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C Decay and Galactic Red-Shifts

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ABSTRACT

C *decay (a decrease in the speed of light) is not enough to explain galactic red-shifts. In the early 1980's, Barry Setterfield found that his* c *decay theory predicted red-shifts much larger than those observed. To fix this discrepancy, he postulated a finely-tuned* ad hoc *contraction of the cosmos to produce large blue-shifts, which in turn would nearly —but not completely —cancel out the large red-shifts. In this paper I will show that Setterfield's large red-shift prediction resulted from an inconsistent application of his own theory, and that a consistent application of his theory yields zero red-shift. This result means that (1) the* ad hoc *contraction is not necessary, (2)* c *decay does not cause the observed red-shifts, and (3) red-shifts neither support nor hinder the* c *decay theory. Another factor is needed to explain the observed red-shifts. From several Scriptural clues, I suggest that the red-shifts could come from a very rapid expansion of the cosmos during the six days of creation.*

INTRODUCTION

In 1912 Vesto Slipher, an astronomer at Lowell Observatory in Arizona, began painstakingly analysing light from distant galaxies with a spectrograph attached to his telescope. His spectograph separated the light into a rainbow spectrum of bright and dark vertical bands spread across a horizontal smear of colour. Each band, or 'spectral line', corresponded to a particular wavelength of the received light. The spectral lines came from hydrogen, helium, or other common atoms in the galaxy being observed. As he analysed the spectra, he was able to recognise the unique patterns of spectral lines produced by each type of atom.

Slipher's work showed that most of the galaxies he observed had spectral lines shifted toward the red side of the spectrum relative to the spectral lines from identical reference atoms on earth. This 'red-shift' of the spectra meant that the received wavelengths were longer than the reference wavelengths. If we call the received wavelength of a particular spectral line λ, and the wavelength of the corresponding spectral line from a reference atom λ_0, then the red-shift parameter z is defined as:

$$z \equiv \frac{\lambda}{\lambda_0} - 1 \qquad (1)$$

For any given galaxy, all the spectral lines have the same parameter z.

In 1924 an astronomer at Mount Wilson observatory, Edwin Hubble, began to measure the received brightness from Cepheid variable stars which were visible in other galaxies. Cepheid variables have well-known light outputs, so Hubble was able to use the inverse-square brightness/ distance law to calculate the distances of the galaxies from earth. As Hubble did so, he noticed that more distant galaxies had bigger red-shifts. In 1929 he published an historic paper[1] showing that the red-shift of a galaxy is roughly proportional to its distance r from us:

$$z \approx \frac{H}{c} r \qquad (2)$$

where c is the speed of light and H is a proportionality constant called the Hubble constant. Equation (2), called Hubble's law, is not exact, because

(1) 'local' motions impose a small variation (causing blue-shifts in some of the nearer galaxies), and

(2) the data for very large distances begin to depart from the straight line predicted by equation (2).

There are also some observed peculiarities, such as galaxies which appear to be joined together but have significantly different red-shifts. But for most of the data the law applies well, since the general trend of the data is quite clear.

Conventional evolutionary cosmologies, such as the 'big bang', try to explain Hubble's law as the result of a slow expansion of the universe for the last 10 to 20 billion years. As most readers of this journal know, such theories ignore a great deal of scientific evidence for a much younger world. Evolutionary theorists prefer to restrict their view to those few processes which at first sight might suggest an old world. However, a good scientist — evolutionist or creationist — must seek to explain all the data, not just the data he is comfortable with. In this spirit, creationist researchers of the last few decades have worked hard to explain the 'old-earth' data, such as radiometric dating, and they have made progress in many areas.

The last major puzzle has been cosmology, about which creationist researchers have recently begun to think seriously. Creationist cosmologies must solve two major problems:

(1) **Transit time** — How has light from distant galaxies reached us in less than 6000 years?

(2) **Hubble's law** — Why are galactic red-shifts proportional to distance?

In their monograph, Barry Setterfield and Trevor Norman tackle the first problem, transit time, by proposing that the speed of light at creation was very high and has been decaying ever since. They also briefly discuss the second problem, Hubble's law, concluding that *a red-shift of light from distant objects occurs as* c *decays.*'[2] Their reasoning is qualitative, not mathematical. It has to do with how *c* decay might affect Planck's constant, the momentum and energy of photons, electromagnetic wave amplitudes, and finally wavelengths. Their chain of logic has many intermediate links, making their argument weaker than a more direct line of reasoning. It is important to know whether their red-shift conclusion can be reached from the first principles of their theory.

In what follows I show directly from those first principles how *c* decay would affect the wavelength of light. It turns out that there are two relevant effects of *c* decay to be dealt with. One is a red-shift of light waves while they are in flight. The second is a blue-shift in the light from the emitting atoms. I show that the two effects cancel each other out exactly, and the result is that there is no net red-shift. In the conclusion, I discuss the implications of this result, and I propose a new direction for research in creationist cosmology.

EFFECT OF *c* DECAY ON LIGHT WAVES IN FLIGHT

In this section I show how *c* decay affects the period — the time between crests — of light waves as they travel. I follow essentially the same mathematical procedure used by many general relativity textbooks to derive red-shifts.[3] Figure 1 illustrates the factors involved. Let us define radial distance *r* and time *t* in an inertial reference system at rest with respect to the earth, and whose origin is at the earth. Consider an atom in a distant galaxy which emits a short train of light waves (a photon) in our direction. The first wave crest leaves the atom at time t_1, when the atom is a distance r_1 from us. The crest travels towards us with a speed *c* which, according to Setterfield's hypothesis, can change with time, *t*. Then the distance *r* between the first crest and us will diminish at the

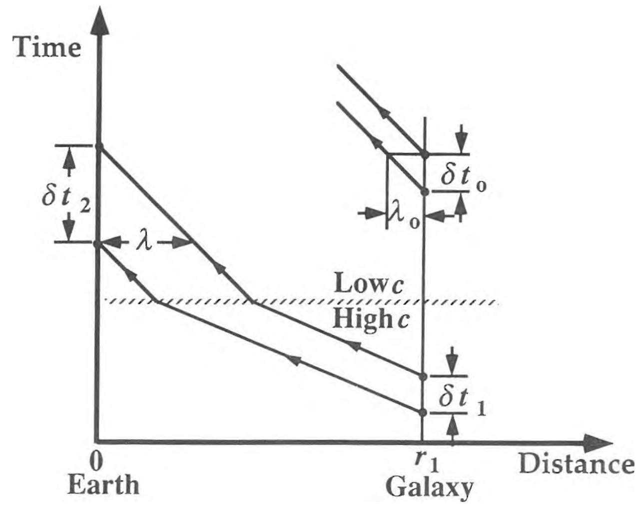

Figure 1. *Space-time path of two successive light wave crests from a distant galaxy to the earth, for the case that* c *decay does not affect atoms. In this illustration, the speed of light decreases abruptly by a factor of about two while the light is in transit, so the slope of the light paths changes abruptly. The period of the emitting atom is not affected by the decrease, so we have* $\delta t_1 = \delta t_0$. *The received wavelength* λ *is twice as long as the reference wavelength* λ_0, *which means that there would be a red-shift.*

rate:

$$\frac{dr}{dt} = -c(t) \tag{3}$$

During time interval *dt*, the crest travels a distance *dr:*

$$dr = -c(t)dt \tag{4}$$

Taking the integral of equation (4) from the emission distance and time (r_1, t_1) to the reception distance and time ($0, t_2$) on earth gives the total distance the crest must travel, which is r_1 :

$$r_1 = \int_{t_1}^{t_2} c(t)\,dt \tag{5}$$

Taking the derivative of equation (5) with respect to the emission time t_1 gives:[4]

$$\frac{dr_1}{dt_1} = c_2\frac{dt_2}{dt_1} - c_1 \tag{6}$$

where

$$c_1 \equiv c(t_1) \text{ and } c_2 \equiv c(t_2)$$

In the Setterfield-Norman cosmos, galaxies are not required by first principles to move. Without further information, we would thus expect the distance r_1 of the galaxy not to change with time (except for small local motions). This would mean that:

$$\frac{dr_1}{dt_1} = 0 \tag{7}$$

We will reconsider this point later. Setting the left side of equation (6) to zero, we can solve for the change of reception time per unit change in emission time:

$$\frac{dt_2}{dt_1} = \frac{c_1}{c_2} \tag{8}$$

Now imagine that the source atom emits a second wave crest at time $t_1 + \delta t_1$, where t_1 is the period of the emitted light wave. The second crest reaches earth at a later time $t_2 + \delta t_2$, where t_2 is the difference in reception time for the two crests. Using equation (8), we can write this received time interval as:

$$\boxed{\delta t_2 = \frac{c_1}{c_2}\delta t_1} \tag{9}$$

This simple but important equation says that the received period depends only on the emission period and the speeds of light at emission and reception. This is similar to a result in standard big-bang cosmology, except that there the periods depend on the ratio of the expansion scale factors.[5]

RED-SHIFT IF *c* DECAY DOES NOT AFFECT ATOMS

In this section I proceed to calculate the red-shift which would result from equation (9). One factor of that equation is the period δt_1 of the waves from the emitting atom. This brings up a major question: Is the period δt_1 affected by the hypothesised change in c? Setterfield and Norman apparently do not consider this question at all in relation to red-shifts, even though they discuss the effect of *c* decay on atoms quite clearly elsewhere in the monograph. In their red-shift section they thus assume by default that the emitted period is not affected by *c* decay. In this section, I will proceed with their implicit assumption in order to show its consequences. In that case, the past period δt_1 of an emitting atom would be the same as the present period δt_0 of an identical reference atom (see Figure 1):

$$\delta t_0 = \delta t_1 \tag{10}$$

The reference atom could be anywhere, but in practice it must be near the observer. Now we must calculate some wavelengths. At any given time, the length of a light wave is the product of its period and the speed of light at that time. For the reference atom at time t_2 those two quantities are δt_0 and c_2, so the length λ_0 of the waves from the reference atom would be:

$$\lambda_0 = c_2\,\delta t_0 \tag{11}$$

Substituting δt_0 from equation (10) into equation (11) gives:

$$\lambda_0 = c_2\,\delta t_1 \tag{12}$$

The length of the light waves received from the distant galaxy is:

$$\lambda = c_2\,\delta t_2 \tag{13}$$

Substituting δt_2 from equation (9) into equation (13) gives:

$$\lambda = c_1\,\delta t_1 \tag{14}$$

which is just what we would get from the product of the speed of light and the emission period at time t_1. Dividing equation (14) by equation (12) gives us the ratio of received and reference wavelengths:

$$\frac{\lambda}{\lambda_0} = \frac{c_1}{c_2} \tag{15}$$

Thus we can write the received wavelength λ in terms of the reference wavelength λ_0:

$$\lambda = \frac{c_1}{c_2}\lambda_0 \tag{16}$$

The red-shift parameter z defined in equation (1) would be:

$$z = \frac{c_1}{c_2} - 1 \tag{17}$$

According to the *c* decay hypothesis, the past speed of light c_1 was greater than the present speed of light c_2, so the received wavelength λ would be greater than the reference wavelength λ_0, and z would be greater than zero. Thus if *c* decay does not affect atoms, we would indeed get red-shifts. Setterfield got the same result. This consequence of a conjectured decrease in *c* is not new; it was known before 1931.[6,7]

Creationists should not rush to embrace equation (17) too quickly. If the cosmos is young, the red-shifts given by equation (17) are much too large. For example, consider one of our nearest galactic neighbours, M 31 in Andromeda. It is so close that its cosmological red-shift is too small to be detected; theoretically it would have a z of about 0.0001, compared to z's as large as 4.0 for the most distant observed galaxies. (In actuality, the local motion of M 31 towards us gives its light a small blue-shift.) Yet even this neighbouring galaxy is about 2 million light-years away. For its light to reach us in 6000 years, the average value of *c* during the trip would have to be about 300 times larger than the value of *c* today:

$$c_{average} = \frac{2 \times 10^6}{6000} c_2 \approx 300\,c_2$$

If c has always decreased, then to get an average of 300, c_1/c_2 would have to be much larger than 300. Then equation (17) would predict a z much larger than 300 for M 31 — millions of times greater than what is observed.

Setterfield recognised this problem — too much red-shift — as early as 1983, and invoked an *ad hoc* contraction of the universe to provide a partly counteracting blue-shift.[8] This contraction would have to be very finely tuned by the theory, since both the in-flight red-shift and contraction blue-shift would be much larger than the net red-shift observed. The Setterfield-Norman monograph of 1987 continued with the contraction idea:

> *'All red-shifts are thus a nett* [sic] *result of* c *decay coupled with cosmological contraction.'*[9]

In the next section, I will show that such a contraction is not necessary to get rid of the oversize red-shifts. All that is necessary is a consistent application of the first principles of Setterfield's own theory.

RED-SHIFT IF *c* DECAY DOES AFFECT ATOMS

The explicit assumption of the previous section, and the implicit assumption of the Setterfield-Norman section on red-shifts — that atoms would not be affected by a change in the velocity of light — is contrary to a major premise of the rest of the Setterfield-Norman monograph. According to the rest of the monograph, the period of atomic clocks should increase as c decreases:

> *'Any change in* c *affects the atom. For example, electron orbital speeds are proportional to* c*, meaning that atomic time intervals are proportional to 1/*c*.'*[10]

In the laboratory, these *'atomic time intervals'* are measured by the period of the light waves emitted by atoms. Setterfield calls the time-frame in which such a change in atomic clocks would be measured *'dynamic time'*. The clocks measuring such time, dynamic clocks, would depend on physical processes which are unaffected by changes in c. I suspect that there are no such processes in our physical universe. However, the concept is a useful one. We could imagine that God has some idealised clock outside the physical universe which would not be affected by any changes occurring within the universe, and we could think of Setterfield's *'dynamic time'* as 'God's time'. So a basic premise of Setterfield's hypothesis is that, as measured in God's time, atoms in the past oscillated faster, and their emitted light would be bluer.

I agree with this premise; it would be a logical consequence of the change in c. For example, consider one of the simplest clocks imaginable — light bouncing back and forth between two mirrors. Figure 2 shows the path of a light ray in such a clock. If the round-trip distance between the mirrors is Ax, then the period of this clock (as measured with God's clock) at the past time t_1 would be:

$$\delta t_1 = \frac{\Delta x}{c_1} \qquad (18)$$

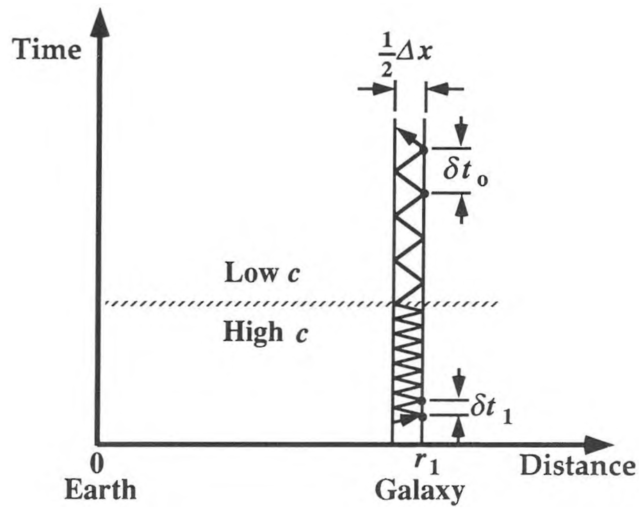

Figure 2. *Path of light ray bouncing back and forth between two mirrors. Note that the period of this very fundamental clock increases by a factor of two when the speed of light decreases by a factor of two. Intervals along the time axis come from some idealized dock which is not affected by the change in c.*

The period of an identical clock at the present time t_2 would be:

$$\delta t_0 = \frac{\Delta x}{c_2} \qquad (19)$$

From the two equations above, we can write the past period of the clock in terms of the present period:

$$\boxed{\delta t_1 = \frac{c_2}{c_1}\delta t_0} \qquad (20)$$

Since by the c decay hypothesis, c_2 is much less than c_1, the past period of the clock would be much shorter than its present period. Such *gedanken* ('thought') clocks as this light-and-mirror concept are often used in relativity theory, not only because they are easy to analyse, but also because their behaviour always turns out to be typical of much more complex clocks, such as atoms. Thus, both standard physics and Setterfield's theory suggest that equation (20) applies to atoms and their emitted light. If we then substitute equation (20) for δt_1 in equation (9) we get:

$$\delta t_2 = \frac{c_1}{c_2}\frac{c_2}{c_1}\delta t_0 = \delta t_0 \qquad (21)$$

Figure 3 illustrates this. Multiplying equation (21) by c_2 shows us that the received and reference wavelengths are equal:

$$\boxed{\lambda = \lambda_0} \qquad (22)$$

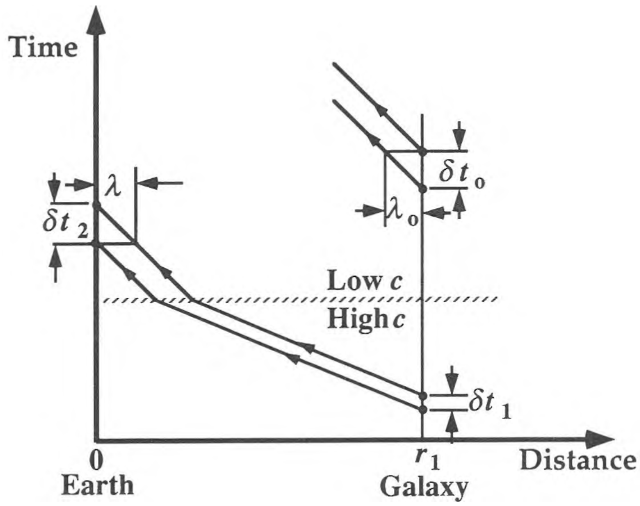

Figure 3. *Path of two successive wave crests for the case that* c *decay does affect atoms. Note that the past period of the atom* δt_1 *is half its present period* δt_0*. This causes the received wavelength* λ *to be the same as the reference wavelength* λ_0*, and there is no net red-shift.*

Using equation (22) in equation (1) shows that the red-shift parameter z is zero. A blue-shift in the source exactly cancels out the red-shift acquired in transit, and we are left with no net wavelength shift. Thus a consistent application of the Setterfield-Norman theory yields no red-shift due to the hypothesised decrease in the speed of light.

CONCLUSION

We have two results:

(a) Applying c decay only to light waves in transit gives red-shifts which are much too large.

(b) Including the effect of c decay on the source atoms yields zero red-shift.

So it appears that c decay by itself cannot account for the moderate but non-zero red-shifts we actually observe.

The good news from this result is that the transit time and Hubble law problems do not appear to be connected. That is, red-shifts place no constraints on what the speed of light may have been in the past. As far as the red-shift question is concerned, the speed of light may have indeed been very high in the past, but if that were the case, we would not be able to determine it from the observed red-shifts. There may be other problems with the c decay hypothesis, but red-shifts neither hinder nor advance it.

In that case, however, creationist cosmologies must still explain the Hubble law. Some factor other than the speed of light must be involved. I suggest that equation (7) would be a good place to insert a new effect. If space were expanding at the time of emission, then the source galaxies would be moving away from us, dr_1/dt_1 would not be zero, and a red-shift would result.

Such an expansion follows straightforwardly from Scriptural references to the creation of the heavens. To date, I have found seventeen different verses throughout the Old Testament referring to a 'stretching' or 'spreading' of the heavens. Some examples are:

[God] Who alone stretches out the heavens . . . (Job 9:8)

Stretching out heaven like a tent curtain . . . (Psalm 104:2)

Who stretches out the heavens like a tent curtain,
And spreads them out like a tent to dwell in. (Isaiah 40:22)

Who created the heavens and stretched them out . . .
(Isaiah 42:5)

. . . He has stretched out the heavens. (Jeremiah 10:12)

. . . Jehovah Who stretches out the heavens . . .
(Zechariah 12:1)

The Old Testament uses three different Hebrew verbs to describe this stretching. This, coupled with the number and diversity of such references, suggests that God may have intended them to be understood straightforwardly rather than metaphorically. Scripture distinguishes 'the heavens' (space) from the 'host of the heavens' (sun, moon, and stars), as in Genesis 1. The above verses, taken at face value, would then refer to a stretching of space itself. Thus the Bible may be describing a process similar to the general relativistic concept of expanding space. However, since the biblical expansion would take place in less than 6000 years, possibly in less than the six days of creation, it would have to be very rapid. The speed of the expansion would be similar to the 'inflationary' phase of Alan Guth's version of big-bang cosmology.[11] Such an expansion could have a great deal to do with galactic red-shifts. Creationist cosmologists should not overlook this significant clue from God as to how He made the heavens.

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