \left(\frac{R_c|_{initial} \sim c \cdot \Delta t}{l_{Planck}} \right) \sim \vartheta(1) \Big|_{Planck}
\end{aligned} \tag{7}
$$

Here, in doing so, to fill in the details of Eq. (4) we will be examining the Camara et al result of [8]

$$
\begin{aligned}
& a_{\min} \sim \alpha_0 \cdot \left(\frac{\alpha_0}{2\tilde{\lambda}} \cdot \left(\sqrt{\alpha_0{}^2 + 32\pi\mu_0\omega \cdot B_0^2} - \alpha_0 \right) \right)^{1/4} \\
& \alpha_0 = \sqrt{\frac{4\pi G}{3\mu_0 c^2}} B_0 \\
& \tilde{\lambda} = \frac{\Lambda_{Einstein} c^2}{3}
\end{aligned} \tag{8}
$$

Specifically, we will be filling in the details of Eq. (1) to Eq. (8) with the adage that we will be using of all things, a modified version of the Noether Current, [2] according to a simplified version of the treatment given in [8] with a scalar field we will define as

$$
\tilde{\phi} = \left[\exp(i \cdot \omega \cdot t) \right] \times \phi \tag{9}
$$

Which will allow, after calculation, that the Noether current will be, if linked to its time component, real valued. Which is a stunning result. Our next trick will be then to put this effective quantum bubble "current' as the magnetic field, B_0, using the results of both Gifffiths, [9] and Landau and Liftschitz, [10] for a magnetic field, for Eq. (7) .This, then will be the plan of what we will be working with in this article, in subsequent details

2. Making a statement about a constituent early universe magnetic field

We start off with Ohm's law [9,10, 11] assuming a constant velocity within the space-time bubble, of

$$
j = \sigma E \tag{10}
$$

Where the velocity of some 'particle' ,. Or energy packet, or what we might call it, does not change. Then use the Griffith's relationship [9] of

$$
\begin{aligned}
&B_0(magnetic-field) = B_{net} \\
&= \sqrt{\varepsilon\mu_0}\cdot\left(1+\left(\frac{\sigma}{\varepsilon\mu_0}\right)^2\right)^{1/4} E_0 \\
&= \sqrt{\varepsilon\mu_0}\cdot\left(1+\left(\frac{\sigma}{\varepsilon\mu_0}\right)^2\right)^{1/4}\cdot\frac{j}{\sigma}
\end{aligned}
\tag{11}
$$

We will comment upon the σ later, but first say something about what j as current is proportional to

The modus operandi chosen here is to employ the following. Use a scalar field defined by Eq. (9) and a Noether conserved current [3] proportional to:

$$
j^{\mu} = i\cdot\left[\left(\partial_{\mu}\tilde{\phi}^{*}\right)\cdot\tilde{\phi} - \tilde{\phi}^{*}\cdot\left(\partial_{\mu}\tilde{\phi}^{*}\right)\right] \tag{12}
$$

Here we take the time component of this Noether current, and use Eq. (9) for $\tilde{\phi}$, and Eq. (6) for ϕ. Therefore

$$
I = j^0 \sim \frac{\gamma}{2\pi G}\cdot\frac{\omega}{\Delta t}\cdot\left[1-\frac{1}{\Delta t}\cdot\sqrt{\frac{\gamma\cdot(3\gamma-1)}{8\pi G\cdot V_0}}\right] \tag{13}
$$

Then our net magnetic field, is to first approximation given by

$$
\begin{aligned}
&B_0(magnetic-field) = B_{net} \\
&\sim \frac{\sqrt{\varepsilon\mu_0}}{\sigma}\cdot\left(1+\left(\frac{\sigma}{\varepsilon\mu_0}\right)^2\right)^{1/4}\cdot\frac{\gamma}{2\pi G}\cdot\frac{\omega}{\Delta t}\cdot\left[1-\frac{1}{\Delta t}\cdot\sqrt{\frac{\gamma\cdot(3\gamma-1)}{8\pi G\cdot V_0}}\right]
\end{aligned}
\tag{14}
$$

This is to be put into our value of Eq. (8) above. So, next we will be looking at the frequency, ω.

3. Rule of thumb estimates for frequency, ω

We will go on the meme of an admissible low to high value for the imput frequency. First of all the high frequency limit. This comes from an argument from Ford [12] i.e. for a black hole of mass M to evaporate, we have

$$
\omega_{\max} \approx \frac{\exp\left(M^2\right)}{M} \xrightarrow[M\to Solar(Value)]{} 10^{10^{75}}\ g(grams) \tag{15}
$$

If we make the assumption, that a white hole, is an evaporating black hole, i.e. and then up the mass, M, from a solar sized black hole, to a white hole, as the starting point for cosmological evolution, according to [13] as given by Mueller, and Lousto, we have that for a small radii (less than one Plank length diameter starring point for a black hole, with the approximation given dimensionally, that

$$
|E| = |\hbar\omega| \xrightarrow[\hbar=c=1]{} |\omega| \equiv |mass| \tag{16}
$$

Then, this means, that the upper limit of frequency, in this case could be effectively infinite,

Now that we have an argument in place for an upper limit, what about the lower limit? To do this, assume the following

i.e. assume a Planck radii for the bubble of space-time. I.e. up to a point this would signify a frequency range of say $10^{35} Hertz$, initially, and then for today, consider that if there are 65 e folds of inflation, that Frequency range is, then for the lower bound given by

$$10^{35} Hertz(initial) \xrightarrow[65-efolds=1.69\times 10^{28}]{} 10^{7} Hertz(today) \qquad (17)$$

i.e. this means that the ***initial frequency*** is initially nearly infinite, to at lowest $10^{35} Hertz(initial)$

With that, we can also take a look at an estimate as to conductivity, which is given by Ahonen and Enqvist [14] to be about $\sigma \simeq 0.76T$ while at $T \simeq M_W$ [14] will obtain $\sigma \simeq 6.7T$, and we can tie that as similar to the strength of the magnetic fields given in [15] as well

Note that the electrical conductivity is used here, with the conversion between an E field to a B field, in magnitude given by Eq. (11)

In all, with all the assumptions so used, we have that [8]

$$a_{\min} \sim \alpha_0 \cdot \left(\frac{\alpha_0}{2\tilde{\lambda}} \cdot \left(\sqrt{\alpha_0^{\ 2} + 32\pi\mu_0\omega \cdot B_0^2} - \alpha_0 \right) \right)^{1/4} \sim 10^{-55} \qquad (18)$$

4. Parameterizing the Role of Eq. (4) in our model, and its importance.

What we have done, is to set up the way which we can obtain inputs into

$$\begin{aligned} \Delta E &\sim \frac{\left(1.66 \cdot \sqrt{g^*} \cdot \frac{T_{Early-Universe}}{M_{mass-scale}}\right)^3 \cdot \hbar}{(2\pi a_{\min})^2 \phi^3} \\ &\sim \frac{\left(1.66 \cdot \sqrt{g^* \sim 110} \cdot \frac{T_{Early-Universe}}{\left(M_{mass-scale} \approx 10^{43} \cdot M_{Planck}\right)}\right)^3 \cdot \hbar}{\left(2\pi \cdot 10^{-55}\right)^2 \cdot \left(\sqrt{\frac{\gamma}{4\pi G}} \cdot \left[\sqrt{\frac{8\pi G \cdot V_0}{\gamma \cdot (3\gamma - 1)}} \cdot \Delta t - 1 \right] \Big/ \sqrt{\frac{8\pi G \cdot V_0}{\gamma \cdot (3\gamma - 1)}} \cdot \Delta t \right)^3} \\ &\propto M_{mass-scale} \approx 10^{43} \cdot M_{Planck} \end{aligned} \qquad (19)$$

Doing it this way, i.e. having the change in energy, crossing the causal boundary of specified Eq.(8) puts a very strong set of constraints upon the allowed values of $V_0, \sigma.\ \gamma$, and Δt on top of $a_{\min} \sim 10^{-55}$ and $T_{Early-Universe}$

What is being said, is that the above Eq. (19) puts in a range of admissible values on $V_0, \sigma. \ \gamma$, and Δt on top of $a_{\min} \sim 10^{-55}$ and $T_{Early-Universe}$ in addition to the frequency, which is referenced in section 3 of this manuscript. In doing so the idea is to come up with experimental constraints which will validate a range of experimental gravitational inputs into evaluation of presumed early universe data sets.

This should be compared to an earlier relationship given by Beckwith at [1] which has, if $a_{\min} \sim 10^{-55} \sim a_{bounce}$

$$a_{bounce} \sim \Delta t \cdot \sqrt{\frac{12\pi G \cdot k(curvature)}{\gamma}} \cdot \sqrt{1 + 2V_0 \cdot \gamma^2 \cdot \frac{(3\gamma - 1)}{32\pi}} \tag{20}$$

We claim that all three of these Eq.(18) to Eq. (20) are inter related. And are part of potential data analysis in our problem.

It also depends, upon, critically, that $k(curvature)$, for initial curvature be finite and nonzero.

5. Revisiting what can be said about the Weyl Tensor

We initiate this section by stating the n=4 (three spatial dimensions and one time dimension) Weyl Tensor, in the case of a Friedman-Lemaitre-Roberson-Walker metric given by [1, 16] which we rewrite as

$$\begin{aligned} C_{abcd} &= \frac{3}{a^2} \cdot \left(a \cdot \ddot{a} + \dot{a}^2 + k(Curvature)\right) \cdot \left(g_{ac} g_{bd} - g_{ad} g_{bc}\right) \\ &+ \frac{1}{6} \cdot \left(g_{ac} g_{db} - g_{ad} g_{cb}\right) - \frac{1}{2} \cdot \left(g_{ac} R_{db} + g_{bd} R_{ca} - g_{ad} R_{cb} - g_{bc} R_{da}\right) \end{aligned} \tag{21}$$

The entries into the above, assuming c=1 (speed of light) in the Friedman-Lemaitre-Roberson-Metric would be right after the Causal boundary given as [1, 17] , namely if we go by [18]

$$\begin{aligned} g^{00} &= -1 \\ g^{11} &= \frac{a^2}{1 - k(Curvature) \cdot r^2} \\ g^{22} &= a^2 \cdot r^2 \\ g^{33} &= a^2 \cdot r^2 \sin^2 \theta \\ R_{00} &= -3 \frac{\ddot{a}}{a} \\ R_{ij} &= \frac{3}{a^2} \cdot \left(a \cdot \ddot{a} + 2\dot{a}^2 + k(Curvature)\right) \cdot g_{ij} \end{aligned} \tag{22}$$

In our rendering of what to expect, we will be setting $k(curvature)$, initially as not equal to zero, and that the minimum value of the scale factor, be defined by $a_{\min} \sim 10^{-55} \sim a_{bounce}$. If so then

$$k(curvature) \sim \frac{R_{ij} \cdot \left(a^2/3\right) - a\ddot{a} - 2\dot{a}^2}{g_{ij}} \tag{23}$$

If so, then approximate having

$$\dot{a} \sim a_{initial} \cdot \gamma \sim a_{initial}\gamma \cdot \left(\frac{t}{t_{Planck}}\right)^{\gamma-1} \sim a_{initial}\gamma$$
$$\ddot{a} \sim a_{initial} \cdot \gamma \cdot (\gamma - 1) \cdot \left(\frac{t}{t_{Planck}}\right)^{\gamma-2} \sim a_{initial} \cdot \gamma \cdot (\gamma - 1) \tag{24}$$

And, up to first order, replace one item by

$$g_{00} = -1 + \delta g_{00} = -1 + a_{initial}{}^{2} \cdot \sqrt{\frac{\gamma}{4\pi G}} \cdot \left(\left[\sqrt{\frac{8\pi G \cdot V_0}{\gamma \cdot (3\gamma - 1)}} \cdot \Delta t - 1 \right] \Big/ \sqrt{\frac{8\pi G \cdot V_0}{\gamma \cdot (3\gamma - 1)}} \cdot \Delta t \right) \tag{25}$$

With the rest of the items in Eq. (22) for the metric tensor held the same. i.e. then we would have , if r in Eq. (22) were of the order of Planck length, that the Weyl tensor, would not necessarily vanish, no matter how close one got to the purported singularity.

The details of this are being reviewed, with a Phase transition model for the transition to Pre Planckian to Planckian physics still in the works.

4. Conclusion. Much to do. I.e. the details are daunting and depend upon confirmation of the idea of the current in Pre Planckian to Planckian space time proportional to a Noether current, being confirmed and verified.

The main crust of our approach is to come up with a thought experiment as to the creation of a Noether style based current, as a would be enabler of a magnetic field, at the start of Planckian space-time dynamics.

Our informed guess is that we will in the end write the initial curvature along the lines of it having the form

$$\begin{aligned} k(curvature) &\sim \frac{R_{ij} \cdot \left(a^2/3\right) - a\ddot{a} - 2\dot{a}^2}{g_{ij}} \\ &\xrightarrow[i,j \to 0,0]{} \frac{R_{0,0} \cdot \left(a^2/3\right) - a\ddot{a} - 2\dot{a}^2}{g_{0,0}} \\ &\sim \frac{\left(a_{initial}{}^{2}/3\right) + a_{initial}{}^{2} \cdot \gamma \cdot (\gamma - 1) + 2a_{initial}{}^{2}\gamma^2}{1 - a_{initial}{}^{2} \cdot \sqrt{\frac{\gamma}{4\pi G}} \cdot \left(\left[\sqrt{\frac{8\pi G \cdot V_0}{\gamma \cdot (3\gamma - 1)}} \cdot \Delta t - 1 \right] \Big/ \sqrt{\frac{8\pi G \cdot V_0}{\gamma \cdot (3\gamma - 1)}} \cdot \Delta t \right)} \end{aligned} \tag{26}$$

I.e. this would be very small, but not zero. The fact it was small, but not zero, even in the Pre Planckian regime of space-time would be of supreme importance, and would affect the evolution of subsequent space-time.

Linking this result, above, to confirmation of the above Eq. (20) would tend to, aside from root finder methods outlined by the author, lend itself to a bounding value of a discrete time step we will write as

$$
\begin{aligned}
&(\Delta t)^2 \sim \cdot \left(\frac{a_{initial} \cdot \gamma}{12\pi G \cdot \left(1 + 2V_0 \cdot \gamma^2 \cdot \dfrac{(3\gamma - 1)}{32\pi} \right)} \right) A_1 \\
&A_1 = \frac{\left(1 - a_{initial}{}^2 \cdot \sqrt{\dfrac{\gamma}{4\pi G}} \cdot \left(\left[\sqrt{\dfrac{8\pi G \cdot V_0}{\gamma \cdot (3\gamma - 1)}} \cdot \Delta t - 1 \right] \Big/ \sqrt{\dfrac{8\pi G \cdot V_0}{\gamma \cdot (3\gamma - 1)}} \cdot \Delta t \right) \right)}{\left(a_{initial}{}^2 / 3 \right) + a_{initial}{}^2 \cdot \gamma \cdot (\gamma - 1) + 2a_{initial}{}^2 \gamma^2}
\end{aligned}
\tag{27}
$$

i.e. to solve for Δt would involve a transcendental non linear root finder scheme, but this could be matched against an earlier result which was represented in [1] as

$$
\begin{aligned}
&\Delta t \cdot \left| \left(\sqrt{\frac{8\pi G V_0}{\gamma \cdot (3\gamma - 1)}} \cdot \Delta t - 1 \right) - \frac{\left(\sqrt{\dfrac{8\pi G V_0}{\gamma \cdot (3\gamma - 1)}} \cdot \Delta t - 1 \right)^2}{2} + \frac{\left(\sqrt{\dfrac{8\pi G V_0}{\gamma \cdot (3\gamma - 1)}} \cdot \Delta t - 1 \right)^3}{3} - \ldots \right| \\
&\approx \left(\sqrt{\frac{\gamma}{\pi G}} \right)^{-1} \frac{48\pi \hbar}{a_{\min}^2 \cdot \Lambda}
\end{aligned}
\tag{28}
$$

Doing so, and making equivalence, if we use Eq. (27) to solve for Δt and use Eq. (28) to parameterize the Cosmological "constant" in our early universe cosmology, would be among other things a way to address the issue of Quinessence, I.e. would the cosmological constant evolve in time, or would the results of Eq. (28) after using Eq. (27) for confirming a value of Δt give credence to the idea of the invariance of the cosmological constant?

This we view as a worthy investigative topic, and one within our reach.

Aside from that, the idea of using a Noether current based upon the idea of a scalar field which is based upon inflaton time exp (i times frequency times time) factor would give a foundational treatment of Non linear electrodynamics magnetic fields as has been brought up by several authors, the writer of this manuscript counts as peers and worthy researchers.

Prior treatments of the scalar fields used in Noether's theorem talk of having a tie in with early universe magnetic fields.

What is being done in this manuscript, is to purport, that the idea should be to make the derived Noether's current the core of a magnetic field, and from there to also do it along the ideas brought up in the manuscript, in a reversal of the usual order of tying in the scalar field, directly with early universe magnetic fields.

The exponential factor of $\exp(i \cdot \omega \cdot t)$, which is multiplied into an inflaton field, makes the Noether current we derive real valued. This will allow us more background in investigating what Corda brought up in [19]

Moreover, in doing so, we are giving a foundational derivation of a magnetic field which is used by, Camara [8] , and other researchers in Non Linear electrodynamics, as to cosmology, which is a necessary appendage as to the inflaton based creation of a magnetic field, at the start of cosmological evolution

In doing all of this, Corda's suggestions as to how early universe conditions can be used to investigate the origins of gravity [19] take on a new significance.

We also, by tying in our work so closely to the origins of a new magnetic field, which we also state will be important to relic graviton production, give new urgency to necessary reviews of Abbot, and the LIGO team as to the evolving experimental science of gravitational astronomy. [20,21

Finally, our suggestions as to a start to the Weyl Tensor problem need to be confirmed and held to be in congruence, with the positions given above.

Note this is in connection to the interior boundary of space-time. And that our supposition will be matched to a causal boundary barrier between the initial boundary of a quantum bubble, and Huang's super fluid universe , post causal boundary barrier, which we write as [1, 18]

$$
\begin{aligned}
& H^2 = \frac{-k(curvature)}{a^2} + \frac{2}{3}\cdot\rho_c \\
& \& \\
& \rho_c = \frac{\dot{\phi}^2}{2} + V(\phi) \\
& \& \\
& H^2(Quantum - bounce) = 0 \\
& \Leftrightarrow a^2 = \frac{3k(curvature)}{2\rho_c} \\
& \Leftrightarrow a_{bounce} = \sqrt{\frac{3k(curvature)}{\dot{\phi}^2 + 2V(\phi)}}
\end{aligned}
\tag{29}
$$

It finally would be a way to investigate some issues raised in [22], as well as the idea, generically of a Gyraton, [1,23, 24] which may be a candidate for a Pre – inflaton graviton.

Our future projects, will be along the lines of what is mentioned in [25], as far as higher dimensional versions of the Weyl tensor. The idea will be if we do not have initial singularities mandated at the start of cosmological evolution to revisit some of the ideas held up as the gold standard in [26] , as well as to also investigate the role of five dimensional cosmologies brought up by Wesson in [27]. In doing so, we recommend that the readers look at exact solutions of the Einstein equations brought up in [28] before commencing their own projects due to how hard the ideas of this inquiry really are.

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