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A Model of Light from Ancient Blue Emissions

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A model is presented to explain the luminar distances and associated red-shifts from ancient supernovae. Light frequencies of supernovae type Ia (SNe Ia) vary smoothly with time, decreasing from singularity to present and intergalactic luminar distances are described as linear combinations of Hubble expansion and smaller components from the time-dependent decrease of emission frequencies. When tested with current cosmic matter densities, SNe Ia distances, red-shifts and the Hubble constant the errors between this model and the vacuum energy model favor this new model, though our model suffers from mathematics about zero. An expression between energy and frequency, derived from the model, reducing to the Planck equation for short observation intervals is also discovered and estimated to within 10% using current SNe Ia data. We also propose a relationship for the deceleration of frequency over time, solve at infinity and discover frequency and time will eventually become uncoupled.

KEY WORDS: supernovae; light; frequency.

1. INTRODUCTION

A wide range of distance and velocity data is required to solve relationships estimating the current Hubble constant (H_0), space-time curvature and Universe age. The time-dependent and large luminosities of supernovae type Ia (SNe Ia) make these a good choice for distance measurements. Determination of accurate astronomical distances has been a historical problem, however, while dependable values of related velocities using associated red-shifts, have been available for over a century. It is thought that SNe Ia explode within a narrow mass range and emit similar amounts of light across a small time period, independent of emission epoch—so most SNe Ia are considered "standard candles." Since the light flux is equivalent to that of a galaxy, SNe Ia can even be observed beyond the age of our solar system (Hillebrandt and Niemeyer, 2000). Astronomers have collected

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data from many different searches of SNe Ia, many with accurate luminosity distances (D_L) and estimated distance errors (Perlmutter *et al.*, 1999; Riess *et al.*, 1998; Tonry *et al.*, 2003). These data, some from the Hubble Space Telescope, have been recently standardized and extend to perhaps half the time to singularity (Riess *et al.*, 2004).

The modeling of these recent results cannot be entirely explained by the standard Friedmann–Robertson–Walker (FRW) model of a homogeneous, isotropic, expanding Universe (Carroll *et al.*, 1992). Inclusion of a term for vacuum energy ($\wedge$) is sometimes used to better fit these data. This concept was first used by Einstein to explain a supposed static Universe (our galaxy); he later abandoned this after Hubble and others proved the Universe is expanding not static and Einstein never favored this concept again. Several recent proposals have been made for the inclusion of vacuum energy with a large value of the cosmic constant ($\Omega_\wedge$) to account for recent SNe Ia results within the general FRW model (Garnavich *et al.*, 1998; Perlmutter *et al,* 1999; Tonry *et al.*, 2003). Cosmological models based upon variations of the FRW model have appeared, which take into account the vacuum energy by adjusting the effective matter density, with fair agreement to the data (Behar and Carmeli, 2000) and interesting galactic velocities are predicted. There is a proposal that systematic errors are still present in SNe Ia data demanding better understanding of the SN explosion and the travel of light through space-time (Drell *et al.*, 2000): a rebuttal has been published (Tonry *et al.*, 2003). Some evidence for vacuum energy from cosmic microwave background radiation data may have been discovered (Sievers *et al.*, 2003). Another model explains the distances of SNe Ia using "replenishing dust" rather than vacuum energy (Goobar *et al.*, 2002).

One outcome of the inclusion of a large cosmic constant is a Universe appearing to be expanding more rapidly now than in the past. While this has the pleasant effect of lengthening the extrapolated Universe age, this resurrected concept also raises many questions. Evidence now suggests that we are coalescing with our neighboring galaxies as predicted by the laws of Einstein, despite local Hubble expansion. It does not appear that across tens of thousands of light years, containing our local group, enough PdV work (or vacuum energy) is being created in deep space to keep the Milky Way apart from our neighbors. So vacuum energy might be indivisible—either working with the entire frames of galaxy clusters or not at all. Problems also arise just beyond the range of current SNe Ia data, where the vacuum energy acts in an attractive rather than a repulsive manner (Öztas and Smith, 2006), making this a really interesting problem.

For light, we do not know the exact emission frequencies from distant objects, though we calculate galactic velocities assuming distant frequencies are identical to nearby. While it must be true that light frequency in our epoch is not highly dependent upon time, precise observations have only been made over the past century—a trifling time period. If emissions from SN Ia are even slightly time-dependent this should be taken into account when calculating intergalactic distances because these distances and times are huge. We suggest the observed SNe Ia observations be analyzed at "face value" using a smoothly developing model of Universe expansion.

We propose a slight increase in emission frequency with increasing look-back time be energy independent and inversely time dependent. We suggest a relationship between frequency decline from singularity over time to account for this and show that SNe Ia data are well-modeled by a linear combination of the FRW model and energy-independent frequency incline without inclusion of a large term for vacuum energy. One outcome of our proposition is the requirement for a time-dependent Planck constant and we can only roughly estimate this underlying constant in terms of a constant of energy alone. We also present a related equation for the deceleration of frequency from singularity over time. When this relationship is evaluated at infinite time we discover frequency and time will eventually decouple.

2. THEORY

We must first present two propositions allowing formulation of a time-dependent, luminosity distance function. We base our model on two limiting situations; atomic frequencies have been invariant the past century and the Universe arose from a tiny singularity. We first propose emission frequencies increase with decreasing absolute time towards singularity and can be described as a time-dependent frequency change approaching space-time singularity.

We choose to explore a current slight frequency dependence upon time only, $d\nu/dt$. This time-dependence must be extremely gentle at present or it would already have been discovered during laboratory experiments. Atomic frequencies measure invariant the past century, which is consistent with this condition upon our model. The term $d\nu/dt$ is the simplest possible expression for a time dependence of frequency and is positive with lookback time and negative when forward pointing. Similar terms are commonly used to describe the remains of the thermal cooling and chemical reactions nearing equilibrium. It is well known that data in these nearly changeless regions, during processes such as cooling and approaching chemical equilibria, must be plentiful and very accurate if any estimate is attempted for describing initial conditions and the rapid changes immediately after reaction initiation.

Though declining with increasing time, frequency should also have an origin and to trace frequency backwards means towards singularity. The ultimate constraint upon wavelength approaching singularity is the tiny dimension of the Universe at origin; because wavelengths cannot be longer than the diameter of the Universe, all associated frequencies must have been enormous. This is the second limiting condition upon our model. Looking in the forward direction during the release of energy, wavelengths will increase and frequencies decline as occasioned by the expansion of space-time. So the situation describing frequency drop is similar to that of thermal cooling both in the beginning of high energy density and towards the end approaching equilibrium.

A means for defining frequency increasing at any time towards singularity, but not necessarily at singularity, is to make this change $d\nu/dt$ proportional to frequency over time, ν/t with the two terms above in the relationship related by a constant for generality as described by

$$d\nu/dt = U_{(t)}(\nu/t). \tag{1}$$

Here $U_{(t)}$ is similar to a conductivity constant and ν resembles the temperature difference between two states. The denominator t is absolute time between singularity and SN Ia emission and is extremely important at very short absolute times, where we predict $d\nu/dt$ was incredibly steep. At great times, as the present, the precise value for t tends towards unimportance. With absolute time in the denominator, (1) also resembles the decline in a potential inversely related to the distance between two objects, also analogous to thermal decline. This expresses the change in frequency as exceedingly mild in our mature cosmos but becoming drastic, when the Universe was young. It is important that (1) becomes undefined, but not necessarily infinite, at singularity because estimate of initial ν, as based upon the accuracy of present SNe Ia data does not allow an estimate of initial frequencies from data of our epoch. Such situations arise commonly in experiments of physical and chemical processes. Equation (1) should be considered an equation of the fundamental type, a broad description supported but never proven by situations and data and we will show that current SNe data well support (1) as a simple explanation. We suggest $U_{(t)}$ a dimensionless constant, to mean a relationship exists between singularity and frequency decline, and it will be shown to behave as a simple but necessary proportionality constant. Our present large value of time will not allow a confident prediction of U_t without many precise observations extending towards the distant past; the time-span of our local observations is short but the accuracy of our astronomical measurements, though very fine, are limited by both technology and interstellar phenomenon.

Examination of (1) suggests frequency decline approaches zero as time approaches infinity, according to (1) and is compactly expressed as

$$\lim_{t\to\infty} \delta\nu_{(t)} = 0. \tag{2}$$

In our local epoch, $t_0 \approx 4.3 \times 10^{17}$ s from singularity, $d\nu/dt$ is small, commonly and conveniently thought as zero. We will provide some more support for this notion later in this section.

For the energies of SNe Ia explosions to remain the same though all epochs but with varying emission frequencies we secondly propose the separations of microscopic atomic energy states are invariant with time and the allowed frequencies relating these states vary as smooth functions of time. According to current understanding, SNe Ia explosions occur within a small range of SN total mass over similar short times—no more than a few days—yielding equivalent light flux. So the total amount of matter converted to energy is constant via the same mechanism for all SNe Ia. If older, bluer SNe Ia released more radiant energy than recent SNe Ia the energies and perhaps even the mechanisms of thermonuclear reactions would be required to change with increasing lookback time, which is impossible. Light emitted from ancient SNe are the record not only of the location of this event but also the absolute time of the explosion; the photons suffer the inevitable red-shift (and energy loss) due to Hubble expansion, which complicates calculation of emission times.

Conservation of SN Ia dynamic output but increasing frequency with increasing lookback times requires a time-dependent constant of Planck. So we suggest the following limitation and will present justification for this later

$$\lim_{t \to 0} h_{(t)} = 0. \tag{3}$$

As emission frequency increases towards singularity the proportionality constant h approaches 0 and the value of h must also be time dependent. A consequence of the enormous present value of absolute time is the current rate of change of h being very mild. Frequencies immediately after the release of the Universe from singularity should have been unusual, for as h approaches 0 we expect the associated frequencies to become extreme, though residuals of this blur might be impossible to ever observe. Hence, a small h is consistent with short wavelengths. (The remnants of the cosmic microwave background radiation may be as close as we can possibly get towards observation of frequencies during the first moments of the Universe. These radiations are the artifacts of light some 300,000 years after singularity, drastically red shifted and quite uniform.)

Separating variables and integrating both sides of (1) gives us

$$\ln(\nu_1/\nu_0) = U_{(t)} \ln(t_1/t_0) \tag{4}$$

and raising both sides with the exponential and dropping the subscript from U yields

$$(\nu_1/\nu_0) = (t_1/t_0)^U. \tag{5}$$

While the frequency decline is presently small, the values of time are very large, so the proportionality constant, U, must be tiny on the scale of the universe and unfortunately difficult to measure. Equation (5) cannot be rationally evaluated, when t_1 and t_0 are 0 as expected at singularity.

First, converting frequency into red-shift z to compare with astronomical measurements we use the relationship

$$(\nu_1/\nu_0) = \frac{1}{1-z} \tag{6}$$

and we can substitute into (5) for the lookback direction for the proportion of the red-shift, which is time-dependent

$$\frac{1}{1-z} = (t_1/t_0)^U. \tag{7}$$

We will use $t_1 - t_0 = D_{L(\nu)}$ as the measure of the luminosity distance $D_{L(\nu)}$, which we define as that portion of the total D_L attributable to the higher frequency of emission at earlier times. We must also make an approximation that t_0 is a constant - true over the lifetime of earthbound observers. The total observed D_L as modeled from the observed red-shift is a linear combination of the astronomical distance from the emitter, which we define as $D_{L(d)}$ and the time dependent frequency difference, which is our $D_{L(\nu)}$ between the emitter and the observer. The total D_L using the red-shifts as the independent observable is the sum of these two terms

$$\mathrm{D}_L = \mathrm{D}_{L(d)} + \mathrm{D}_{L(\nu)}. \tag{8}$$

Because the Hubble law well describes recent SNe Ia (Riess *et al.*, 1995) the influence of $D_{L(d)}$ should be greater than $D_{L(\nu)}$ in (8) and we will only observe effects of $D_{L(\nu)}$ at great lookback times. The linear combination of terms allows (8) to be smooth and continuous over all space-time if both terms are such.

Solving for only the time-frequency dependent portion of (8) and isolating the frequency portion of the luminosity distance in a few steps

$$((t_0 + D_{L(\nu)})/t_0)^U = \frac{1}{1-z} \tag{9}$$

$$D_{L(\nu)} = t_0((1-z)^{-1/U} - 1). \tag{10}$$

This reduces to a $D_{L(\nu)}$ of 0, when z is 0—as it must for local emissions—but very unfortunately becomes undefined at $z = 1$. So we are forced to limit use of (10) away from $z = 1$, when in this form.

Second, we need to expand (10) to avoid drastic problems of evaluation, when z is close to 1 and find there are two useful, but only approximate solutions. So we have solved for the following expression with U $\neq 0$ and assuming locally constant t_0 and $z \ll 1$, the expansion is

$$D_{L(\nu)} \approx t_0 z/U + (t_0/2)(z/U)^2(1+U) + (t_0/6)(z/U)^3(1+U)(1+2U) + \cdots \tag{11}$$

the second expansion presumes $U \approx 0$, a locally constant t_0 and $z \ll 1$ and the first few terms are

$$D_{L(\nu)} \approx t_0 e^{z/U}(1 + (z^2/U)(1/2 + z/3 + z^2/4\ldots) + (z^4/U^2)(1/8 + z/6 + 13z^3/72\ldots)) - t_0. \quad (12)$$

We are aware of a third possible expansion for $z \approx 1$ but believe this not to be a useful approximation.

Third, another derivation of (5) can be made with some reasonable substitutions leading to a very interesting result. If we substitute E/h for ν_1 the emission frequency, we find a new energy-frequency relationship of a fundamental not previously thought to be time-dependent

$$E = h\nu_0(t_1/t_0)^U. \quad (13)$$

For times as short as the last century, with $t_1 \approx t_0$ this reduces to the familiar Planck–Einstein equation $E = hv$, where $h \propto (t_1/t_0)^U$. For longer lookback times than the past century we refer to our second proposition with Planck constant displaying a very weak time dependence and substitute the red-shift of ancient SN Ia explosions to yield

$$E = h_t\nu_0\left(\frac{1}{1-z}\right). \quad (14)$$

For the Planck constant to be smoothly declining with time we replace the term h_t by at least two terms and we choose energy, s and for time, t_1 the time at emission. This is the simplest manner of pseudoconstant separation we think useful, though other separations may be possible

$$st_1 = \frac{E(1-z)}{\nu_0}. \quad (15)$$

Equation (15) only holds for $z \ll 1$ and we substitute for t_1 and rearrange for an estimate of the new constant s for short lookback times

$$-D_{L(\nu)} = \frac{E(1-z)}{s\nu_0} - t_0. \quad (16)$$

A plot of $-D_{L(\nu)}$ versus $(1 - z)$ should yield a slope of $E/s\nu_0$(or h/s) with an intercept of $-t_0$. Equation (16) can only be evaluated for recent and small values of z; as z becomes large, $1 - z$ rapidly approaches 0. Errors of determination of D_L and hence $-D_{L(\nu)}$ are also magnified at large z, so this derivation does not appear useful for estimating our time from singularity. These relationships are also consistent with our second proposal, for while ν_0 is locally constant it does change proportionally with space-time, however, E remains constant for atomic transitions.

We have also examined possible solutions for tracing the acceleration of frequency increase with lookback time. Such a situation could be described by

$$\ddot{\nu} = Y_t(\nu/t) \tag{17}$$

where $\ddot{\nu}$ is the frequency acceleration and the right side is similar to (1), with Y_t being a constant with units of s^{-2}. Our justifications for introducing (17) are identical and consistent with those presented for (1), for (17) is but another fundamental equation describing the very same situation. This description of deceleration of frequency is also highly likely but undetectable in the laboratory or with current astronomy because of our extremely large absolute time. We shall continue with a solution of this equation to examine the boundary conditions and utilizing a few substitutions uncover an interesting situation. We rewrite this as

$$\frac{d}{dt}\left(\frac{d}{dt}\nu(t)\right) = Y_t\left(\frac{\nu(t)}{t}\right) \tag{18}$$

and substitute u^2 for t leading to

$$\frac{1}{2u}\frac{d}{du}\left(\frac{1}{2u}\frac{d}{du}\nu(u)\right) - Y_t\frac{\nu(u)}{u^2} = 0 \tag{19}$$

and with rearrangement this gives

$$u\left(\frac{d^2}{du^2}\nu(u)\right) - \frac{d}{du}\nu(u) - 4uY_t\nu(u) = 0. \tag{20}$$

We need to replace $\nu(u)$ with the proportional $uy(u)$ to give us the equation

$$u\frac{d}{du}\left(\frac{d}{du}(uy(u))\right) - \frac{d}{du}(uy(u)) - 4uY_tuy(u) = 0 \tag{21}$$

and with more rearrangement this leads to

$$u^2\left(\frac{d^2}{du^2}y(u)\right) + u\left(\frac{d}{du}y(u)\right) - (4u^2Y_t + 1)y(u) = 0 \tag{22}$$

and by substituting $x = 2Y_t^{1/2}u$ gives us the modified Bessel differential equation

$$x^2\left(\frac{d^2}{dx^2}y(x)\right) + x\left(\frac{d}{dx}y(x)\right) - (x^2 + 1)y(x) = 0. \tag{23}$$

Reversing the many substitutions we can rewrite the above into the Bessel form

$$\nu(t) = t^{1/2}[C_1I_1(2(Y_tt)^{1/2}) + C_2K_1(2(Y_tt)^{1/2})] \tag{24}$$

where I_1 represent a modified Bessel function of the first kind and K_1 of the second kind and C_1 and C_2 are constants. For the purposes of evaluation at the boundaries we can eliminate one constant by allowing a value for frequency $\nu(0) = \nu_0$ at $t = 0$ and take the limit of both sides

$$\lim_{t\to 0} \nu(t) = \lim_{t\to 0} t^{1/2}[C_1 I_1(2(Y_t t)^{1/2}) + C_2 K_1(2(Y_t t)^{1/2})] \tag{25}$$

$$\nu = C_1 \lim_{t\to 0} t^{1/2} I_1(2(Y_t t)^{1/2}) + C_2 \lim_{t\to 0} t^{1/2} K_1(2(Y_t t)^{1/2}). \tag{26}$$

Evaluating the first term as 0 to replace C_2 by other terms we find

$$\nu_0 = C_2(2Y_t)^{-1/2} \text{and } C_2 = 2\nu_0 Y_t^{1/2}. \tag{27}$$

So equality (24) can be rewritten without the second constant for the condition of $\nu(0) = \nu_0$

$$\nu(t) = t^{1/2}[C_1 I_1(2(Y_t t)^{1/2}) + 2\nu_0 (Y_t t)^{1/2} K_1(2(Y_t t)^{1/2})]. \tag{28}$$

We can evaluate this equation at the other boundary to eliminate the other constant, allowing $t \to \infty$ and only requiring that ν be a finite value at ∞. The evaluation of the first term above at this boundary is

$$\lim_{t\to\infty} I_1 = \infty C_1 = 0. \tag{29}$$

Which allows us to reduce our (24) to a single term

$$v(t) = 4\nu_0 K_1 Y_t t. \tag{30}$$

An extremely interesting result is predicted, when we again evaluate this relationship, now at $t \to \infty$ with $\nu(t)$ required to be of finite value

$$\lim_{t\to\infty} v(t) = \lim_{t\to\infty} 4\nu_0 K_1 Y_t t \tag{31}$$

and this reduces to the simple relationship at infinite time

$$\nu(\infty) = 0 \tag{32}$$

which is consistent with equality (2). At infinite time all frequencies will decline to zero as well as the rate of frequency decline.

We take this to mean that as the Universe continues to expand, frequency shall eventually become completely decoupled from time with no possibility for change of energy state, photon production or capture. This is equivalent to a gradual decoupling between energy and frequency due to the slow increase of Planck's constant, which is consistent with equality (3). Equation (32) is also compatible with many suggestions that the eventual fate of a "nonbouncing" Universe, being driven by entropy, is one of eventual dissipation towards an uninteresting state. It has been shown that the value for h is proportional to the dimensionality of space-time (Al-Jaber, 2003); lacking dimensions at singularity a value of 0 is expected for this constant, also supporting equality (3).

3. MODELS

The expression favored by many from a model considering homogeneous matter with radiant energy, space-time curvature and the cosmic constant is (2) of Riess *et al*. (1998)

$$D_L = \frac{c(1+z)}{H_0\,|\Omega_k|^{1/2}} \sin n \left\{ |\Omega_k|^{1/2}\, X \int [(1+z)^2(1+\Omega_m z) - z(2+z)\Omega_\wedge]^{-1/2} \right\} dz \tag{33}$$

where $\Omega_k = 1 - \Omega_m - \Omega_\wedge$ and sin$n$ is sinh for $\Omega_k \geq 0$ and sin for $\Omega_k \leq 0$ with integration limits from 0 to z where values for Ω_m and $\Omega_\wedge$ are normalized densities and Ω_k is space-time curvature (e.g. Kolb and Turner, 1990). An $\Omega_k \geq 0$ is usually considered indicating closed space-time, while $\Omega_k \leq 0$ indicates open space-time. For a flat Universe the pre-integral reduces to $c(1+z)H_o^{-1}$. Equation (33) is derived from what is termed the standard model, incorporating elements of matter with radiant energy together, with space-time curvature, and antigravity or vacuum energy, all as normalized terms. We use *vacuum energy* to describe this model (33).

To test our propositions we evaluated the matter dependent and curvature portions only of (33) for the $D_{L(d)}$ portion of (8), in linear combination with the expansions (11, 12) for the $D_{L(\nu)}$ portion of total D_L. For these models we let $\Omega_k = 1 - \Omega_m$ sin$n$ as above in the algebraic form

$$D_L = \frac{c(1+z)}{H_0\,|\Omega_k|^{1/2}} \sin n \left\{ 2 \left(\operatorname{arctanh}(\sqrt{1-\Omega_m}) - \operatorname{arctanh}\left(\frac{\sqrt{1-\Omega_m}}{\sqrt{1+\Omega_m z}} \right) \right) \right\} + (11). \tag{34}$$

Model 34a is above and *model 34b* is the above substituting with (12) and 34*c* substitutes with (10). Models 34 are continuous and smooth everywhere. For comparison we also tested the matter only portion of (33) without additions of (10, 11, 12)or the inclusion of terms for vacuum energy; this model reflects a matter, radiant energy and curvature only universe; *FRW matter only*. All data were weighed with respect to reported standard deviations and models were fit using the robust least squares method.

4. COMPARISONS OF MODELS USING SUPERNOVAE RESULTS

For evaluation of these new relationships we used the favored "gold," 157 data pairs of SNe Ia luminosity distances and red-shifts recently published as an internally consistent collection from many studies (Riess *et al*., 2004). These SNe Ia values have been selected by those authors after discarding data with $z < 0.01$ and pairs with extremely large errors about D_L and the data range from z of 0.0104 to 1.755. The effects of gravitational lensing and dust upon the long-traveling photon have been addressed (Tonry *et al.*, 2003) and probably skew the data in a similar manner for the models. A model of "*replenishing dust*"—which is postulated to continuously replenished at the same rate as dilution in the expanding Universe—was recently evaluated and also seems viable (Goobar *et al.*, 2002). We evaluated Ω_m of 0.20 to 0.30; the preferred values of Ω_m of 0.27 and $\Omega_\wedge$ of 0.73 have been reported and used here (Riess *et al.*, 2004). The preferred space-time geometry with $\Omega_k = 0$ of (Riess *et al.*, 2004), was used to fit the *vacuum energy model* while a closed geometry of space-time with Ω_k between 0.70 and 0.80 was allowed to float for fits with our model. We compared the goodness of fit using the special χ^2 statistic preferred by Riess and coworkers, which is a χ^2 statistic modified by the addition of a term in the denominator to account for dispersion in galactic red-shifts due to peculiar velocities and large errors in determination of red-shifts for some data pairs.

When tested with all 157 data pairs of the "gold" data, the values for χ^2 of *model 34a* is only slightly larger than the v*acuum energy* model and much smaller than the *FRW matter only* model. Inspection of the best fit lines for the v*acuum energy* and *model 34a* in Fig. 1, exhibit but slight differences up to z ≈ 1.25.

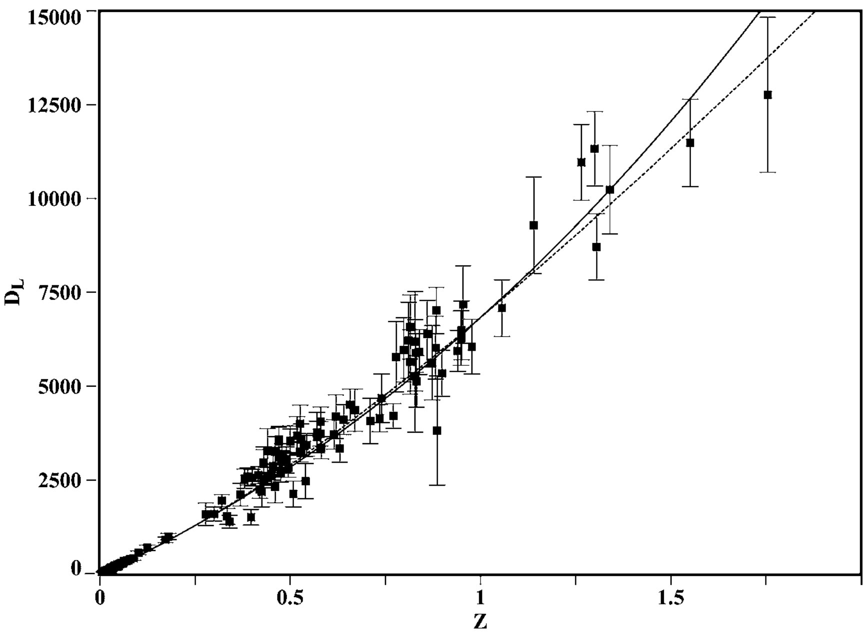

Fig. 1. D_L (Mpc) versus z. Best fits of all 157 SNe Ia used to fit the models with Ω_m of 0.27. Errors are single standard deviations and all fits were weighed with respect to errors. At right, top solid line, *model 34a*; bottom dotted line, *vacuum energy*.

Table I. Values from best fits of all SNe Ia data*

Model	Ω_m	χ^2	$H_0 (km\, s^{-1} Mpc^{-1})$
Vacuum energy	0.27	178	70
34a	0.25	182	78
34a	0.27	183	80
FRW matter only	0.27	206	65

*From Riess *et al.*, 2004; data set termed "gold" by those authors.

H_0 was found to be slightly larger for *model 34a* than for frequency independent models as expected because the Hubble expansion is corrected for the effect of the frequency-dependence of the observed red-shift, but within range of estimates of the Hubble constant (Freedman *et al.*, 2001) and the value for the unitless constant U, was found to be 13. One should remember that *model 34a* is an approximation necessitated by the $1 - z$ term in (10). The *replenishing dust* model fit slightly best by the measure of the smallest value for χ^2, 175, with $\Omega_m = 1.00$ and $\Omega_\wedge$ of 0.00 (Riess *et al.*, 2004). Our other approximation, *Model 34b* did not fit as well as *34a* (Table I).

To test *model 34c,* which is not an approximation, we reduced the data set slightly by examining all "gold" 144 data pairs between z of 0.01 and 0.90, avoiding the region immediately about z of 1 and the results are presented in Table II. Using goodness of fit as the guide, *models 34c* is a better fit than the v*acuum energy model* and both models fit the data significantly better than the *FRW matter only* model. Figure 2 presents the curves for both the v*acuum energy* and *model 34 c* for z between 0.01 and 0.90. For both models *34a* and *34c,* a matter density of Ω_m of 0.25 presented even better results with H_o well within the range currently thought important.

Table II. Values from best fits of all 144 SNe Ia data with z < 0.90*

Model	Ω_m	χ^2	$H_0 (km\, s^{-1} Mpc^{-1})$
34c	0.25	146	74
34c	0.27	147	73
Vacuum energy	0.27	153	69
FRW matter only	0.27	174	65

*From Riess *et al.*, 2004; data set termed "gold" by those authors.

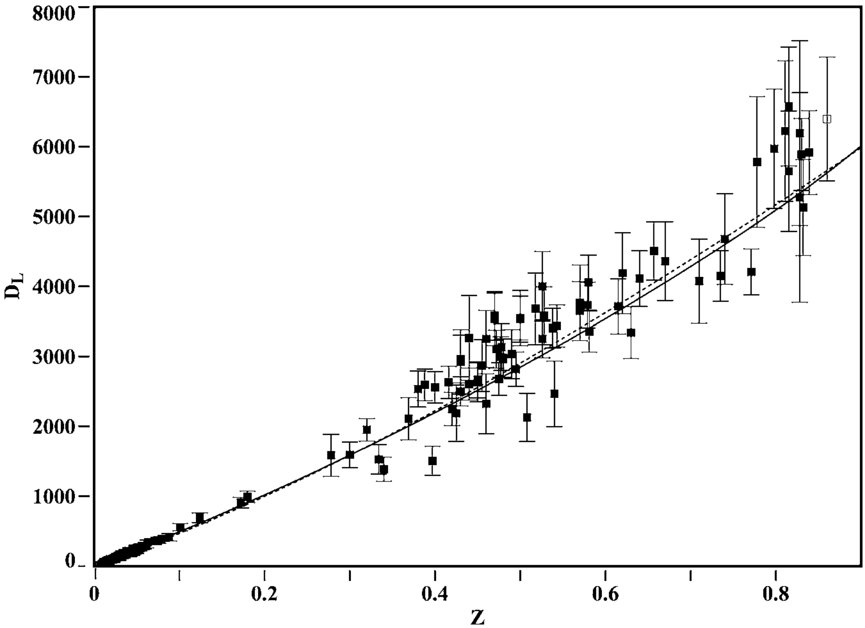

Fig. 2. D_L (Mpc) versus z. Best fits for all 144 SNe Ia used to fit the *model 34c* and v*acuum energy* model with Ω_m of 0.27. Errors are single standard deviations and all fits were weighed with respect to errors. Top dotted line, *vacuum energy;* bottom solid line, *model 34c*.

5. BENEFIT OF MODEL

There seems to be at least one benefit of evaluating SNe Ia data using the model; we can estimate the underlying constant of Planck, here termed s, within about 10%. For estimation of the local value of a drifting Planck's h, we used t_0 of 13.6 ± 0.2 Gyr for a flat universe as the initial estimate (Spergel *et al.*, 2003). From this values and an h of 6.63×10^{-27} erg-s we calculate an energy constant s of 1.5×10^{-44}ergs, with an uncertainty of at least 10% from the initial estimate of the Universe age (Freedman *et al.*, 2001).

6. CONCLUSIONS AND SUGGESTIONS

Recent experiments matching SNe Ia distances and red-shifts allow us to view our past several billion years with some precision for the first time. While it is reasonable to assume most relationships of physics applied then as well as now, we have no guarantee that past frequencies relating atomic transitions were identical to present. If not, we should expect some observations from antiquity to drift from expectation. Though the calculation of the red-shifts of ancient objects seems straightforward this assumes ancient emission frequencies were identical to present, which has never been unequivocally shown true. We suggest the slight increase in frequency retreating towards ancient times may model SNe Ia data as well as inclusion of a large cosmological constant. A tiny, time-dependence of z and h could probably not be discovered but by experiments over such large times and it will be interesting to see if future data from SNe Ia continue to follow the trend observed these past years. We will need hundreds or thousands more data pairs from many telescopes to discriminate between our model and models incorporating vacuum energy or replenishing dust, especially if errors of D_L cannot be dramatically reduced.

We do hope astronomers can reduce the errors about D_L to equivalency with current errors of z. This will allow solution of z as a function of D_L, which is necessary for proper evaluation of models with $(1 - z)$ terms. We suggest a predictive model for space-time-frequency with z as a function of D_L and dependence upon absolute time, t_0 as

$$z = (H_0 D_L \Omega_m)/2c + (2 - \Omega_m)((1 + 2H_0 D_L/c)^{1/2} - 1)/2 \\ - \{1 - (t_0/(D_L + t_0))^U\}. \tag{35}$$

Equation (35) presumes $1 = \Omega_m + \Omega_k$ and other terms as previous; this relationship is well-defined and not zero except at the origin. The last term may not introduce difficulties if U is estimated to be small. Numerical methods will have to be used to solve an equation analogous to (35), but including terms to represent vacuum energy and will be considerably more complicated.

We cannot imagine any violation of natural laws with a time-dependent h, because h is a proportional measure of allowed energy transitions and the value has not been derived. A slight increase of h with time would not inconvenience any laboratory experimentation or calculations for experiments over short times. Likewise, we think the time-dependence of Planck's h much too small to add noise or complicate any local experiment and will continue to go undetected by laboratories. Recent theory also suggests that h is dimensional dependent and consistent with becoming quite small at singularity (Al-Jaber, 2003). A review of current understanding of the first moments of the universe to one second failed to include direct reference to the Planck constant, so frequencies associated with energy level separations may be rather unimportant until later (Schwarz, 2003).

Our model might also be considered conservative because our calculations do not attribute special properties to space-time and fits best with closed geometry; both preferred by Einstein (1916). Of course one does not really know how large a value for Ω_k is necessary for detection of space-time curvature (Stelmach, 1999). We do not anticipate creating problems for those formulating scenarios of the first moments of the Universe either, for a drastic frequency decline accompanying the early Universe expansion need not effect conservation of energy, charge, particle synthesis and space-time expansion.

The SNe Ia experiment seems to us to be analogous to an enormous cyclotron where time is the variable replacing energy and is controlled by selection of SNe Ia. Just as numerical values for our current proportionalities have been refined through laboratory experimentation, the minute values of subconstants might be refined through improved astronomical technology. It may also be possible to prove or disprove (1, 3, 8, 17, 32) and our propositions in our lifetimes, but only through evaluation of the usefulness of these relations will we understand if these are worthwhile. Another interesting point is that (13) implies every photon emitted contains a tiny record of our time from creation, so photon propagation not only evidences a point of origin but also the time in space-time.

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