



Why No Dark Energy, No Big Bang, But A Likely Fractal Universe?

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Abstract: Recently, it has been shown that the “Big Bang Model” (BBM) actually corresponds to zero pressure and zero temperature (Mitra, Astr. Sp. Sc., 333, 351, 2011). Thus BBM cannot explain the observed universe having radiation and pressure. Consequently, the very idea of a “Dark Energy” resulting from the attempt of explaining the observed universe by BBM gets invalidated. Also, the fact that the BBM badly violates the principle of energy conservation independently suggests that it is physically unacceptable (Mitra, Gen. Rel. Grav. 42, 443 2010). To confirm this, we consider the transformation of vacuum de-Sitter metric from comoving coordinates to original Schwarzschild coordinates. Since the proper spacetime volume must remain invariant for all such coordinate transformations, it is found cosmological constant $\Lambda = 0$; implying no dark energy. It is pointed out that, recent observations have (actually) shown that observed universe has fractal structure upto largest observed scale with $D \approx 2.2$. Thus the universe is likely to be infinite hierarchial fractal rather than any smooth distribution of matter presumed by BBM. It is pointed out that the observed microwave background radiation may be explained as superposition of gravitationally red-shifted quiescent thermal radiation from the photosphere of the so-called black hole candidates.

Keywords: Dark Energy- Cosmology - Cosmic Background Radiation

1 Introduction

The most popular framework for explaining cosmological observations is the so-called “Big Bang Model” (BBM). Here the observed redshift, z of distant galaxies is explained in terms of kinematics; i.e., it is **assumed** that the redshift originates from mutual recession of the galaxies though in principle there might be non-kinematic reasons. In conjunction with the *assumption* of isotropy and homogeneity, this *recession interpretation* leads to the concept of an expanding universe with a scale factor $a(t)$. In terms of natural units, $G = c = 1$, the dynamics of the BBM gets determined by mass energy density ρ and isotropic pressure p (an overdot represents temporal differentiation):

$$\frac{\ddot{a}}{a} = -\frac{4\pi}{3}(\rho_e + 3p_e) = -\frac{4\pi}{3}(\rho + 3p - \Lambda/4\pi) \quad (1)$$

where $\rho_e = \rho + \Lambda/8\pi$, $p_e = p - \Lambda/8\pi$ and Λ is the cosmological constant. In the absence of a cosmological constant or “dark energy” ($\Lambda = 0$), the RHS of the foregoing eq. is -ve because $\rho + 3p \geq 0$, and one would expect only decelerated expansion with $\ddot{a} \leq 0$. However, by 1998, it was found that, the distant Type I supernovae are fainter than what is expected in the *context of BBM*. Though, in principle, such supernovae may not be standard candle because of evolution effects or could appear fainter because of dust extinc-

tion, such a faintness was promptly explained by assuming the sources to be farther away, i.e., by assuming $\ddot{a} > 0$, as if the universe is undergoing an accelerated expansion. Such an interpretation, in turn, got readily explained by assuming a $\Lambda > \rho > 0$ or equivalently, by *assuming* the presence of some sort of “Dark Energy” which cannot be directly seen or detected! However, it has recently been shown that, the absence of a pressure gradient in the BBM is possible only when there is no pressure at all, i.e., $p_e = 0$ [1]. Then the foregoing equation, would become

$$\frac{\ddot{a}}{a} = -\frac{4\pi}{3}\rho_e = -\frac{4\pi}{3}(\rho + \Lambda/4\pi) \leq 0 \quad (2)$$

Therefore, even the assumption of a positive Λ cannot explain $\ddot{a} > 0$.

2 Why Pressure = 0 in BBM?

In terms of comoving coordinates r, t , the spherically symmetric metric can be written is

$$ds^2 = g_{00}dt^2 + g_{rr}dr^2 - R^2(r, t)d\Omega^2 \quad (3)$$

where $d\Omega^2 = (d\theta^2 + \sin^2\theta d\phi^2)$ and $R = R(r, t)$ is the invariant area coordinate. By virtue of Einsteins’s equation

$G_b^a = -8\pi T_b^a$, the metric coefficients g_{00} and g_{rr} are determined by the matter energy momentum tensor T_b^a . And it has recently been shown that, for isotropic and homogeneous case; i.e., for the BBM, one has[1]

$$g_{00} = g_{00}(t) = e^{\frac{-2p_e(t)}{\rho_e(t) + p_e(t)}} \quad (4)$$

In general relativity (GR), whenever $g_{00} = g_{00}(t)$, one can set $g_{00} = 1$ by choosing a new time label $t \rightarrow t'$ *without any loss of generality*. Accordingly, one can set

$$\frac{-2p_e(t')}{\rho_e(t') + p_e(t')} = 0; \quad \text{or, } p(t') = 0 \quad (5)$$

But since pressure is a scalar, its value must remain unchanged by any coordinate transformation. In other words, one must **intrinsically** have $p_e(t) = 0$ in the BBM. One might however question this result by arguing that the BBM metric

$$ds^2 = dt^2 - a^2(t) \left[\frac{dr^2}{1 - kr^2} + r^2 d\Omega^2 \right] \quad (6)$$

satisfies the Einstein equation for arbitrary $\rho(t)$ and $p(t)$. Nonetheless, note that, for collapse/expansion of a homogeneous dust with $T_b^a = \text{diag}[\rho(t), 0, 0, 0]$, one obtains exactly same metric (6). And such an intrinsically zero pressure dust metric too apparently satisfies the Einstein equation with arbitrary $\rho(t), p(t)$! Thus the logic that the BBM metric can satisfy the Einstein equations for arbitrary $p(t)$ is *no justification to deny the exact and direct result that intrinsically*, BBM corresponds to $p_e = p - \Lambda/4\pi = 0$. Apparently, this result may lead to a *fine tuned* finite $p = \Lambda/4\pi > 0$. However, in the following, we shall show that actually, $\Lambda = 0$ too. And thus the BBM corresponds to $p = 0$. In reality the distribution of galaxies and their interactions can never be described by an equation of state (EOS) $p \equiv 0$. More importantly, for $p = 0$, one must have temperature $T_{bb} = 0$ too. In such a case, one cannot explain the observed microwave background radiation or any other radiation in the cosmos. Therefore, the BBM cannot describe the actual physical universe[1]! Further, it was shown that the BBM badly violates the principle of energy conservation[2], the cornerstone of physically valid theories, if indeed one would have $p \neq 0, \rho \neq 0$ as well as $\Lambda \neq 0$. Such a violation too suggests that the BBM cannot explain the actual physical universe[2].

3 Direct Proof that $\Lambda = 0$

The best way to see whether GR intrinsically allows a $\Lambda \neq 0$ or not would be examine the de-Sitter model supposedly driven by a *pure* Λ and no matter at all. In this case, one has

$$a(t) = e^{Ht}; \quad H = \dot{a}/a = \sqrt{\Lambda/3}; R = a(t)r \quad (7)$$

The de-Sitter metric is spatially flat with $k = 0$:

$$ds^2 = dt^2 - a^2(t) [dr^2 + r^2 d\Omega^2] \quad (8)$$

For this comoving metric, the metric determinant is

$$g_1 = -R^4 a^2 \sin^2 \theta \quad (9)$$

Interestingly, the de-Sitter metric can also be expressed in a **static** Schwarzschild form:

$$ds^2 = (1 - H^2 R^2) dT^2 - (1 - H^2 R^2)^{-1} dR^2 - R^2 d\Omega^2 \quad (10)$$

by means of the following transformations

$$t = T + \frac{1}{H} \log x \quad (11)$$

where $x = \sqrt{1 - H^2 R^2}$, and as already noted

$$R = ra(t); \quad dR = adr - \dot{a}r dt \quad (12)$$

Note that for the static form of the de-Sitter metric, the metric determinant is

$$g_2 = -R^4 \sin^2 \theta \quad (13)$$

Now we recall the fact that for all curvilinear coordinate transformations, the spacetime volume element remains invariant. In the present case, this means that

$$\sqrt{-g_1} dt dr d\theta d\phi = \sqrt{-g_2} dT dR d\theta d\phi \quad (14)$$

By using (9) and (13) in (14), we arrive at

$$a dt dr = dT dR \quad (15)$$

Also, from (11) we have

$$dt = dT - \frac{HR}{x^2} dR \quad (16)$$

while from (12), we have

$$adr = dR - HR dt \quad (17)$$

By feeding (16) and (17) into (15), and after some simplification, one finds that

$$H \left[dt^2 + \frac{H^2 R^2}{x^2} dR^2 \right] = 0 \quad (18)$$

The only solution of this equation is

$$H = \sqrt{\Lambda/3} = 0; \quad \text{i.e., } \Lambda = 0 \quad (19)$$

One may wonder here whether this exact but concise proof is correct and how can Λ be zero when thousands of articles have appeared in the past 13 years by assuming $\Lambda \neq 0$! Despite such natural apprehensions, *the foregoing proof is indeed correct*. All one has to bear in mind is that, here dr, dt etc. are *infinitesimal coordinate intervals and not any one forms* \tilde{dr}, \tilde{dt} . Further, (13) is not to be confused with oriented 4-volume form resulting from wedge product of 1-forms:

$$\sqrt{-g_1} \tilde{dt} \wedge \tilde{dr} \wedge \tilde{d\theta} \wedge \tilde{d\phi} = \sqrt{-g_2} \tilde{dT} \wedge \tilde{dR} \wedge \tilde{d\theta} \wedge \tilde{d\phi} \quad (20)$$

This is so because (16) and (17) correspond to coordinate intervals like dr, dt etc. and not to any 1-forms. For such coordinate intervals, $dr^2 = dr \times dr > 0$ whereas for wedge product of one-forms, $\tilde{dr} \wedge \tilde{dr} = 0$.

4 Discussions

The **exact result** that, *intrinsically*, $\Lambda = 0$, is in conformity with Einstein's late intuition. And this practically rules out the hypothesis of "Dark Energy" even though, at this moment, there are innumerable claims to the contrary. Far more importantly, we found that, BBM is unsuitable to explain the physical universe having matter pressure and radiation. This is so because, BBM, intrinsically corresponds to $p = 0$ and $T_{bb} = 0$ [1]. In fact, the BBM is the simplest (time dependent) cosmological model, and, being simple, it had a special beauty too. However, it lost its beauty by adding more and more parameters with undefined ranges as it struggled to explain actual observations. Interested readers may look into the *Monthly Newsletters of Alternative Cosmology Group* to appreciate the problems and challenges associated with BBM[3]. This is however not to say that there is any other parallel cosmology which can satisfactorily explain all the cosmological observations. In fact, if one would ignore the **exact** results that BBM corresponds to zero pressure and temperature[1] and $\Lambda = 0$ (as shown here), the BBM might still appear to be the best overall bet for explaining the observations.

Even if one would ignore various critiques of BBM[3], the **exact** results that BBM corresponds to zero pressure and temperature[1] and $\Lambda = 0$ (as shown here), prove that, the real universe is something completely different from the idealistic and simplistic BBM. To see what it could be, we recall that, now there is a huge body of evidence that the observed universe is of fractal nature with a fractal dimension $D \sim 2.0$. This is in accordance with the direct observation that the matter in the universe is lumpy in the form of *walls, fillaments, membranes* rather than in the form of a homogeneous smooth liquid in a glass or the air in a room[4, 5, 6, 7, 8, 9, 10, 11]. Note, a homogeneous matter distribution should correspond to $D = 3.0$. As we know, most of the natural processes are complex and complexities give rise to fractal structures rather than smooth idealistic geometrical objects. Note here that Einstein offered the simplest model of a static universe comprising smooth homogeneous fluid in 1917 based on his philosophical choice of a *closed and finite universe* rather than on any observational consideration or by taking into account prior concepts of likely fractal nature of cosmic matter distribution. In fact, in 1922, Franz Selety made the model of an inhomogeneous fractal universe **not having a definite centre**[12] and communicated it to Einstein. In this case though the matter distribution was isotropic, from the vantage point of a given observer, the matter density falls off. But, Einstein decided to ignore Selety in favour of his own philosophical prejudices[12, 13] and also by claiming that a fractal universe would violate Mach's Principle. The interesting and important review paper[13] has however refuted this particular and other objections raised against fractal models from time to time. It turns out that the Selety's model is getting corroborated by latest obser-

vation analyzed using novel statistical technique ignored by BBM proponents[4, 5, 6, 7, 8, 9, 10, 11, 14].

4.1 Likely Origin of Cosmic Background Radiation

As long as one would be unaware of the result that BBM intrinsically corresponds to $p = 0$ and $T_{bb} = 0$, the existence of cosmic microwave background radiation (CMBR) would appear as the biggest evidence in favour of BBM. But since, in reality, $T_{bb} = 0$ in BBM, the origin of CMBR must be attributed to something else. Though, at this moment, we really do not have a detail explanation for the origin of CMBR, we may recall one offered three years ago[15, 16]. This explanation relies on the fact that the so-called black hole (BH) candidates cannot be true BHs. This is so, because it has been shown that true Schwarzschild BHs have unique gravitational mass $M = 0$ [17] and this is true even for the Kerr BHs too[18]. In general, actually, the idea of finite mass BHs is in contraction with GR[19]. It is also a myth that GR ever yielded exact solution for the formation of true BHs in gravitational collapse[20]. On the other hand, it has been shown that, the so-called BH candidates are likely to be extremely hot balls of plasma whose radiation pressure (mostly transverse) renders quasi-stability against gravitational collapse[21, 22]. However, in a strict sense, such hot balls of plasma are ever contracting at an infinitesimal rate and called "Eternally Collapsing Objects" (ECOs).

Though the photosphere of the ECOs are emitting black body radiation at extremely high temperature, the extreme self-gravitation of ECOs make this black body appear as an extremely cool object to a distant observer. Further, it has been found that the distantly observed temperature of the ECOs is *independent of their mass*. Consequently all the ECOs of the universe give rise to a low temperature thermal background. By using the upper limit of the quiescent radiation from M87, it has been found that, a value of $T_{bb} \approx 2.7$ K is consistent[15, 16].

4.2 Static or Expanding Universe?

If the observed redshifts of distant galaxies would indeed be of kinematical origin, the *patch of the universe* we have witnessed so far may be considered to be "expanding". In fact, in an infinite fractal universe, it is possible that a certain finite patch is expanding just like in a huge lake, locally, there may be outgoing water ripples in a certain region. However, in the absence of BBM, the basic rationale for the assumption of a kinematic origin of the observed red-shifts vanishes. In fact, most of the cosmological observations might be fitted into a paradigm of *static universe* too[23, 24, 25, 26, 27]. Thus there is a real possibility that the spectral red-shifts of the distant galaxies may be due to some sort of *tired light* effect which we fail to fully explain at this epoch! It could be that photons from distant sources lose some energy as they interact with quantum mechnam-

ical vacuum fluctuation which we are not able to comprehend now.

5 Conclusion

One thousand year ago, the *concordance cosmology* was that Earth was at the centre of the solar system and probably at the centre of the cosmos. And no theory of gravitation or any other interaction was known. Yet astronomers of those days could predict reasonable sky maps and even occurrences of eclipses, tides etc with reasonable accuracy. Further, by definition, at any given epoch, astronomers have the *latest* knowledge. Some of the confident and intellectually arrogant astronomers of those days might have thought, particularly in view of the ability to predict eclipses and tides, that, they had not only correct knowledge about cosmology but also *precision cosmology*. However, we know now that their knowledge of cosmology was not only badly incomplete but completely erroneous too. In fact, here we may quote Karl Popper “*The main source of our ignorance lies in the fact that our knowledge can only be finite, while our ignorance must necessarily be infinite*”[28]. As to the claims of “Precision Cosmology”, we may recall another pertinent quotes by Karl Popper “Since we can never know anything for sure, it is simply not worth searching for certainty; but it is well worth searching for truth; and we do this chiefly by searching for mistakes, so that we have to correct them”[28]. And here we found “mistakes” in the BBM – that it corresponds to zero pressure and zero temperature - hence it cannot represent the physical universe. On the other hand since observations indicate fractal nature of **observed** cosmic matter distribution, the cosmos is more likely to be of fractal nature, though we can never know the nature of the cosmos with certainty. Further, it is interesting to note the claim that the idea of a static universe rather than an expanding universe is much more suitable to explain the cosmological observation[23].

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