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Research Article

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Cosmological Gravitational Redshift and Hubble Tension

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Abstract
For almost a century since its first measurement by Hubble in 1929 the value of the Hubble constant, H, has been the subject of intense debate. In the last few years a new dimension has been added to this debate because there appears to be a significant discrepancy between the values of H derived from present-day universe (cepheids, supernova, lensed quasars, tip of the red giant branch), which are minimally dependent on cosmological theory and those derived from early universe observations (cosmic microwave background and baryon acoustic oscillations), which are based on the standard cosmological theory, ΛCDM , whereby ΛCDM in turn is based on the assumption that the universe is expanding. This discrepancy is known as Hubble tension. We resolve the Hubble tension by introducing a universe which is governed by the Taub-NUT solution to the field equations of general relativity. The Taub-NUT universe is not expanding. In this universe the observed cosmological redshift is due to the gravitational redshift associated with the Taub-Nut solution, which we refer to as cosmological gravitational redshift. Time dilation in this stationary universe has the same dependency on redshift, that generally has been seen as proof that space is expanding.

Keywords: Cosmology, General Relativity

1. Introduction

There appears to be a significant discrepancy, ≥ 5σ between the value of the Hubble constant as determined by early universe measurements and late universe measurements [1-20]. For a non-technical comprehensive review [21,22]. There has been many attempts to explain this discrepancy by modifying *ΛCDM* such as just to mention a few [23-31]. There is no consensus on how to modify *ΛCDM*.

We suggest that the solution to the Hubble tension lies completely outside *ΛCDM*. It has long been believed that the gravitational redshift can not explain the observed cosmological redshift. The purpose of this work is to show that this assertion is not correct. In the following we develop a theory of cosmology based on the cosmological gravitational redshift.

In 1922 the concept of expansion of space was first introduced by Friedmann [32]. Independently in 1927 Lemaitre discovered the same concept, but he also went on to derive Hubble's law, a value for Hubble's constant, and to introduce the concept of a "primordial atom", which today we call the Big Bang. Big Bang cosmology rests on the assumption that cosmological redshifts are caused by the expansion of space [33].

The most fundamental observational relationship in cosmology is the redshift-distance relationship, which Hubble is often given credit, although historically inaccurate [34-37]. At the end of his publication Hubble specifically mentioned that the observed redshifts of extragalactic nebula could be caused by gravitational redshift, which following DeSitter he called "an apparent slowing down of atomic vibrations" [38,39]. De Sitter's work differs from our results because he did not employ the metrics below, which had not yet been discovered.

Hubble also mentioned that they could be caused by scattering on intervening material particles. In his publication Hubble however did not investigate these later possibilities instead he simply assumed that cosmological redshifts are Doppler shifts caused by radial velocity. Before Hubble this assumption was also made by Wirtz [40].

Humason, who worked with Hubble, made it clear that it was in no way certain that cosmological redshifts correspond to velocities [41]. Consequently, he referred to them as "apparent velocities". Later Hubble and Tolman explicitly stated that the cosmological redshift-recessional velocity relationship is an “assumption“ [42]. Hubble eventually turned away from the expanding universe interpretation and embraced the infinite static universe [43]. Critical discussions of this assumption can be found in [44-46]. We suggest that the most fundamental question of cosmology is: Are the observed cosmological redshifts due to the expansion of space?

The Big Bang theory, which following Lemaitre assumes that the observed cosmological redshifts are due to the expansion of space, has been extremely successful. It predicts the redshift-distance relationship, the existence of the Cosmic Microwave Background (CMB) and its properties, primordial nucleosynthesis, and supports observational evidence that the universe is evolving.

The Big Bang theory, however, still possesses fundamental problems. There are the horizon, magnetic monopole and flatness problems. Some scientists feel the theory of inflation resolves these issues, but others are of a different opinion, while still others suggest that a varying speed of light (VSL) is a viable alternative to cosmic inflation [47-57]. The theory also predicts that the universe should contain equal amounts of matter and anti-matter, which we do not observe. There is also the lithium problem whereby 3 times as much lithium is produced during Big Bang nucleosynthesis as is observed [58].

Assuming that the cosmological redshifts are due to the expansion of space, then the observed redshift-distance relation for Type Ia Supernova leads to the conclusion that the expansion rate of the universe is increasing rather than decreasing as attractive gravity demands [59,60]. This means there must be something else in the universe (an unknown form of energy), which is overwhelming attractive gravity. We call this unknown energy dark energy, which corresponds in Big Bang cosmology to negative pressure. Dark energy can be explained by a non-zero cosmological constant. The cosmological constant, however, corresponds to the energy of the vacuum. But, theoretical calculations of the vacuum energy density according to quantum field theory differ from the astronomically measured value by up to about 123 orders of magnitude [61]. To say the least this vacuum catastrophe is an incredibly embarrassing circumstance.

Despite these fundamental difficulties the achievements of the Big Bang theory are so impressive that the overwhelming majority of theoretical work in cosmology today involves just extensions and refinements of this theory. In contrast we develop below a theory of cosmology, which is not based on the assumption that cosmological redshifts are due to the expansion of space instead our theory maintains they are caused by the cosmological gravitational redshift.

2. The Gravitational Field Equations

After Einstein developed a framework for the theory of general relativity, Einstein sought field equations, which would correspond to the field version of Newton’s universal law of gravitation [62]. Einstein and independently Hilbert achieved this in November 1915 [63-65]. However, when Einstein tried to apply his theory of gravitation to the universe as a whole (cosmology), he found that his equations from 1915 appeared to be incompatible with a static mass distribution of constant density [66-68]. He discovered that a consistent model of the universe could be developed, if he added an additional term to his field equations that contained a constant, λ. Einstein’s and Hilbert’s field equations from 1915 are:

$$R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R = -8\pi G T_{\mu\nu} \tag{1}$$

and Einstein’s field equations from 1917 are:

$$R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R + \lambda g_{\mu\nu} = -8\pi G T_{\mu\nu} \tag{2}$$

$R_{\mu\nu}$ is the Ricci tensor, $g_{\mu\nu}$ the fundamental tensor, R the curvature scalar, $T_{\mu\nu}$ the energy-momentum tensor, G the gravitational constant, the speed of light is 1 and λ is a number, which is called the cosmological constant, λ. We do not employ the usual symbol, Λ, for the cosmological constant. Instead we use Einstein’s original symbol, λ. Our theory differs from *ΛCDM*. Consequently, there is no reason to assume that $\lambda = \Lambda$. In order to differentiate between the two sets of equations we call equation 1 the Einstein-Hilbert field equations and equation 2 the Einstein field equations. The spherically symmetric solution of the Einstein-Hilbert field equations for the empty space surrounding a nonrotating point mass is called the Schwarzschild solution. The corresponding solution of Einstein’s field equations is called the Kottler solution. If $\lambda > 0$, the Kottler metric is also known as the Schwarzschild-de Sitter metric and If $\lambda < 0$, as the Schwarzschild anti-de Sitter metric.

3. Theory

The solutions to the field equations are expressed in terms of the equation:

$$ds^2 = g_{\mu\nu} dx^\mu dx^\nu \tag{3}$$

ds is the line element, $g_{\mu\nu}$ is the metric tensor or fundamental tensor and both dx^μ and dx^ν are coordinates. The metric tensor contains constants, whose values are obtained from observations. In the specific case of cosmology the basic observational relationships are the redshift-distance diagram and time dilation, which we will employ to derive the constants contained in the metric tensor

A valid cosmological metric tensor must satisfy three conditions. It must be a solution to the field equations of general relativity, it must lead to the observed redshift-distance relationship and to the observed time dilation. Below we show that among the well known solutions to the field equations of general relativity there is at least five, which lead to the observed redshift distance relationship and to the observed time dilation.

3.1 Cosmological Gravitational Redshift

In standard relativistic cosmology there are three distinct possible causes of redshift: Doppler, gravitational and cosmological. We will show that the observed cosmological redshift, z, is due to the cosmological gravitational redshift. Consequently, we will conclude there are only two causes of redshift in relativistic cosmology: Doppler and gravitational.

In general the gravitational spectral shift between any two points A and B in space is given by:

$$z = \sqrt{\frac{g_{00}(r_B)}{g_{00}(r_A)}} - 1 \tag{4}$$

We assume that r_A in the above equation is a constant meaning that we can let $\gamma = g_{oo}(r_A)$. Consequently, we can drop the subscripts to obtain:

$$(z+1)^2 = \frac{g_{00}(r)}{\gamma} \tag{5}$$

3.2 Time Dilation

Time dilation in relativity is defined via the proper time, $d\tau = \sqrt{ds^2}$. In our cosmological theory the proper time is:

$$d\tau = \sqrt{g_{00}}dt \tag{6}$$

We employ equation 5 to obtain the relationship between time dilation and redshift in our theory of cosmology. We find:

$$d\tau = \sqrt{\gamma}(z+1)dt \tag{7}$$

Suggestions by Wilson and Rust that light curve broadening should occur in Type Ia Supernova, if the universe is actually expanding, have been observationally confirmed by [69-73]. These authors found a time dilation or slowing down of the supernova by the factor of (z+1). They interpreted this result as evidence that cosmological redshifts are caused by an expanding universe.

The above equation for time dilation in the stationary universe has the same (z+1) dependency, but it is not associated with cosmic expansion rather it is due to the cosmological gravitational redshift. We conclude: the observed light curve broadening can not be used to prove that the universe is expanding. Segal, Andrews and Holushko came to the same conclusion although their theoretical standpoints are completely different than ours [74]

Comparing the above equation with observations of time dilation we conclude: $\gamma = 1$ and equation 5 reduces to:

$$(z+1)^2 = g_{00}(r) \tag{8}$$

3.3 Cosmological Solutions to the Field Equations

In our work cosmological solutions to the field equations of general relativity refers to those that lead to the observed redshift-distance relationship and to the observed time dilation. We call the gravitational redshifts associated with these solutions cosmological gravitational redshifts.

The solutions to the field equations contain constants. Our objective in this work is to demonstrate that the cosmological gravitational redshift explains the observed redshift-distance relationship and the observed time dilation. So we are not concerned with the physical meaning of the constants. Rather we merely ask: What numerical values must the constants assume so that they lead to the observed redshift-distance relationship and to the observed time dilation? Consequently, this initial formulation of our theory is purely parametric.

To obtain the numerical values of the constants in $g_{00}(r)$ we will employ equation 8. The left side of this equation is known from observations, whereas the right side is theoretical and comes from the solutions to the field equations of general relativity. The numerical values of the constants in $g_{00}(r)$ are obtained by curve fitting the $g_{00}(r)$ to the observations.

The first two solutions of the field equations that we consider are the most well known and also the simplest, the Schwarzshild and Kottler metrics. For the Kottler metric we have:

$$g_{00} = 1 - \frac{\alpha}{r} - \frac{\lambda}{3} r^2 \tag{9}$$

Inserting this into equation 8 yields:

$$(z+1)^2 = 1 - \frac{\alpha}{r} - \frac{\lambda}{3} r^2 \tag{10}$$

The above equation is valid for the Schwarzschild metric too if we let $\lambda = 0$.
The zero point of the redshift-distance relationship is: $z = 0$ at r = 0, whereby equation 8 becomes:
$g_{00}(0)=1$. But, this point does not exist according equation 10 because $\frac{\alpha}{r} \rightarrow \infty$, as r $\rightarrow$ 0. Thus, neither the Kottler nor the Schwarzschild metric lead to the observed redshift-distance relationship and they are therefore not cosmological solutions meaning that the gravitational redshifts associated with them are not cosmological gravitational redshifts.

We investigated 17 solutions to the field equations to see, if they are cosmological solutions. Two of the solutions that are not cosmological are the Kerr solution, which corresponds to a rotating massive body and the Kerr solution with the cosmological constant.

We found five solutions that are cosmological. All five solutions are members of the Taub-NUT family of solutions. The Taub-NUT solution to the vacuum field equations is considered a generalization of the Schwarzschild solution [75]. Taub discovered the solution [76]. Newman extented its static region. Misner stated "Taub-NUT space as a counterexample to almost anything" in gravity. Below we give the $g_{00}(r)$ components of the fundamental tensor for each of the five solutions and derive the numerical values of the constants they contain [77].

3.4 Comparison of Theory with Observations of Type Ia Supernova

In this section we compare the theoretical cosmological gravitational redshift on the right side of Equation 8, with the observed redshift-distance diagram from **(Brout et al. 2022),** which consists of 1699 Type Ia supernova. The data contains the observed relationship between spectral shift, z, and distance modulus, μ. We employ:

$$r = 10^{(\frac{\mu}{5}+1)-9} \tag{11}$$

to convert μ to r, the distance of a supernova in Gpc.
The Brout et al. data contains the errors in the redshift, z, but in our analysis we employ $(z + 1)^2$, so we need to compute the error in this quantity. Expansion of $(z + 1)^2$ is:

$$(z+1)^2 = z^2 + 2z + 1 \tag{12}$$

If the uncertainity in z is δz, then the uncertainity in z^2 is $\sqrt{2}\delta z$ and the uncertainity in $2z$ is also $\sqrt{2}\delta z$. Thus the uncertainity in $(z+1)^2$ is 2 $\sqrt{2}\delta z$, which is significantly larger than δz.

3.4.1 Taub-NUT

The part of the Taub-NUT solution that interests us is Bardoux et al [79].

$$g_{00}(r) = -(\frac{r^2 - 2\alpha r - n^2}{r^2 + n^2}) \tag{13}$$

n is called the NUT parameter. As mentioned above we do not attempt to give α and n in our cosmological theory a physical meaning. In this work we are concerned only with their numerical values. Assuming the validity of the Big Bang theory Taub 1951 applied his metric to cosmology. In contrast we employ this metric to compute the cosmological gravitational redshift and show that it leads to the observed redshift-distance relationship.

Curve fitting the above equation to the left side of equation 8 leads to numerical values of the constants: α = 17318.721 and n = 269.27087. Figure 1 shows that equation 8 along with the above equation lead to the observed redshift-distance relationship.

We found that another set of numbers leads to agreement between theory, the right side of equation 8 and observation, the left side of equation 8. They are $\alpha = 6.86977\times10^{12}$ and $n=5.36492\times10^{6}$. Presumably the numbers given below for the other solutions are also not unique. This circumstance may make it difficult to find physical interpretations of the constants employed in the $g_{00}(r)$.

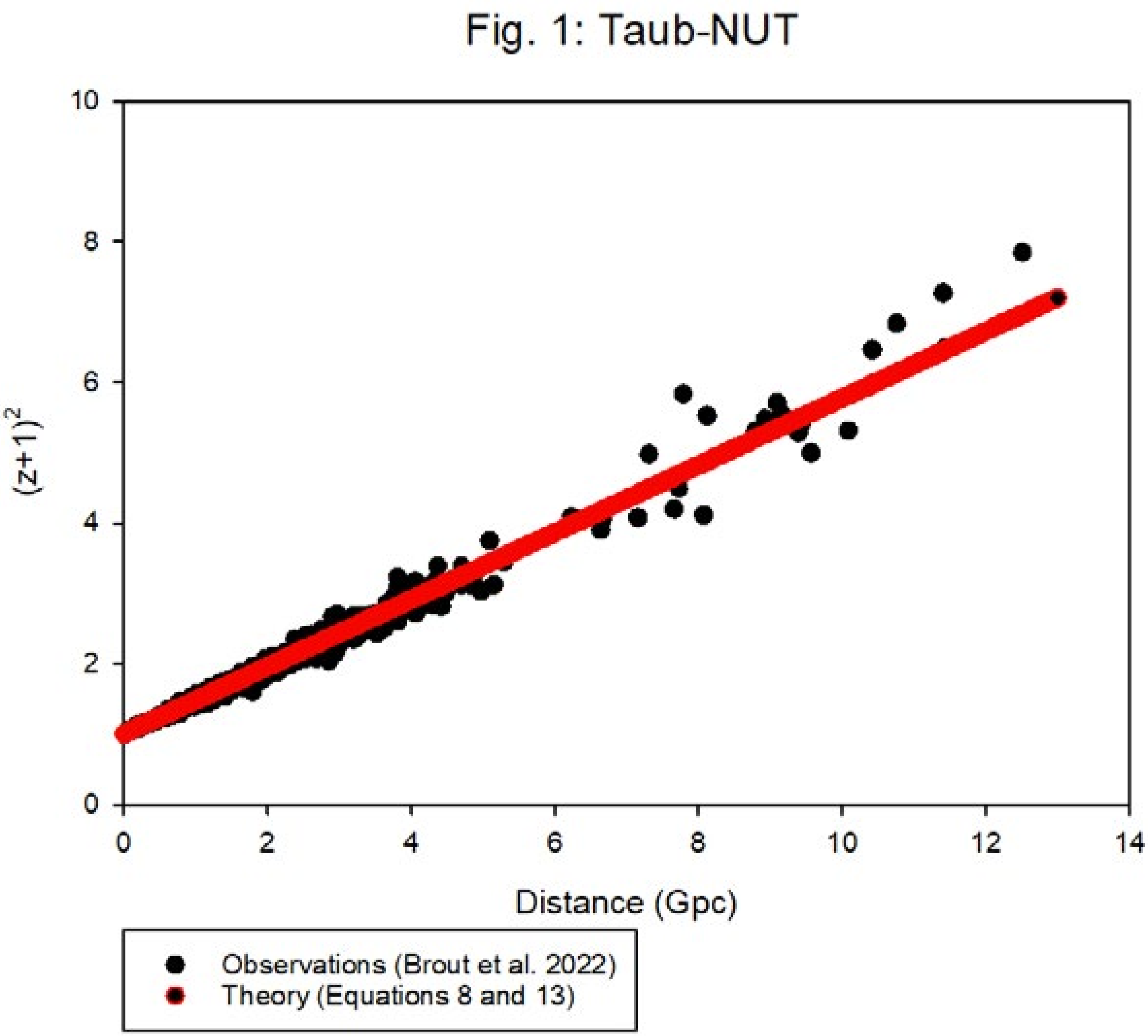

Figure 1.

3.4.2 Charged Lorentzian Taub-NUT

Following Abbasvandi (Abbasvandi et al. 2021):

$$g_{00}(r) = -(\frac{r^2 - 2\alpha r - n^2 + 4n^2g^2 + e^2}{r^2 + n^2} - \frac{3n^4 - 6n^2r^2 - r^4}{l^2(r^2 + n^2)}) \tag{14}$$

Curve fitting the above equation with equation 8 leads to agreement between theory and observation except for a small constant difference at $r < 0.9$ *Gpc*. However, if we demand $g_{00}(0) = 1$ as mentioned above, we obtain the constraint:

$$e = \frac{\sqrt{3n^4 - 4n^2g^2l^2}}{l} \tag{15}$$

Curve fitting these last two equations to the left side of equation 8 leads to the numerical values: $\alpha = 2.20965\times10^{12}$, $n = -3.04266\times10^{6}$, $l = 7.67264\times10^{8}$ and $g = 1$. Figure 2 shows the agreement between theory and observation. This agreement also holds for $r < 1$ *Gpc*.

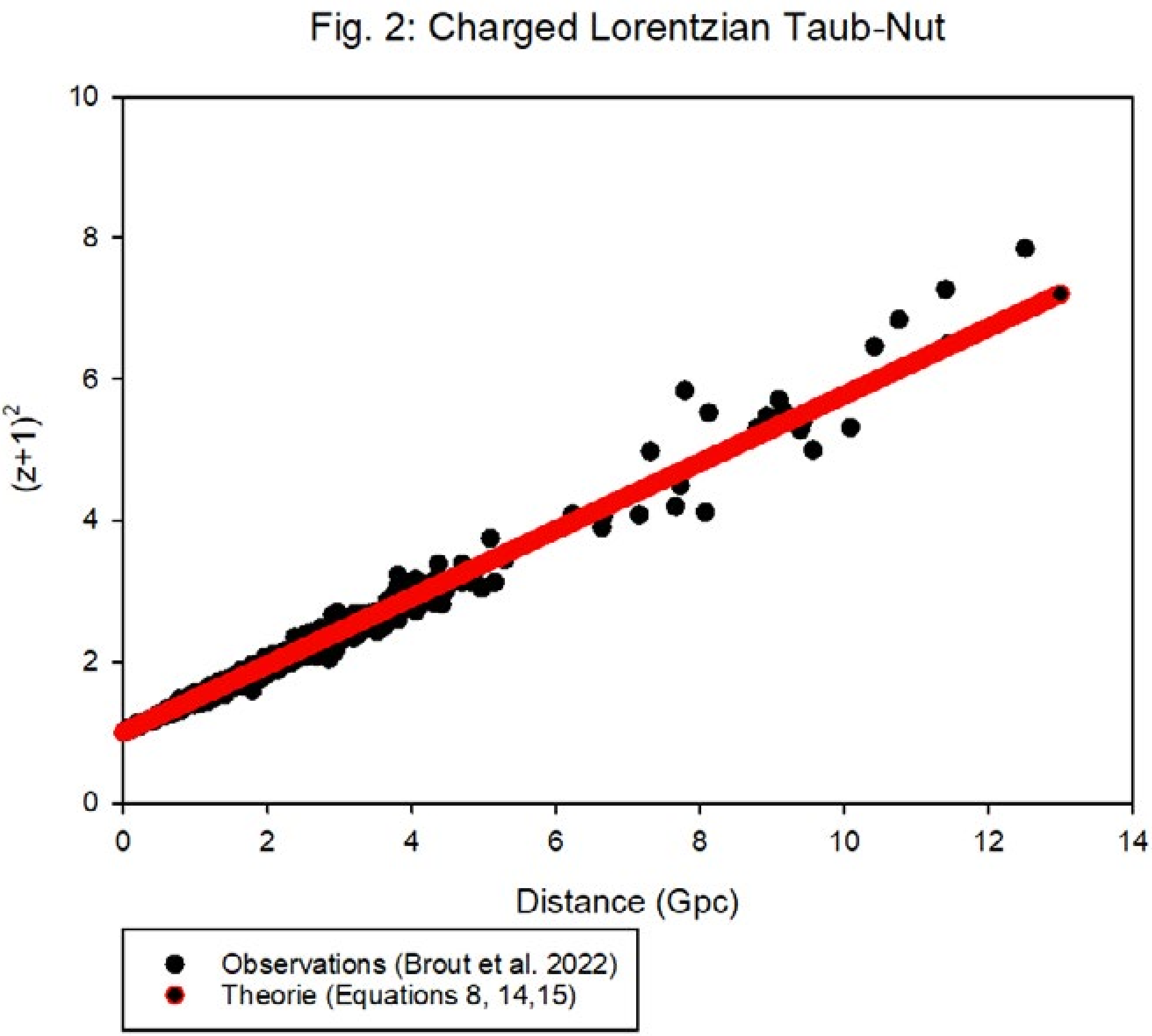

Figure 2.

3.4.3 Taub-Nut AdS

Following Mann [80].

$$g_{00}(r) = \frac{l^{-2}(r^2+s^2)^2 + (\kappa + 4l^{-2}s^2)(r^2-s^2) - 2\alpha r}{r^2+s^2} \tag{16}$$

s is the NUT charge and the cosmological constant is: $\lambda = -\frac{3}{l^2}$. We were not able to curve fit this equation due to lack of convergence. However, when we added the condition: $g_{00}(0) = 1$, which lead to the equation:

$$\kappa = \frac{l^2 - 3s^2}{l^2} \tag{17}$$

we were able to obtain a fit with the constants: $\alpha = 4.3767 \times 10^{12}$, s = 4.28218×10^6 and l = 1.88052×10^9. The values of *l* and s lead to: $\lambda = -8.48327 \times 10^{-19}$. Figure 3 depicts this fit.

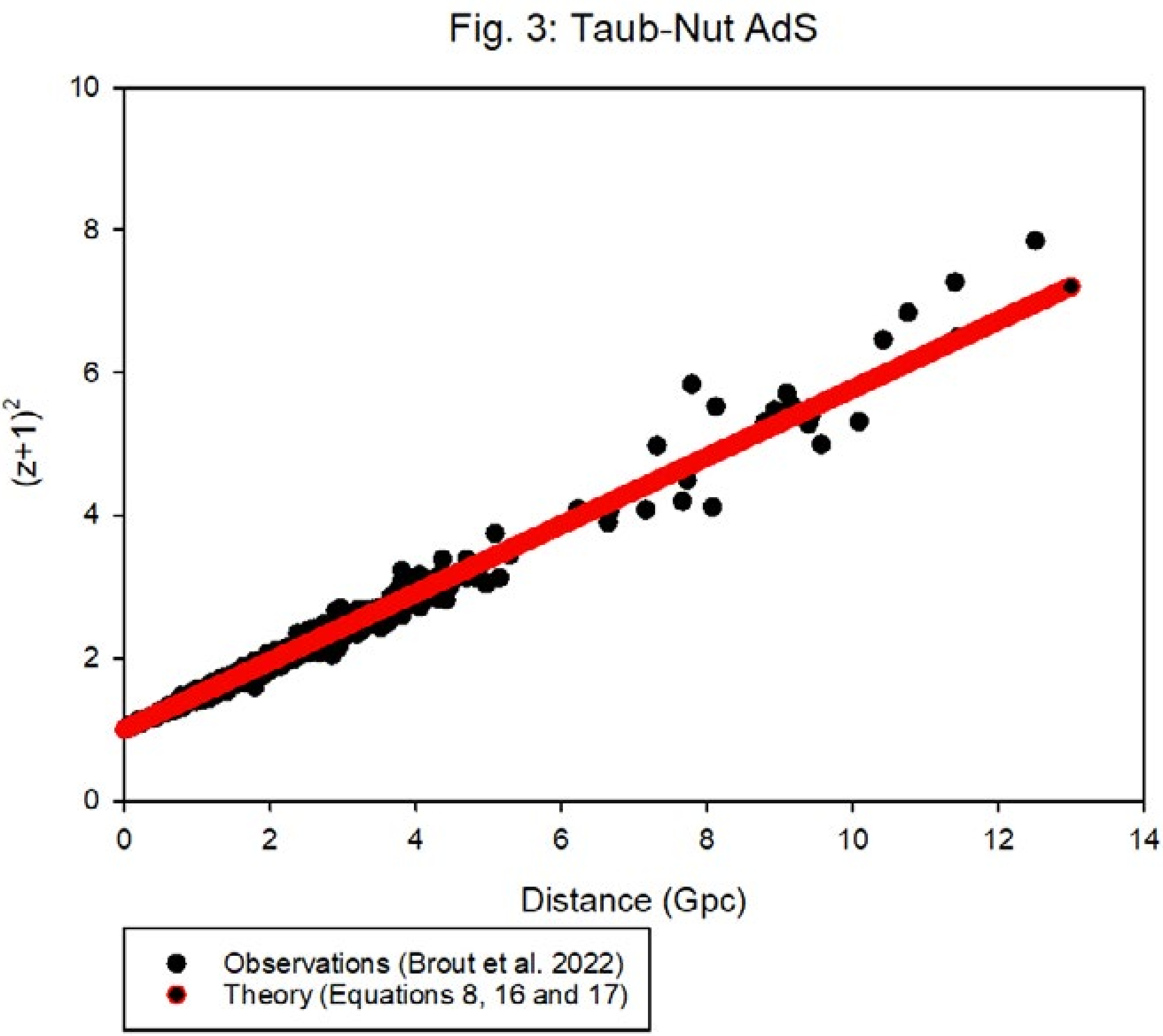

Figure 3.

3.4.4 Kerr-Taub-NUT

The Kerr-Taub-NUT metric is a solution to the vacuum Einstein-Maxwell equations, which is locally analytic. We obtain the g_{00} from Miller [81].

$$g_{00}(r) = a^2 \frac{\sin(\theta)^2}{\Sigma(r)} - \frac{\Delta(r)}{\Sigma(r)} \tag{18}$$

with:

$$\Sigma(r) = r^2 + (l + a\cos(\theta))^2 \tag{19}$$

and

$$\Delta(r) = r^2 - 2\alpha r - l^2 + a^2 + e^2 \tag{20}$$

Curve fitting leads to an agreement between theory and observation for $r > 0.9$ *Gpc*. At radial distances less than this value a small constant deviation occurs. So we demand that the condition $g_{00}(0) = 1$ be fulfilled. This leads to the equation:

$$l = \frac{(-a^2 - e^2 - a^2\cos(2\theta))\sec(\theta)}{2a} \tag{21}$$

Curve fitting now leads to complete agreement between theory and observation over the entire range of the observational data with the constants: $a = -94.5928$, $\theta = 246.622$, $\alpha = 7.59802 \times 10^7$ and $e = -156.663$. Figure 4 shows this agreement.

3.4.5 Kerr-Taub-NUT AdS

We obtain the required $g_{00}(r)$ from Rodriguez [82]:

$$g_{00}(r) = \frac{a^2 \Delta\theta}{\Sigma(r)} - \frac{\Delta(r)}{\Sigma(r)} \tag{22}$$

whereby

$$\Sigma(r) = r^2 + (n + a\cos(\theta))^2 \tag{23}$$

$$\Delta\theta = (1 - \frac{4an\cos(\theta)}{l^2} - \frac{a^2\cos(\theta)^2}{l^2})\sin(\theta)^2 \tag{24}$$

$$\Delta(r) = r^2 + a^2 - 2\alpha r - n^2 + \frac{3(a^2 - n^2)n^2 + (a^2 + 6n^2)r^2 + r^4}{l^2} \tag{25}$$

As above the cosmological constant is: $\lambda = -\frac{3}{l^2}$. The curve fitting procedure did not lead to convergence. Consequently, we introduced the constaint: $g_{00}(0)= 1$, which leads to:

$$l = \frac{\sqrt{-3a^2n^2 + 3n^4 - 4a^3n\cos(\theta)\sin(\theta)^2 - a^4\cos(\theta)^2\sin(\theta)^2}}{\sqrt{a^2 + 2an\cos(\theta) + a^2\cos(\theta)^2 - a^2\sin(\theta)^2}} \tag{26}$$

These equations lead to convergence with: $\alpha = 21.2367$, $a = 9.11243$, $\theta = 0.585696$, and $n = 2.1556$. These values inserted into the above equation lead to: $\lambda = 0.10533$ Figure 5 shows the theoretical curve in red along with the Type Ia Supernova data. It depicts an excellent agreement between theory and observation.

Note how for $r > 10$ Gpc the red theoretical curve turns upward, unlike the other four solutions. A large number of highly accurate Type Ia Supernova observations at $r > 10$ Gpc may confirm this upward bending. If that is the case, then this solution may be the one unique solution, which fits the data. This would mean that $\lambda \neq 0$ and the Einstein field equations (equation 2) are the correct equations for cosmology.

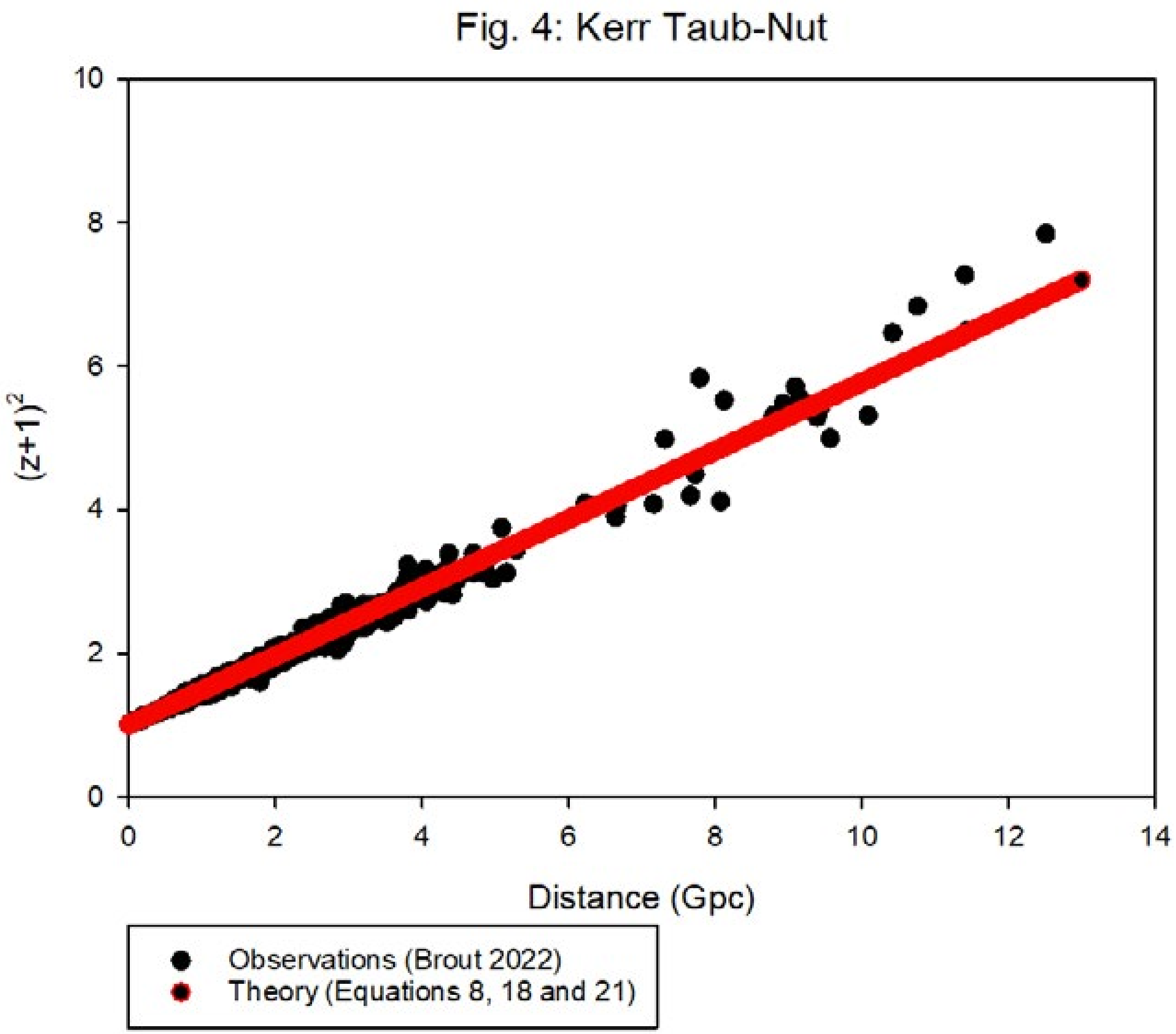

Figure 4.

4. Comparison With Other Cosmological Theories

4.1 Big Bang Theory

Physical theories are based on assumptions. Different theories are based on different assumptions. Big Bang Theory is based on the Cosmological Principle, that is on the assumptions of homogeneity and isotropy. They lead to the Friedman-Lemaitre-Robertson-Walker (FLRW) metric. Instead our theory is based on the Taub-Nut solutions to the field equations of general relativity. They are spatially homogeneous. The fundamental tensors employed in our cosmological theory are not the metric of our entire universe for all spacetime, in the sense that the FLRW metric claims to be, rather they are the metrics associated with the celestial sources from which we obtain the observed redshift-distance relationship. These metrics are a generalization of the Schwarzchild metric.

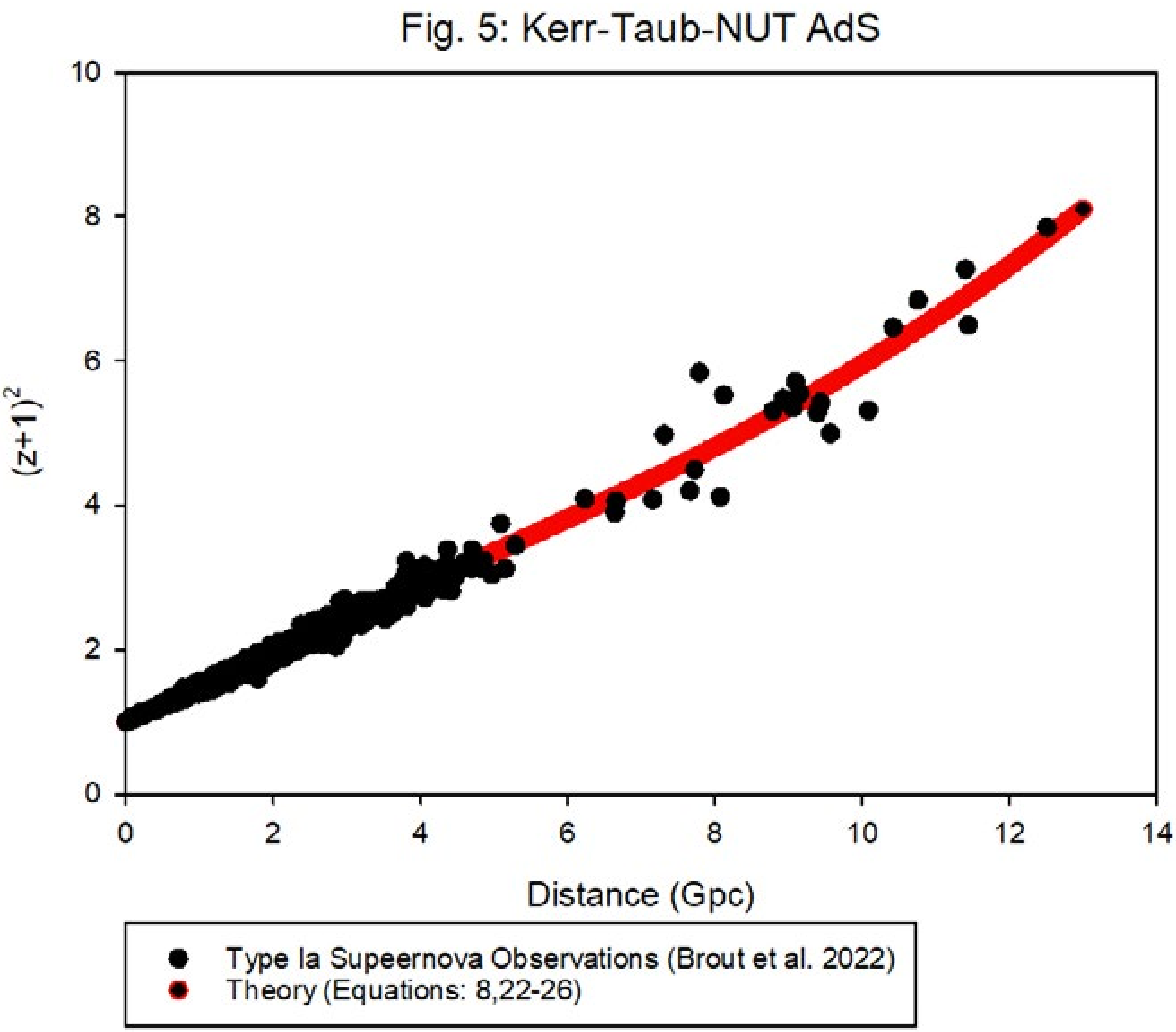

Figure 5.

In our theory non-relativistic matter and the CMB are not included (more on this circumstance below). This differs from Big Bang cosmology, where the deceleration parameter and consequently the redshift-distance relationship which depends upon it, is determined by the average density of matter and energy in the universe. In our cosmology to the contrary the redshift-distance relationship is determined by well-known solutions to the field equations of general relativity, whereby the average density of matter and energy in our universe play absolutely no role.

In Big Bang cosmology dark energy is an unknown form of energy required to explain the acceleration of the expansion of space. In our theory of cosmology there is no expansion and therefore no accelerated expansion and therefore no need to introduce the concept of dark energy as it is understood in ΛCDM cosmology. Consequently, the vacuum catastrophe mentioned in the introduction does not exist in our theory. In addition the other fundamental problems of the Big Bang theory: horizon, magnetic monopole, flatness and the prediction that the universe should contain equal amounts of matter and anti-matter also do not exist in our theory.

In the Big Bang theory to a good approximation the redshift is:

$$z = \frac{H_0}{c} r + \frac{1}{2} (\frac{H_0}{c})^2 (1 + q_0) r^2 \tag{27}$$

Where H_0 is Hubble's constant and q_0 is the deceleration parameter. It follows that the gravitational redshift would be:

$$(z+1)^2 = (\frac{H_0}{c} r + \frac{1}{2} (\frac{H_0}{c})^2 (1 + q_0) r^2 + 1)^2 \tag{28}$$

The values obtained by curve fitting this equation with equation 8 do not lead to agreement between observation and theory. We conclude: the Big Bang theory and our theory are incompatible with each other.

We believe this conclusion is important and we strengthen it with the following: Using the Taub- NUT solution specifically equations 8 and equation 13 along with the above equation we are lead to the equation:

$$-\frac{r^2-2\alpha r-n^2}{r^2+n^2}=(\frac{H_0}{c}r+\frac{1}{2}(\frac{H_0}{c})^2(1+q_0)r^2+1)^2 \tag{29}$$

Solving the above equation for α we obtain:

$$\alpha(r)=\frac{1}{2r}((n^2+r^2)(-\frac{n^2}{n^2+r^2}+\frac{r^2}{n^2+r^2}+(1+\frac{H_0}{c}r+\frac{1}{2c^2}(H_0(1+q_0)r^2)^2 \tag{30}$$

But the Taub-NUT solution tells us that α is a constant and is not a function of r. Again we conclude: the Big Bang theory and our theory are incompatible with each other. We suspect this incompatibility means that both theories cannot be correct, that is at least one of the two theories is false. Finally, we note if we assume $q_0 = 0$ in the above equations, we obtain the same results and come to the same conclusions.

4.2 Cosmic Microwave Background

In the theory of the expanding universe, the CMB is the radiation left over from the Big Bang. Clearly, our theory of cosmology demands that the CMB must have a different origin. This task however has already been accomplished by the many scientists, who have discussed its origin without Big Bang cosmology. First Guillaume calculated that the temperature of interstellar space from the presence of starlight to be 5.6°K and Eddington 3.1°K while Regener using the energy density of cosmic rays found it to be: 2.8°K, which is very close to the measured value of: 2.72548°K. Nernst calculated the temperature of intergalactic space to be: 0.75°K and Finlay-Freundlich calculated 1.9⁰K ≤ T ≤ 6.0⁰K for its temperature [82-86].

All of the above calculations were made without employing the notion of a Big Bang. Born was the first to realize that these temperatures mean that the electromagnetic waves emitted would fall in the radio region [87,88]. No one looked for these electromagnetic waves and they (the CMB) was serendipitously discovered by Penzias and Wilson. Following Kellermann's suggestion one can spreculate how the history of cosmology might have been very different, if radio astronomers had looked for and found the CMB based on the above calculations and Born's insight. In fact, because these values were more accurate than those initially predicted by proponents of the Big Bang (Alpher, Herman and Gamow (Alpher & Herman 1948; Alpher et al. 1948; Gamow 1953, 1961)), Assis and Neves (Assis & Neves 1995) concluded that the CMB provides evidence for a nonexpanding universe rather than for an expanding one [89-99]. Other non-Big Bang explanations for the origin of the CMB are(Layzer & Hively 1973; Rees 1978; Carr 1981; Wright 1982; Assis 1993; Assis et al. 2009; Fahr & Zönnchen 2009) [94-99].

4.3 Stationary Universes

The concept of a non-expanding universe is not at all new. In fact, historically, it was the first theory of physical cosmology. Starting with Olbers and continuing with Einstein, DeSitter, Lense, Lanczos and Nernst it dominated up until the 1920's. The discovery of cosmological redshifts by Slipher 1915 eventually caused a change of thought.

The cosmological redshift-recessional velocity relationship being an assumption has opened the door to a variety of possible explanations for the origin of cosmological redshifts (see Kragh for a review). One of these explanations was that the observed cosmological redshift is due to the gravitational redshift Kaiser [100].

Many of these explanations come under the broad term tired-light hypothesis. Starting with Zwicky and continuing with Hubble and Tolman. A non-expanding universe explanation for the cosmological redshift is also found in many other publications [101-111].

Our approach is not related to any of these other explanations. It differs from them in that in our theory of cosmology the origin of the observed cosmological redshift is the cosmological gravitational redshift. This interpretation of redshift agrees with the work of (Ostermann 2002, 2003).

5. Conclusion

The goodness of the fit in figures 1-5 makes clear that a stationary (non-expanding) universe based on the cosmological gravitational redshift explains the observed redshift-distance relationship. It also explains the observed time dilation, which has generally been seen as proof that space is expanding. Thus, the concept of the expansion of space is not needed to explain these fundamental observational relationships in cosmology.

In our theory of cosmology there is no Big Bang and therefore no early universe as it is understood in *ΛCDM* cosmology. Consequently, there is no Hubble tension in our theory of cosmology.
Both *ΛCDM* and our cosmology are based on the field equations of general relativity. However, Big Bang cosmology assumes that cosmological redshifts are caused by the expansion of space, whereas our theory suggests that they are a manifestation of the cosmological gravitational redshift. From the standpoint of our cosmology the concepts of Big Bang cosmology are superfluous [112-127].

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