The Explanation of the New Astronomical Distance Data That Has Resulted From Measurements of Type Ia Supernovae Lies Not In a Cosmological Constant and Accelerating Expansion; Rather, It Is Another Aspect / Effect of the General Exponential Decay of the Overall Universe.

Roger Ellman

Abstract

In the Hubble model of the universe, the distance to far distant sources is determined from the redshift, from which the speed of recession, v, [the redshift being deemed due to its Doppler effect] and then the distance $^{V}/_{H}$ [where H is called the Hubble constant] are determined.

Recently it has become possible to determine the distance to Type Ia supernovae by other independent means.[1,2] The intrinsic brightness [luminosity] of such supernovae is related to the pattern [light curve] of their flare up and back down, a process taking weeks. By comparing the intrinsic brightness, determined from that pattern, to the observed brightness the distance can be determined from the inverse square law.

Those new distance determinations exceed the Hubble distance by 10 - 15%. The explanation others propose is that an "antigravity effect" is accelerating the universe' expansion, which had hitherto been thought to be slowing down because of gravitation. That has led to their proposing reinstatement of Einstein's "cosmological constant", a term in his equations introduced to account for gravitation not promptly collapsing the universe and which he disavowed upon Hubble's discovery of the expansion of the universe. And that has further led to their proposing some form of the Ancients' fifth essence, quintessence [the first four being earth, air, fire and water], to account for the "antigravity effect".

Any "antigravity effect", regardless of its cause, would have the effect of counteracting ordinary gravitation. Inasmuch as one of the major current problems in cosmology is to identify more gravitation to account for the cosmos's large scale structure and galaxies' centrifugal force, any "antigravity effect" to act as the cause of acceleration would not appear to fit with the rest of the cosmological situation.

An alternative explanation is presented -- the general exponential decay of the overall universe, which has been analyzed and developed in several papers.[3,4,5,6] The universal decay accounts for the greater distances and the necessary cosmic energy without the challenge to theory and to reasonableness that acceleration, its unknown cause, and a cosmological constant involve.

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Background of the Problem

[While unnecessary for astronomers and astrophysicists this review is included for the benefit of other scientists, who may not be familiar with the details of the development, details which are essential to understanding the issues.]

The, for years generally accepted, Hubble astronomical model of the universe is of a uniformly expanding cosmos in which all galaxies are moving apart so that their speed away from us is proportional to their distance from us, the constant of proportionality being called the Hubble Constant, H. Until recently the distance to far distant such bodies has been determined by measuring the redshift, deemed a Doppler effect. From that one obtains the speed of recession, v, and then the distance $^{V}/_{H}$.

Recently it has become possible to determine the distance to far distant galaxies by an alternative independent means based on observations of Type Ia supernovae in those galaxies.[1,2] It has been found that the intrinsic brightness [luminosity] of such supernovae is related to the pattern [light curve] of their flare up and back down, a process taking weeks overall. By comparing the intrinsic brightness, as determined from that pattern, to the observed brightness the distance can be determined from the inverse square law.

Those new distance determinations indicate distances exceeding the Hubble model distance by 10% to 15%. The interpretation of that result as proposed by the researchers who developed the data and others is that some "antigravity effect" is accelerating the universe's expansion, which expansion had hitherto been thought to be slowing down because of gravitation. That "antigravity effect", by default, would have to be a property of the empty space, the vacuum, of the universe since it is certainly not a property of the matter.

That line of thought has led to the reinstatement of Einstein's "cosmological constant" a term in his equations that he introduced to account for the universe not promptly collapsing due to gravitation and which he later disavowed upon Hubble's discovery of the expansion of the universe.

Those implications are so unsettling to theory and to reasonableness that the data had been initially deemed in error. As a result there have been extensive analyses of sources of error and measurements have been taken on a large enough number of Type Ia supernovae to be statistically significant all with the conclusion that the new distance measurements are valid and that theory must be adjusted accordingly.[1,2]

But, there is an explanation of the data alternative to that of accelerating expansion, one that carries considerably less challenge to theory and negligible challenge to reasonableness -- the general exponential decay of the overall universe, which has been analyzed and developed in several papers. [3,4,5,6] Exponential decay is found throughout nature so that overall decay of the universe is not unreasonable.

The universal decay accounts for the observed greater distances [and shows that they are actually greater than the reported measurements indicate] and provides the necessary cosmic energy without employing an arbitrary "cosmological constant", a new "quintessential" substance, and "an antigravity effect", which are otherwise unknown, unsupported by theory, and contrary to all other data and experience.

The General Universal Decay

The theory of the general exponential decay of the overall universe is derived and developed in *The Origin and Its Meaning*.[6] The decay is of the same form as the myriad exponential decays found throughout nature because all such decays are aspects of the general solution to the 2nd order linear differential equation with constant coefficients. The universal decay is decay of the quantities that we refer to as the fundamental constants, c, h, q, G, and so forth, essentially a decay of the fundamental substance(s) of material reality.

The values of these fundamental constants are the same everywhere in the universe at any instant of time. The decay means that they are everywhere uniformly and consistently exponentially decaying with time. The requirement that the laws of physics and their fundamental constants be the same everywhere in the universe [Einstein's "invariance"] includes within it the decay processes acting consistently everywhere.

These fundamental constants interact through the various physical laws of nature and, therefore, the decay of each constant must be consistent with the decays of all of the others. Analysis of all of the implications of that requirement shows that the decay is of the length dimensional component of those constants. That is, from among the fundamental dimensional components length $[L]$, mass $[M]$ and time $[T]$, it is length $[L]$ that is in decay. That develops as follows.

The decay being an exponential function the independent variable of which is time, t, as in for example equation 1, it cannot be the time dimensional component, $[T]$, that is decaying.

$$(1)\qquad c(t) = c_0 \cdot \varepsilon^{-t/\tau}$$

Furthermore, mass and time are closely interrelated as in equation 2,

$$(2)\qquad h \cdot f = E = m \cdot c^2$$

so that if mass, $[M]$, were to decay it would imply that frequency decays and that time, $[T]$, the inverse of frequency, inversely decays, which the independent variable cannot do. That leaves only the length component, $[L]$ to be the dependent variable in the decay.

Equation 2 also illustrates another point. Planck's constant, h, appears in the equation with an exponent of 1 whereas the speed of light, c, appears with an exponent of 2. For the two decays, that of h and that of c, to be consistent their time constants must be different. Planck's constant, h, must decay twice as rapidly as the speed of light, c; its time constant, τ_h, must be half that of light, τ_c. That is,

$$(3)\qquad \left[\varepsilon^{-t/\tau_h}\right]^1 = \left[\varepsilon^{-t/\tau_c}\right]^2 \text{ for consistency of the decays,}$$

$$\therefore \tau_h = 0.5 \cdot \tau_c$$

The time constant of the general exponential decay of the overall universe is derived and calculated in *The Origin and Its Meaning.*[6] The value for c, the "fundamental" value as compared to that for, for example, $h = {}^1/_2$ of that for c, is

(4) $\tau_c = 3.57532 \cdot 10^{17}$ s = about 11.3 billion years
"c" dimensions are $\mathbf{L^1}/_T$

The values for other constant's decays are the appropriate multiple or sub-multiple of the value for c. For example:

(5) $\tau_h = {}^1/_2 \cdot \tau_c = 1.78766 \cdot 10^{17}$ s = about 5.65 billion years
"h" dimensions are $M \cdot \mathbf{L^2}/_T$

$\tau_G = {}^1/_3 \cdot \tau_c = 1.19177 \cdot 10^{17}$ s = about 3.77 billion years
"G" dimensions are $\mathbf{L^3}/_{M \cdot T^2}$

The first definitive experimental observation of this decay [although it remained unrecognized at the time] was in the tracking of the Pioneer 10 and 11 satellites. The observations were reported in 1998 in *Indication, from Pioneer 10/11, Galileo, and Ulysses Data, of an Apparent Anomalous, Weak, Long-Range Acceleration.*[7] and were further analyzed in 1999 in *The Apparent Anomalous, Weak, Long-Range Acceleration of Pioneer 10 and 11.*[8] These reported that a weak long-range acceleration towards the Sun has been observed in the Pioneer 10 and 11 satellites for which no satisfactory explanation had been obtained in spite of diligent efforts by a number of parties, for which reason it was described as "anomalous".

The interpretation of the anomalous acceleration as being a direct effect of the universal decay was presented in *Exponential Decay of the Overall Universe is the Cause of "The Apparent Anomalous, Weak, Long-Range Acceleration of [the spacecraft] Pioneer 10 and 11".*[5] Decay in the gravitational acceleration, a_G, acting on the satellites and due to the Sun means that a_G was greater in the past, which means that the satellites were slowed more in the past than we now would expect in terms of the current value of a_G. That effect is the "anomalous acceleration" toward the Sun.

The time constant for this decay, $\tau_{a,G}$, is as given in equation 6.

(6) $\tau_{a,G} = \tau_c = 3.57532 \cdot 10^{17}$ s = about 11.3 billion years
"a" dimensions are $\mathbf{L^1}/_{T^2}$

For that the corresponding [that is the decay-related] acceleration toward the Sun is $8.38505 \cdot 10^{-8}\ {}^{cm}/_{s^2}$ (the observed value was reported as $8.5 \cdot 10^{-8}\ {}^{cm}/_{s^2}$ including other secondary effects) and the anomalous frequency drift, stated as clock acceleration, is $2.79695 \cdot 10^{-18}\ {}^{s}/_{s^2}$ (the observed value was $2.8 \cdot 10^{-18}\ {}^{s}/_{s^2}$).

While this was the first definitive, although not then recognized, experimental observation of the decay, every redshift measurement is a partial such observation. That is, the decay in the speed of light, c, means that the light from far distant sources, which we now observe a long time after it was emitted, was emitted at a larger value of c than the value we know now. That greater speed means that the wavelengths all are longer, are redshifted as we perceive them.

Furthermore, the more distant the source the earlier its light was emitted and the less decayed is the light's speed. That means that the greater the [decay-caused] redshift the more distant the source is. That relationship is non-linear as is the exponential decay function and unlike the Hubble model linear relationship.

However, the sources of such light are, nevertheless, moving away from us so that there is also some Doppler effect. The redshifts that we observe are a combination of Doppler and decay effects.

The analysis of the universal decay in *The Origin and Its Meaning*.[6] addresses the problem of determining what part of the observed redshifts is due to the Doppler effect and what part to decay. The results are that the Doppler-caused part of the redshifts could not be more than 10% of the total redshift and is more likely on the order of only 1% or less. The remainder of the observed amounts of redshift, 90-99% of them, are due to the universal decay of the speed of light. The reasons for this are as follows.

At the Big Bang the material of the universe was thrust rapidly outward in all directions. Since then the mutual gravitational attraction of all of that material has been slowing it all down. The amount of the gravitational slowing is inversely proportional to the square of the distant between the mutually attracting bodies. Starting at a very large speed the distance of separation increased rapidly, meaning that the slowing was rapidly reduced. Therefore, most of the slowing, most of the speed loss, had to occur early after the "Big Bang".

A very large part of the slowing must have taken place by the time the earliest galaxies formed, about $2^1/_2$ to 3 billion years after the "Big Bang". Even if the initial speeds of those earliest galaxies immediately after the Big Bang were almost the speed of light, c, their speeds $2^1/_2$ to 3 billion years later could not have been more than $^1/_{10}$ as much, $^c/_{10}$, and more likely were on the order of $^c/_{100}$, or less.

Since of the observed amounts of redshift, 90-99% is due to the universal decay of the speed of light it is within the precision of the Type Ia supernovae data to deem the redshifts to be dominantly due to universal decay.

Application to the Type Ia Supernovae Observations

The values of the fundamental constants c and h in the light, emitted long ago, that we now observe from a far distant astronomical source are much less decayed than our local here, now values of those constants. That is, the light travels at a much greater speed than the c that we know and its photons carry much greater energy for each same frequency than the $E = h \cdot f$ amounts that we know, meaning that they appear more luminous to us. Both constants are actually greater than, greater relative to, the values, the standards that we inherently use, directly experience, and in terms of which we interpret that ancient light -- the values to which those constants have currently decayed, "our" values.

Because that light that we observe from a far distant astronomical source is traveling faster, its source is farther away from us than we deem based on our understood speed of light. For example, the situation for a source the light from which is 5 billion years old when it reaches us is as follows.

```
(7)    As we perceive it:
             distance = [age] · [our value of c]
                      = 5 billion (our) light years
       As it really is:
             distance = [same age] · [155% of our value of c]
                      = [155% of same age] · [our value of c]
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= 7.75 billion (our) light years
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That would tend to make the apparent, the observed, luminosity of the source appear less to us by the factor $[^5/_{7.75}]^2 = 0.416$ because of the inverse square effect. However, that same light that we observe from its far distant astronomical source also carries a larger value of Planck's constant which makes its intrinsic luminosity greater. For example, the situation for the same source the light from which is 5 billion years old when it reaches us is as follows.

```
(8)    As we perceive it:
             luminosity = per our Planck's constant
       As it really is:
             Luminosity = 242% of per our Planck's constant
                        = 2.42 · [As we expect it]
```

That would tend to make the apparent, the observed, luminosity of the source appear greater to us by the factor 2.42. The combined effect of the two, the reduction due to greater distance, greater c, and the enhancement due to larger Planck's constant, h, is for the present example as follows.

```
(9)    Net combined effect on perceived luminosity =
             = 0.416 · 2.42
             = 1.00
```

There is not net change in the perceived brightness, the inverse square effect of greater distance being exactly cancelled by the effect of greater intrinsic luminosity.

However, in the case of the Type Ia supernovae experiments, the subject of this paper, the situation is not the same. In those experiments, as reported in the papers[1,2], the relationship between intrinsic luminosity and the light curve [flare up and back down pattern] of Type Ia supernovae was calibrated by observations on relatively near sources. It is that calibration which is in error, error caused by the [unknown to the experimenters] effects of the general universal decay of the constants c and h. That error develops as follows.

The distances were determined by means of data on Cepheid variable sources. As described in the paper[1],

> "The relative luminosities of this "training set" of SNe Ia were calibrated with independent distance indicators (Tonry 1991; Pierce 1994). The absolute SN Ia luminosities were measured from Cepheid variables populating the host galaxies (Saha, et al. 1994, 1997)."

[Again for the benefit of non-specialists in astronomy or astrophysics] Cepheid variables cyclically vary in brightness with regular periods ranging from less than 1 to about 100 days. In 1912 a relationship [since improved] between the period and the brightness of Cepheids was discovered. Using Cepheids near enough that their distance could be measured by triangulation, the brightness - period relationship for Cepheids was calibrated. With that calibration, the distance to more distant Cepheids could be determined by comparing the observed brightness with the intrinsic brightness calculated from the Cepheid's period and applying the inverse square law.

The calibration of Cepheids by triangulation means that the source stars were so near that the [very large time constant] universal exponential decay had negligible effect - the source stars were essentially contemporary. Therefore, Cepheid determined distances take no account of the universal decay.

A distant Cepheid has a greater intrinsic brightness as compared to a quite near but otherwise identical Cepheid because the h of the light from the distant Cepheid is larger than the h of the light from the quite near Cepheid. The distant Cepheid's actual distance is also greater because the c of its light is greater. Its light has traveled the time corresponding to the redshift but at a greater speed so that its source's distance must have been greater. As in the hypothetical example of equations 7 - 9, the two effects cancel out. Its observed brightness is unaffected by the decay.

For the calibration of the Type Ia Supernovae light curves by observations on relatively near sources at redshifts in the range $z = 0.01$ *to* 0.08 the actual distances to those sources were as follows.

(10) The relationship between the effect on the observed wavelength due to exponential decay vs the Doppler effect is as follows [neglecting the minor residual Doppler part in the exponential decay case].

Exponential Decay

$$\frac{\lambda_{t=T}}{\lambda_{t=0}} = \varepsilon^{-T/\tau}$$

Doppler Effect

$$1 + z = \frac{\lambda_{\text{obs } v=V}}{\lambda_{v=0 \text{ source}}}$$

where

$\lambda_{t=T}$ corresponds to $\lambda_{v=0 \text{ source}}$

$\lambda_{t=0}$ corresponds to $\lambda_{\text{obs } v=V}$

therefore

$$1 + z = \frac{\lambda_{t=0}}{\lambda_{t=T}} = \varepsilon^{+T/\tau}$$

$$\ln[1 + z] = {}^{T}/_{\tau}$$

$$T = \tau\cdot\ln[1 + z] = \text{Distance in Light-time}$$

The relationship between the initial and final values of a quantity that decays exponentially over a time interval, T, with a decay constant, τ, is as follows.

(11) $$c(T) = c(0)\cdot\varepsilon^{-T/\tau} \quad \text{or} \quad c(0) = c(T)\cdot\varepsilon^{+T/\tau}$$

(12) For the relatively near sources used for calibrating the Type Ia Supernovae light curve vs luminosity.

z	Eq 10: T = $\tau\cdot\ln[1+z]$	D_1 @ c(T)≡ Current *c*	D_2 @ c(0) ≡ Actual [Less-Decayed] *c*	$^{D_2}/_{D_1}$
0.01	0.11	0.11	0.11	1.01
0.02	0.23	0.23	0.23	1.02
0.03	0.34	0.34	0.35	1.03
0.04	0.45	0.45	0.47	1.04
0.05	0.56	0.56	0.59	1.05
0.06	0.66	0.66	0.70	1.06
0.07	0.77	0.77	0.82	1.07
0.08	0.88	0.88	0.95	1.08

where:

τ = 11.3 billion light years

T is in billions of years

D is in billions of light years

And (from the distribution of the data points):

typical z ≈ 0.04; high z ≈ 0.07
typical T ≈ 0.45; high T ≈ 0.77

The corresponding data and calculations for the distant sources, which are the ultimate subject of the papers at issue[1,2] and of the theoretical interpretation being corrected, are as follows.

(13) For the distant sources being investigated.

z	Eq 10: T = $\tau \cdot \ln[1+z]$	D_1 @ $c(T)$= Current ***c***	D_2 @ $c(0)$ = Actual [Less-Decayed] ***c***	D_2/D_1
0.40	3.84	3.84	5.38	1.40
0.45	4.24	4.24	6.15	1.45
0.50	4.62	4.62	6.93	1.50
0.55	5.00	5.00	7.75	1.55
0.60	5.36	5.36	8.58	1.60
0.65	5.71	5.71	9.42	1.65
0.70	6.05	6.05	10.29	1.70
0.75	6.38	6.38	11.17	1.75
0.80	6.70	6.70	12.06	1.80

where (from the distribution of the data points):
typical z ≈ 0.55; high z ≈ 0.75
typical T ≈ 5.00; high T ≈ 6.38

To trace the effects of the universal exponential decay as it causes deviations of results in observations of distant Type Ia Supernovae from as they would otherwise be in the absence of the decay, the effects on the cases corresponding to the above cited typical values are analyzed below. The actual investigations presented in the papers[1,2] were of a statistically significant number of such determinations on specific Type Ia Supernovae, the set approximately averaging the typical values above. The analysis process is as follows.

A. The effect of *c* decay on the "training" Cepheid

A Cepheid variable is identified in the host galaxy of one of the relatively near "training" Type Ia Supernovae and its distance is determined according to the usual Cepheid distance scale. That is, its intrinsic brightness is determined from its variation period and its observed brightness is noted. From those its distance is inferred from the inverse square relationship.

That distance to the Cepheid is then assigned or designated as the known distance to the "training" SN Ia.

In the light from that Cepheid both its *c* and its *h* are greater than our contemporary values. The greater *c* means a greater distance and greater inverse-square dimming of observed brightness. The greater *h* means greater photon energy and an enhancement of observed brightness. As in the hypothetical example of equations 7 - 9, the two effects exactly cancel. The resulting observed brightness of the Cepheid is the same as would be the case in the absence of universal decay. The resulting distance determination to the Cepheid is, in that sense, unaffected by the universal decay.

However, from equation 12 that distance is moderately incorrect. That is, the calibration of the Cepheid "yardstick" on stars near enough for distance measurement by triangulation takes no account of the universal decay and the related actual progressively greater distances of more distant sources.

The correct distance to the typical Cepheid and the correct deemed distance to its companion "training" SN Ia, for a typical value and a high value, respectively, of those reported in the papers[1,2] and so noted in equation 12, is about 4.2% - 7.5% greater. The intrinsic brightness of the typical "training" SN Ia, inferred from its observed brightness and the Cepheid-determined distance, will be overstated [due to that cause, alone] over its actual intrinsic brightness by about 8.5% - 15.6% because of being inferred using too small a distance. That is, the affect of the distance on brightness is as the inverse square of the distance so that $[1.00/(1.00-0.04)]^2 = 1.085$ and $[1.00/(1.00-0.07)]^2 = 1.156$.

B - The effect of *c* decay on the "training" Type Ia Supernova

The observed brightness of the "training" SN Ia is noted. That in conjunction with its distance [from Step A] makes it possible to calculate the intrinsic brightness of the "training" SN Ia using the inverse square relationship. However, the above-described understatement of the Cepheid's distance and, therefore, of the "training" Type Ia Supernova's distance by about 4.2% - 7.5% therefore overstates the "training" SN Ia's intrinsic brightness by about 8.5% - 15.6% due to the effect of c decay, alone.

That intrinsic brightness is correlated with the "training" SN Ia's light pattern, which completes the calibration of the SN Ia. However, there is a further effect on the SN Ia.

C - The effect of *h* decay on the "training" Type Ia Supernova

As in the hypothetical example of equations 7 - 9, the combined effects of the c decay and the h decay on the observed brightness of the SN Ia exactly cancel; the observed brightness is independent of the decay. However, while both distance and intrinsic brightness affect observed brightness, distance has nothing to do with intrinsic brightness; the intrinsic brightness simply is what it is; it is intrinsic to the source. [The determining of intrinsic brightness in some cases by inference from observed brightness and distance is not the same thing.]

The "training" SN Ia's intrinsic brightness is greater [than expected in the absence of knowledge of the universal decay] because its h is greater and greater h means greater photon energy, which enhances brightness. This excess brightness is calculated using the decay time constant for Planck's constant, which is half that for the speed of light; $\tau_h = 0.5 \cdot \tau_c = 5.65$ billion light years. Per equation 11 and using $T = 0.50$ and $T = 0.77$ [equation 12 typical and high values, respectively], the result is as follows.

$$(14) \qquad c(0)/c(T) = \varepsilon^{+T/\tau} = \varepsilon^{+0.50/5.65} = 1.093$$

$$= \varepsilon^{+0.77/5.65} = 1.146$$

That is, taking account of h decay the "training" SN Ia's intrinsic brightness is about 9.6% - 14.6% more, due to this effect alone. That means that its observed brightness is likewise that much greater due to taking account of the h decay, which means that the calibration of Step B, above further overstates the calibration that much.

D - The resulting "training" calibration

The calibration of intrinsic brightness versus light curve for Type Ia Supernovae obtained from the "training" set overstates the intrinsic brightness by 8.5% - 15.6% due to distance deviation, Step B, and by 9.3% - 14.6% due to brightness deviation, Step C, which combined is the range from $1.085 \cdot 1.093 = 1.185$ or 18.5% to $1.156 \cdot 1.146 = 1.325$ or 32.5% overstatement of brightness.

E - The distant Type Ia Supernova independent distance determination

Armed with the SN Ia Light Curve vs Intrinsic Brightness relationship, the investigation shifts from the "training" to the far distant SN Ia sources of interest. A distant Type Ia Supernovae is studied and its intrinsic brightness is developed based on its light curve. Its observed brightness is noted. Based on those two datums its distance is inferred from the inverse square relationship.

> In the light from that SN Ia both its c and its h are greater than our contemporary values. The greater c means a greater distance and greater inverse-square dimming of observed brightness. The greater h means greater photon energy and an enhancement of observed brightness. As in the hypothetical example of equations 7 - 9, the two effects exactly cancel. The observed brightness is not affected by the decay in that sense. However, the intrinsic brightness, obtained from the light curve, is overstated as at Step D. Per the inverse square relationship, that corresponds to the SN Ia appearing to be at a greater distance by
>
> from: the square root of 1.185, equals 1.089, or about 8.9%
>
> to: the square root of 1.325, equals 1.151, or about 15.1 %
>
> farther away then expected.

E - The distant Type Ia Supernova "expected" distance determination

The "expected" distance, is determined by identifying a Cepheid variable in the host galaxy of the SN Ia and attributing its distance to the SN Ia, also. In this case no deviation due to the universal decay is applicable because the "expected" distance means that found per the usual methods and with no knowledge of the decay.

F - Overall results

The "expected" distance being unchanged and the light curve derived distance being overstated by 9 - 15% results in a total distance deviation from the "expected" of 9 to 15 %.

> That is what accounts for, what produces, the observation reported in the abstract to astro-ph 9805201[1] that "The distances of the high-redshift SNe Ia are, on average, 10% to 15% farther than expected...."

Because the effects of c and of h decay combined leave observed brightness unchanged it would appear that the decay has no effect on the observation of SN Ia light curves. The analysis of the light curves involves several sophisticated aspects so that the possibility of a decay effect cannot be ruled out.

Actual Distances and Conclusion

From equation 13 at values typical of those reported in the papers[1,2] and so noted in equation 13, the correct distance [due to a somewhat greater value of c] is actually about 45% greater than the expected. These actual greater distances [and, of course, the reported 10% to 15% greater distances] do not result from acceleration of expansion, nor an "anti gravity effect", nor a cosmological constant. Rather the Big Bang product particles were not limited to our value of the speed of light. The limit back then was much larger. If the present age of the universe is about the 30 billion years [somewhat over 2.65 time constants of the speed of light decay] calculated in *The Origin and Its Meaning*.[6] based on the universal decay, then the original value of c was 14.2 times greater than today's value, as follows.

(15) $$c(0) = c(T)\cdot\varepsilon^{+T/\tau} = c\cdot\varepsilon^{+30/11.3} = 14.2\cdot c$$

While the universal decay accounts for the Type Ia Supernovae observations in a reasonable way, the concept proposed by others that expansion of the universe is accelerating, rather than decelerating as has been thought, has problems of consistency with the rest of cosmology. Any "antigravity effect" to account for acceleration of expansion of the universe, regardless of its cause, would have the additional effect of counteracting ordinary gravitation. Inasmuch as one of the major current problems in cosmology is to identify more gravitation to account for the cosmos's large scale structure and galaxies' centrifugal force, any "antigravity effect" to act as the cause of acceleration would not appear to fit with the rest of the cosmological situation.

The greater distances and greater energy disclosed by the SNe Ia studies are the result of greater initial and then decaying speeds and the much greater values of Planck's constant at the time of the Big Bang and during decay after.

Actions Needed to Complete the Verification of the Universal Decay

The universal decay can be verified and further investigated by conducting two experiments set forth in *The Origin and Its Meaning*[6]; the measurement of the value of each of the two fundamental constants, c and h, directly as they are in the light from far distant astronomical sources. The measurements must be of the actual light emitted long ago from a far distant astronomical source, not local, just emitted, light.

The measurements must directly measure the constant sought; they cannot be a measurement of other quantities with the calculation of the fundamental constant using laws of physics relating the quantities. For example, in the usual determinations of the values of the various fundamental constants Planck's constant is not directly measured. Rather its value is inferred from other measurements [e.g. the Rydberg constant] and calculated via other formulations [e.g. the fine structure constant]. Such indirect procedures may not give correct results in the present experiments.

The expected results of the experiments are given in Figure 1, below, which gives the multiples of our contemporary value of the constants c and h that are expected to be found in light that was emitted at various times in the past.

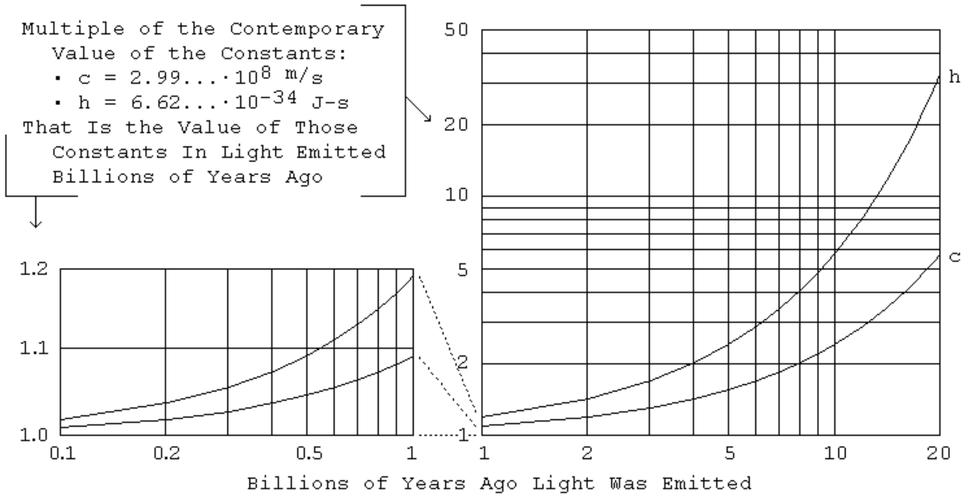

Figure 1

Measuring The Speed of Light, *c*

Modern measurements of the speed of light are done by measuring certain frequencies and wavelengths that are measurable with very great precision, c being the product of a frequency and its related wavelength. To measure the speed of ancient light from far distant sources the product of frequency and wavelength is useless. We already know that the wavelength is significantly different from that in our local light, the difference being the redshift. If that redshift were entirely due to universal decay then the frequency-wavelength product would give the correct speed, but at least some of the redshift is due to the Doppler effect [on the order of 1% - 10%].

The data of interest is a comparison of the c in ancient light with that in contemporary light. That can be determined by an interferometer type measurement such as those of Michaelson / Pease and Pearson using the Foucault method. In those revolving mirrors or a toothed wheel were used to break a monochromatic [single frequency] light beam into segments. The beam was then split into two beams which were directed over two different paths of known length and then recombined. If the speed of travel over the two paths were the same then the recombination would produce a perfect overlap of the waves, but if it were different the difference would show in the resulting interference wave pattern.

To compare far distant ancient light against contemporary local light the interference must be generated between a single frequency of the ancient light [as selected by a spectroscope, one of the lines of the distant source's line spectrum being selected] and a beam of local light [the same frequency line as in the ancient light spectrum being spectroscopically selected], no beam splitting being involved. As indicated in the sample data above, the speed difference of the two light beams will be large and the resulting interference pattern will be accordingly.

Measuring Planck's Constant, *h*.

Planck's Constant, h, can be directly measured using the photoelectric effect. Figure 2, below, illustrates the photoelectric effect and its relationship to Planck's constant. While the accuracy using the photoelectric effect is not nearly as good as that provided by other less direct means, the method is quite sufficiently accurate for the accuracies involved for the present purposes. The lines in the figure [which are straight lines] can be plotted from as little as two data points for any one substance [of course accuracy improves with a greater number of data points and interpolation among them].

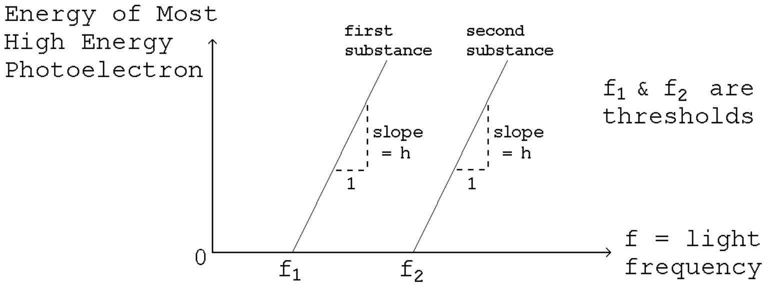

Figure 2

Each data point is obtained by shining light [in the present situation the light must be from a far distant astronomical source] of a single frequency [as selected by a spectroscope, one of the lines of the source's line spectrum being selected] on a photosensitive surface that emits photoelectrons [the selected line must be of a frequency greater than the cut-off frequency, e.g. f_1 or f_2, for the particular photosensitive substance being used].

Normally in the use of the photoelectric effect the objective is to readily collect a current of photoelectrons so that the collection anode is set at a positive electrical potential relative to the photoelectron source, the photosensitive surface on which the light is shined. [Of course, the entire structure must be in a vacuum for the photoelectrons to be free to travel without the interference of a relatively dense gas.]

In the present experiment the collection anode is set negative relative to the photoelectron source, that negative potential being adjustable. Then the negative potential is made progressively less negative until the first, initial photoelectron current is detected. That potential is the energy of the most energetic photoelectron produced by the particular frequency of the light being used [the photoelectrons emitted at lesser energies having been freed from the photosensitive surface with the same high energy but having lost some within the material before becoming free]. The data point is the energy and the frequency.

As indicated in the figure, Planck's constant is the slope of the resulting line(s), which develops as follows. The energy of a photon of light is given by

(16) $E = h\cdot f$

where:
E is the energy,
h is Planck's constant, and
f is the frequency of the particular photon.

The initial energy datum is the electric retarding potential and must be converted to the units of Planck's constant times frequency as required for the *E* of equation *16*. That done, then the slope of the line in the figure is

(17) $^{Energy}/_{frequency} = {}^{h\cdot f}/_{f} = h$, Planck's constant.

This measurement performed on light from distant astronomical sources will result in values for Planck's constant quite noticeably larger than our domestic value, the difference being the decay that has taken place since the time the sample light was originally emitted at its distant source.

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