Non Linear electrodynamics and a minimum vacuum energy("cosmological constant") allowed in Early Universe cosmology

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Abstract

This article poses the question of a minimum cosmological constant, i.e. vacuum energy at the start of the cosmological evolution from a near singularity. We pose this comparing formalism as given by Berry (1976) as to a small time length, and compare that in its entirety to compare this value given by Berry (1976) with a minimum time length at the start of cosmological space-time evolution. Using the methodology of Zeldovich (1972) as to a problem with electron-positron pair production we also propose another upper bound to the problem of minimum time length which may be accessible to experimental inquiry. This then makes the problem of minimum time length a way of specifying a magnetic field dependence of the cosmological constant, which has major implications to answering if quinessence , i.e. a changing cosmological vacuum energy, or a constant for the "cosmological constant" problem . Our answer is an initial value $10^{10} - 10^{20}$ greater than today which suggests either Quintessence, or if still a constant,a much better value for this parameter than what is suggested by traditional field theory methods.

Key words:, cosmological vacuum energy., energy density ,initial time step.
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1 Introduction

We first of all cite there exists formalism of Berry[1] as to the formation of a shortest time step consistent to FRW space-time metrics. Then we will compare the results to the derived minimum time step derivation which is consistent with NLED. In doing so we will isolate what is a range of values for the vacuum energy, and "cosmological constant" dependent upon NLED inputs

Berry's results [1] are that for a standard flat space FRW cosmology, with positive cosmological 'constant'

$$t \sim \frac{2}{\sqrt{3\Lambda}} \cdot \operatorname{arcsinh}\left[a(t) \cdot \sqrt{\frac{\Lambda}{8\pi G\rho}} \right] \tag{1}$$

We will compare this answer with a minimum time step consistent with NLED and use it to obtain an NLED bound on the Λ cosmological constant term.

2 . First the NLED inputs into a minimum time step

If we consider the role of an electromagnetic charge, as freely given in this presentation, we should also look at a derivation of what Zel'dovich [2] gave as far as charge and anti charge particles, in an applied E and M field could yield, which would be of the form (when ξ is an energy expression, and E an applied electric field of the value of)

$$\frac{d\xi}{dt} < \frac{eE\xi}{mc} \tag{2}$$

Again to generalize this, we consider if the electric field is such that the commensurate bulk charge will have the following relationship to the given electromagnetic charge, to read as

$$\begin{aligned} & dE = -4\pi\, j dt \Rightarrow E = -4\pi\, jt \\ & \&\, j = 2enc \Rightarrow \\ & (\Delta t)^2 e \cdot n \cdot c = \frac{m}{4\pi c} \ln \frac{\xi_{init}}{\xi_{final}} \quad . \\ & \Rightarrow e = \frac{m}{4\pi n c^2 \cdot (\Delta t)^2} \ln \frac{\xi_{init}}{\xi_{final}} \end{aligned} \tag{3}$$

Picking the time variation as given by Δt, the number of charges as given by n, and $m_{E\&M}$ the mass of a hypothetical 'magnetic' charge as, derived by the author to read as

$$\begin{aligned} & e = \frac{m}{4\pi n c^2 \cdot (\Delta t)^2} \ln \frac{\xi_{init}}{\xi_{final}} = e_{E\&M} \\ & \sim \sqrt{\frac{B^2 \cdot r_{\min}}{\mu_0 \cdot \left[1 - 2 \cdot \frac{B^2 \cdot r_{\min}}{c} \cdot \mathrm{X}_0\left(\frac{B_c}{B}\right) \right]}} \end{aligned} \tag{4}$$

Eq. (3) has a deeper meaning. That that not only is there a net 'magnetic' monopole charge, as given in Eq. (4), that there is a minimum non zero E and M 'energy density, as given by either ξ_{init} or ξ_{final} for an emergent 'magnetic monopole' charge from an initial space-time configuration. This energy density value will lead to, to first order a minimum upper time step which we will characterize as

$$(\Delta t)^2 = \frac{m}{4\pi nc^2 \cdot e} \ln \frac{\xi_{init}}{\xi_{final}} = \sim \sqrt{\frac{B^2 \cdot r_{\min}}{\mu_0 \cdot e^2 \cdot \left[1 - 2 \cdot \frac{B^2 \cdot r_{\min}}{c} \cdot X_0\left(\frac{B_c}{B}\right)\right]}} \quad (5)$$

In doing so we will characterize the .values to be set for Eq. (4) as follows. i.e. $r_{\min}$, n, B, and energy densities as given by ξ_{init} and ξ_{final}. These values come from the work of the author as interpreting [2] as well as applying the results for a minimum radial density which are implied by the minimum scale value for the initial 'radii' of the universe due to electro dynamics given in [3], and of course the function $X_0\left(\frac{B_c}{B}\right)$ given in [4] . The next section will give inputs into these values and will be used to show how non linear electrodynamics may -influence an upper bound choice for the minimum time step which may arise in the start of the evolution of the universe

2 Examining inputs for $r_{\min}$, n, B, and energy densities as given by ξ_{init} and ξ_{final}.-----

In this section we will lay out arguments given in [2] to their logical conclusion as well as build upon several of the procedures given in [3], [4] to fill in these quantities, so as to give an upper bound to the minimum time step as referenced in Eq.(5) .To do so it would be useful to look at the formalism of Zeldovich [2] very closely, and if that is done, we can assert that the nucleation life-time for an electron – positron pair is give by setting $\Delta t \sim \tau_{e^+-e^-\,pair}$ with $\tau_{e^+-e^-\,pair}$ defined as below

$$\tau_{e^+-e^-\,pair} \sim \frac{m_{e^+,e^-}c}{eE} \quad (6)$$

Then the numerical density of the electron-positron pair may be given as

$$n \sim \frac{eE^2}{4\pi mc^4} \cdot \ln\left[\frac{\xi_{initial}}{\xi_{final}}\right] \quad (7)$$

We will next begin to analyze what should be for ξ_{init} and ξ_{final}.Which will in turn lead to the 'net' electric field. i.e. the net 'E and M' field is, in reality a consequence of work in [2],[3], and [4] which gives a minimum figure as to non linear electrodynamics and its consequence to a non zero initial radii of the universe. We go into this detail after giving order of magnitude estimates as to a minimum radii for the start of inflationary expansion.

2a. What are working values for ξ_{init} and ξ_{final} *as well as Eq.(6) n value.?*

To engage on this, we use the Zeldovich [2value for the net frequency which is given as

$$\omega \sim \mathrm{mc}^2/\hbar \quad (8)$$

We assume that the net frequency remains in initial nucleation invariant, but that the initial and final volumes change, by an amount we will quantify next. i.e. start with an initial to final radii of

$$r_{initial} \sim 7.7 \times 10^{-30}\, meters$$
$$r_{final} \sim 7.7 \times 10^{-29}\, meters \qquad (9$$

Then

$$\ln\left[\frac{\xi_{initial}}{\xi_{final}}\right] \sim 6.908 \qquad (910$$

This is the simplest interpretation of the consequence of varying energy density. Now for background to confirm it:

Making use of [3,4]],[we assert that the minimum radii of Eq. (8) is consistent with predictions of [3,4], i.e. we are looking at what happens if an electron moves at a velocity of v, with

$$|v| = |E/B| \qquad (11)$$

Implying if c is the speed of light, and $\tilde{\beta} > 0$, then the magnitude of the electric field should be given by

$$|E| = c \cdot 10^{-\tilde{\beta}} |B| \qquad (12)$$

i.e. in [2] we look at a generalized density .

$$\rho = \frac{1}{2\mu_0} \cdot B^2 \cdot \left(1 - 8 \cdot \mu_0 \cdot \omega \cdot B^2\right) \qquad (13)$$

This has a positive value only if input (E and M ?) frequency ω is such that.

$$B < \frac{1}{2 \cdot \sqrt{2\mu_0 \cdot \omega}} \qquad (134$$

In this situation we will be setting $B \equiv B_0$ What we are asserting is, that the very process of an existent E and M field, also,sets a 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

$$\alpha_0 = \sqrt{\frac{4\pi G}{3\mu_0 c}} B_0 \qquad (145$$
$$\lambda = \Lambda c^2 / 3 \qquad (16)$$

Then if , initially, Eq. (15) is large, due to a very large initial vacuum energy parameter Λ the time, given in Eq.(53) of [2] is such that we can write , most likely, that 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

$$a_{\min} = a_0 \cdot \left[\frac{\alpha_0}{2\lambda}\left(\sqrt{\alpha_0^2 + 32\lambda\mu_0\omega B_0^2} - \alpha_0\right)\right]^{1/4} \qquad (17)$$

The above scale factor should be such that the value of Eq. (17) should be in its smallest , i.e. 480,000 times proportionately larger than a Planck length of $l_{Planck} \sim 1.6162 \times 10^{-35}\, meters$, i.e. scale $a_0 \propto 10^{-29}$

Then, we will have that

$$\left[\frac{\alpha_0}{2\lambda}\left(\sqrt{\alpha_0^2+32\lambda\mu_0\omega B_0^2}-\alpha_0\right)\right]\geq 1 \quad (18)$$

$$\Rightarrow \frac{\alpha_0^2}{2\lambda}\left(\sqrt{1+32\frac{\lambda\mu_0\omega B_0^2}{\alpha_0^2}}-1\right)\geq 1$$
$$\Rightarrow 8\mu_0\omega B_0^2 \geq 1 \quad (19)$$

Eq.(18) puts a strong constraint upon the frequency and magnetic field strength, whereas Eq. (12) gives a strong set of values as to allowed E, so as to have, then

$$E^2 \geq c^2\cdot 10^{-2\tilde{\beta}}/8\mu_0\omega \quad (20)$$

This value for the square of the electric field should be then put into obtaining

$$n \sim \frac{eE^2}{2mc^4} \sim \frac{10^{-2\tilde{\beta}}\cdot e}{16\mu_0\omega\cdot mc^2} \quad (201$$

The numerical 'density' of electron-positron pairs drops as when the frequency ω rises. Which is counter intuitive, but it meshes well with

$$\left(\Delta t\right)^2 \sim \frac{m_e}{2nc^2\cdot e}$$
$$\xrightarrow[\omega\rightarrow small]{} t_{Planck}^2 \propto \left(5.39\times 10^{-44}\right)^2 \sec^2 \quad (22)$$
$$\xrightarrow[\omega\rightarrow much-l\arg er]{} \#\cdot t_{Planck}^2 > \left(5.39\times 10^{-44}\right)^2 \sec^2$$

I.e. for low frequency, we have a collapse to the Planck time frequency value, whereas, the minimum time step rises as frequency ω rises. Furthermore keep in mind that this result holds even if Eq. (23) is formed in a way independent of a changing vacuum energy, as given by[2]

$$\Lambda(t) \sim \left(H_{\text{inflation}}\right)^2 \quad (23)$$

Whereas this may tie into a massive graviton mass as given by the author as

$$m_g^2 = \frac{\tilde{\kappa}\cdot\Lambda_{\max}\cdot c^4}{48\cdot h\cdot\pi\cdot G} \quad (234$$

i.e the time step is then independent upon elementary arguments as to massive graviton mass. Furthermore, even if [4]

$$\Lambda_{0,M} = \frac{G}{32\pi}\cdot m_0^4\cdot\exp\left[3\cdot\left(\frac{m_g}{m_0}\right)^4\right] \quad (25)$$

And there is a relationship between Eq.(24) and Eq. (22), as well as a density functional which may relate to initially scaled mass m_0, that due to a very weak linkage between a density functional and m_0, and Eq.(20) that there is no clear linkage between Eq.(21) and Eq. (20), which is also counter intuitive We will nxt then compare Eq. (21) with Berry's formalism [1] based on the FRW metric

3. Minimum time according to the FRW metric allows for a NLED bound to Λ

The easiest case to consider is, if the Λ is not overly large, and the initial scale factor $a(t)$ is small. Then we have

$$t \sim \frac{2}{\sqrt{3\Lambda}}\cdot\left(a(t)\cdot\sqrt{\frac{\Lambda}{8\pi G\rho}}-\frac{a^3(t)}{2.3}\left(\frac{\Lambda}{8\pi G\rho}\right)^{3/2}+HOT\right) \quad (26)$$

Then we are looking at

$$\Lambda \sim \frac{8\pi G\rho_{galaxies}}{a^2(t)} \cdot \left[1 - \sqrt{\frac{3}{4}} \frac{m^2 \mu_0 \omega}{e^2 a(t)} \sqrt{8\pi G\rho_{galaxies}} \cdot 10^{2\tilde{\beta}} \right] \tag{27}$$

Here, $a(t_{initial}) \sim 10^{-30}$ is very small, but we are also assuming an ultra low $\rho_{galaxies}$ and ω, and small m

The net effect is for a small positive Λ as one is observing

$$\frac{8\pi G\rho_{galaxies}}{a^2(t)} < 1 \tag{28}$$

4 Conclusion:

. The previously done work by the author as to graviton production invoking non linear electrodynamics in cosmology was re introduced for the purpose as to density functions which are used to create an upper bound to the largest initial time step, in cosmological evolution. Counter intuitively, Eq. (22) has no connection as to the scaled value of a vacuum energy as given in Eq.(23), which suggests that when frequency rises, as may be connected to alternative values of cosmology, that different processes as to graviton production, as exemplified by Eq.(25) still keep a sharp independence as to initial time size as we state it for Eq. (22). Keep in mind, that what is being attempted is to upgrade work represented by Maggiore,[6in what may become gravitational astronomy, once falsifiable experimental procedures are agreed upon for vetting a minimal time step. In a future article, the author intends to represent the formation of a minimum time step as a classical back drop for the formation of quantum gravity. I.e. the minimum time step will be a pre cursor to the development of quantum gravity (formation of massive gravitons).

Eq.(27) and Eq.(28) in themselves argue for an NLED influenced cosmological “vacuum energy”, i.e. what we observe, initially is that the above, using $a(t_{initial}) \sim 10^{-30}$ and Eq.(28) that the value of Λ would be greater than the present value of the cosmological constant, perhaps by $10^{10} - 10^{20}$, arguing that some form of quintessence is argued for. But this value of Eq. (27) is far lower than the 10^{120} overshoot, obtained by traditional QFT methods.[7]

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