Proposed Explanations for Apparent Age of the Universe in a Creationist Framework
Part I: Change in the Speed of Light

Version 1.0

Here we give the technical details of the first of two principal approaches of Creationist thinkers to account for the apparent great age of the universe. Problems with this approach are also discussed. This is the make-or-break issue for Creationism, because an old universe undermines the entire Creationist explanatory paradigm, but leaves the other schools intact. And correspondingly a young universe demolishes Neo-Darwinism and Meta-Darwinism. (Intelligent Design survives under either hypothesis). The following material is rather technical in nature, and for that reason and on account of its length, it was not included in the book. It is, however, important for a thorough understanding of the Creationist position. Creationists may in the future come up with additional explanations, or modify those discussed here to deal with objections. In that case, this text will be revised.

Approach 1: Change in the Speed of Light

If one postulates that the speed of light has decreased by a large factor over the past 10,000 years or so, it is possible to reduce the age of the universe drastically while still maintaining the current distance scale. We shall investigate this hypothesis and its consequences here. This is the approach to the age of the universe problem currently favored by many Creationists, including Walt Brown.

First, some background to show that the idea is not far-fetched. Speculation about changes in the speed of light goes back nearly a century, but interest in the subject has grown recently in conventional science because a variable speed of light permits an elegant solution to certain cosmology problems. Specifically, it addresses the so-called "horizon problem", the extremely high degree of uniformity of the universe, as manifested by actual measurements of the Cosmic Background Radiation.[1,2] If the speed of light were much greater in the past (just after the Big Bang), then distant parts of the universe would have been in communication, and the observed uniformity can be accounted for quite elegantly. Other methods of resolving the horizon problem, such as Alan Guth's inflationary theory, would no longer be needed. Guth's theory smacks of an *ad hoc* solution, and is no less arbitrary than the notion of a speed of light change. However, it is well-developed and makes three testable predictions, two of which have been borne out to some degree.[3] Other problems which may be affected by a variable speed of light include the value of the cosmological constant (Λ), and the formation of large-scale structures in the universe. (The fact that Λ is anywhere from 55 to 120 orders of magnitude too large as calculated by quantum mechanics is a great embarrassment to theoretical physics. Other ideas are being floated to account for the observed expansion of the universe, including dark energy.)[4]

However, the effect of any hypothesized change in the speed of light is critically dependent upon the nature of that change. For example, a sharp drop to the present value just after the Big Bang, such as that proposed to solve cosmology problems, affects overall properties of the universe such as its uniformity, but does not change its age. On the other hand, a more gradual deceleration over the past ten thousand years or so will drastically lower the age of the universe, and affect different properties of it, such as the need for cold dark matter. These contrasting functional forms for the speed of light naturally will yield different predictions, which is advantageous for our purposes. He we shall concentrate on the slower deceleration, as we are interested in learning about how it lowers the age of the universe, and what observable consequences it may have.

One of the problems with discerning a specific form for the decrease is that the strength of the evidence for any particular possibility is a function of which measurements from the past are discarded, and which kept. In addition, the results will be influenced by what type of correction, if any, is applied to the measured data. For example, Olaus Roemer's 1676 measurement (the first successful attempt) yielded a result about 33% too low: 2.1 x 10^8 m/sec. The error is attributed to Roemer's incorrect assumption about the diameter of earth's orbit. Correcting for this, Roemer's data yield 3.01 x 10^8 m/sec.[5] Should this measurement be "fixed" using the correct distance information, or discarded? And should other measurements be discarded because of assumed or documented problems with equipment? For example, Foucault's 1850 measurement based on a rotating mirror yielded 298,000 m/sec, with an error of ±2,000 m/sec, lower than earlier and subsequent measurements. These are not easy questions, especially since our knowledge of early experimenter's skill, measurement equipment, and general circumstances is incomplete. Nonetheless, there does appear to be a general trend of falling measurement values. Creationists were not the first to notice this trend or to propose that the speed of light is decreasing; the idea goes back at least to 1927,[6] and more recently was advanced by a Soviet scientist,[7] as well as Western scientists attempting to resolve well-known cosmological problems, one of which was alluded to above.[8] Creationist Barry Setterfield's table of what he regards as the most reliable data, when plotted, clearly reveals this tendency, as illustrated in Figure C-1.

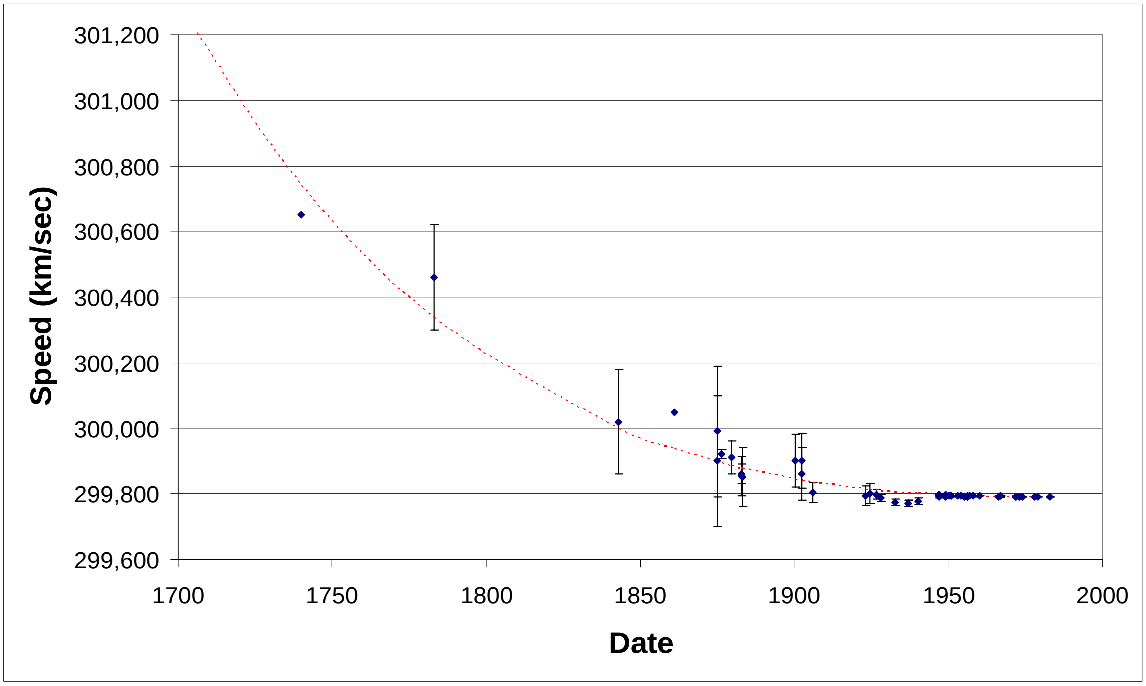

Figure C-1. Speed of light measurements over three centuries, with "best fit" curve shown as dotted line.[9]

It is the trend shown in this graph which has fueled so much speculation about the decreasing speed of light (*c*). In particular, the apparent acceleration in the speed as one moves to the left has led some mathematicians to attempt to fit the data to a curve, and then extrapolate it backwards in time. There are numerous functional forms which can be employed, including power laws, cosecant-squared curves, or polynomials. Setterfield favors the following equation:

$$c(t) = \sqrt{a + e^{kt}(b + dt)} \qquad \text{C-1}$$

where $a = 9.029 \cdot 10^{10}$, $b = 4.59 \cdot 10^{13}$, $d = -2.6 \cdot 10^{10}$, and $k = -0.0048$. This equation gives the speed of light in km/sec, as a function of year in the AD/BC system. It yields estimates (extrapolations) of 75% higher speed around 1000 BC, twenty times as fast at the time of Christ, 300 times as fast around 1000 BC, and 50,000 times faster before 3000 BC,[10] as shown in Figure C-2. To determine how much this shrinks the age of the universe, we need to examine just how far light could travel as a function of time before the present, using Setterfield's formula. There is a minor problem of units, as the formula gives speed in km/sec, but requires that *t* be measured in years. We would also like to have distance in light years (ly) rather than km. Making suitable adjustments, we have the following formula for the distance light travels in light years between start time t_0 and end time t_f:

$$s = \frac{1}{k_1} \int_{t_0 \cdot k_2}^{t_f \cdot k_2} \sqrt{a + e^{kt/k_2}\left(b + \frac{dt}{k_2}\right)}\, dt \qquad \text{C-2}$$

where k_1 is km/light year ($9.46 \cdot 10^{12}$) and k_2 is seconds/year ($31.56 \cdot 10^{6}$). Other constants are as defined above. Setting t_f equal to 2000, this equation allows us to determine how far light has traveled to reach us at the present time for any year in the past. Because the speed of light increases as we go back in time, the distance light has traveled is much greater than would be calculated assuming the speed of light to be constant.

Calculating distance as a function of t_0, we see that for relatively short times, distances become quite large, as shown in Figure C-3. This means that light from the farthest reaches of space, about 15 billion light years, can reach us in about 12,000 years, effectively shrinking the age of the universe to this value.

Setterfield's general approach is to show that a change in the speed of light, such as that proposed above, can be made compatible with known (or well-established) invariants, and at the same time show that quantities which would be affected by a change in the speed of light do in fact manifest appropriate changes. While a comprehensive review of his discussion is beyond the scope of this book,* we may sketch the outlines of it. First he deals with the standard equation relating c to the permittivity ε_0 and the permeability μ_0 of free space:

$$c^2 = \frac{1}{\varepsilon_0 \mu_0} \quad \text{C-3}$$

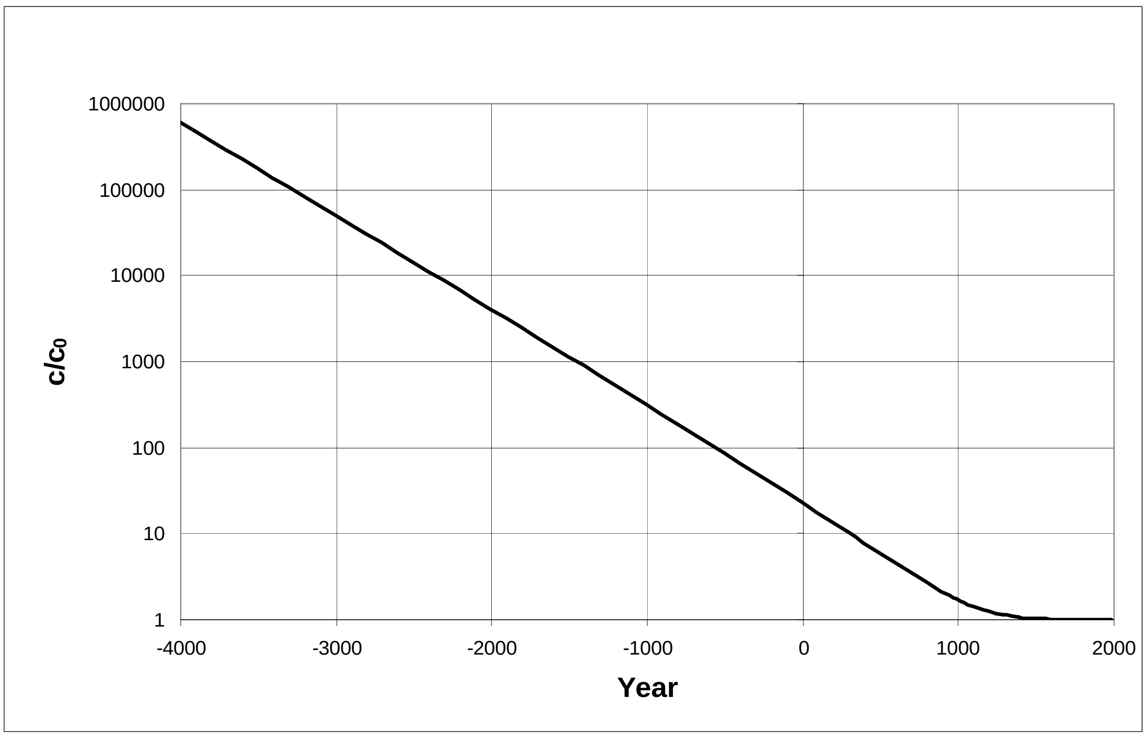

Figure C-2. Speed of light as function of year, calculated with Setterfield's formula

* And is complicated by the numerous typographical errors in his paper, which was not published by any peer-reviewed journal.

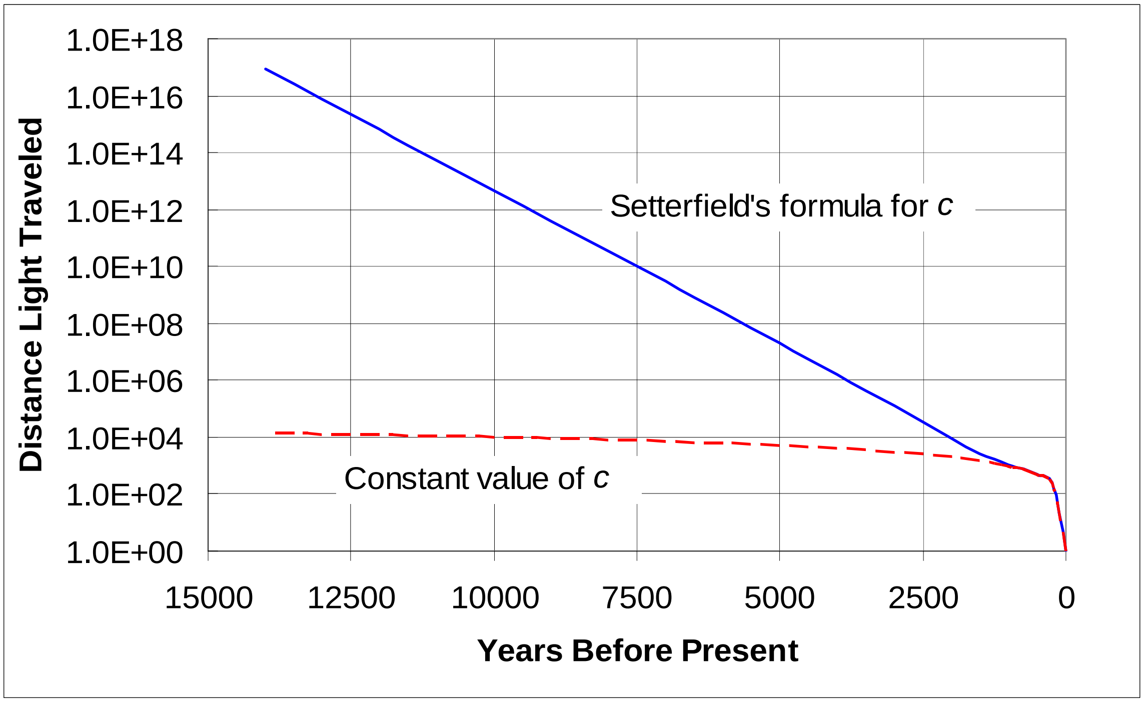

Figure C-3. Distance light has traveled to earth as function of time in past

Based on experimental results, he concludes that it is ε_0 which is constant, making $\mu_0 \propto 1/c^2$. He then infers the constancy of the unit electric charge *e* and Avogadro's number *N*. The well-known formula $E = mc^2$ implies that $m \propto 1/c^2$, which means that mass was smaller in the past and has increased over time. Constancy of atomic orbital radii implies that Planck's constant $h \propto 1/c$, and that wavelength of emitted photons λ is constant, but frequency $f \propto c$. The fine structure constant α is, indeed, constant, but λ^*, the alpha particle escape frequency, is proportional to *c*, which implies that radioactive decay has slowed down over time. Energy density *W* is inversely proportional to *c*, which implies that it was lower when *c* was higher, and thus more atoms had to decay to produce the same energy flux *S* as now. Finally, and quite intriguing, the cosmological constant Λ has a negative sign under this approach, potentially resolving the problem of the missing mass in the universe (usually resolved by the assumption of some form of cold dark matter), since a negative Λ acts as a form of gravity over large distances. We also note that Setterfield's hypothesis entails a separation of atomic time (based on orbital properties of atoms) and dynamical time (based on astronomical phenomena). In particular, since atomic processes are closely related to *c* because of electron orbital speeds (and thus photon emission and absorption), it follows that atomic time will be proportional to $1/c$, and thus will slow down as *c* increases. While the net result, according to Setterfield, is that matter remains stable, the impact of this separation (and the changes in the other constants) on biological and geological processes remains to be investigated.

But fortunately, we do not have to await such a study, because even without it we can still deduce the signature effect of the kind change in the speed of light envisioned: an extreme from of time dilation.* Brown has pointed out this effect,[11] but we wish to take his reasoning a bit further and develop some numerical estimates, as these lend themselves to direct empirical test. First, however, let us consider the matter in qualitative terms. The origin of the effect is as follows. If the speed of light is decreasing, then a light wave emitted at one time t_0 will have an average velocity slightly higher than one emitted a short time Δt later. As a result, it will arrive at the earth in less time, and so the observed difference in time between the two light waves will be *greater* than Δt; this is known as "time dilation"—see Figure C-4. The magnitude of the time dilation will be a function of distance from earth (or equivalently, the time when light headed toward the earth started its journey). Thus, the same kind of event will appear to take longer the farther it is from earth. Quantitatively, the effect can be estimated by noting that for values of t near the present (t = 2000), c is essentially constant, so the time dilation factor (i.e., by how much time is dilated) can be estimated by differentiating equation C-2 with respect to the lower limit t_0. To do this we first make a substitution $u = t / k_2$, which yields for s:

$$s = \frac{k_2}{k_1} \int_{t_0}^{t_f} \sqrt{a + e^{ku}(b + d \cdot u)}\, du \qquad \text{C-4}$$

Taking the derivative and applying the Fundamental Theorem of Calculus, we have

$$\frac{\partial s}{\partial t_0} = \frac{k_2}{k_1} \sqrt{a + e^{kt_0}(b + d \cdot t_0)} \qquad \text{C-5}$$

The time dilation factor for similar events viewed at different distances from the earth can be calculated directly from this equation or from equation C-2; it is illustrated in Figure C-5.

So if this general approach is correct, we should observe processes and events far away from us proceeding much more slowly than events nearby. As a result, the time dilation effect should be readily visible even on typical stars in our own galaxy that are commonly used to measure distances in the universe, such as Cepheid variables or RR Lyrae stars. Similar or greater effects should be observable in other "standard candles" used to gauge distances in the universe, such as type Ia supernovae.[12] So the critical test only involves measurement of something whose period is known to be constant, at two different locations in the universe, one close to earth and the other far away. Statistical analysis of large numbers of such stars at known distances should reveal the time dilation effect immediately, as it is rather large: a factor of about 200 for something on the other side of the Milky Way galaxy (~100,000 light years), and 10,000 for something in the Andromeda Galaxy (~2,000,000 light years). Of course, due to the fact that the speed of light is steadily decreasing, we could also observe the time dilation effect by watching the same periodic event (such as the change in magnitude of an eclipsing binary star system) over a long period and noting that it would happen *faster* as time went on; but that requires more careful observations over a longer time interval.

To see the origin of this aspect of the time dilation effect in more detail, let us consider the plot shown in Figure C-4. Consider two events in the past, spaced a time Δt apart. Assume that the first event occurred at time t_0, and the second at t_1, as shown on the graph. The vertical gap correspond to these points is shown as the difference in initial velocity. Note that at time t_2, t_3, which occur later but correspond to the same time difference Δt, the difference in initial

* Time dilation is an effect in which time intervals measured in one place or frame appear *longer* when measured in another.

velocities is significantly less. As a result, the difference in arrival times of light waves from the two events will be much less than in the first case.

To date, neither of the effects (slowdown correlated with distance, slowdown over time) has been observed, casting doubt on the change in speed of light hypothesis. Is there any way out of this problem? As we have noted, *any* drop in the speed of light will result in *some* time dilation effect; the magnitude however will vary. For example, if the present speed of light was reached very soon after the Big Bang, the impact of time dilation would not be visible in the periodicities observed in stars, quasars, and other cosmic entities, as they were all formed long after the effect ceased. For the Creationist theories, however, the present speed is not reached until very recently, so the time dilation effect should be visible throughout the universe. The exact functional form assumed by the changing speed of light is irrelevant—it will affect the details of the calculations only. The fact that the speed has dropped by a factor of a million or more over a 10,000-15,000 year interval before the present is what governs, leading directly to the time dilation effect. Of course, the magnitude of the effect could be sharply reduced by adopting a functional form which drops the speed of light to near its present value shortly after the creation of the universe; but that would have the distinct disadvantage of destroying the curve fit to the data in Figure C-1. While this cannot be ruled out as an alternative, it is up to the Creationists who advocate such an approach to develop and justify a suitable functional form for $c(t)$, one which fits observed data, not only for the presumed change in fundamental constants over time, but also such effects as the time dilation discussed above. If Creationists succeed in this endeavor, and empirical studies confirm their theoretical predictions, it will be an enormous boost to the young earth theory. If they cannot do so it bodes ill for this method of accounting for the age of the universe.

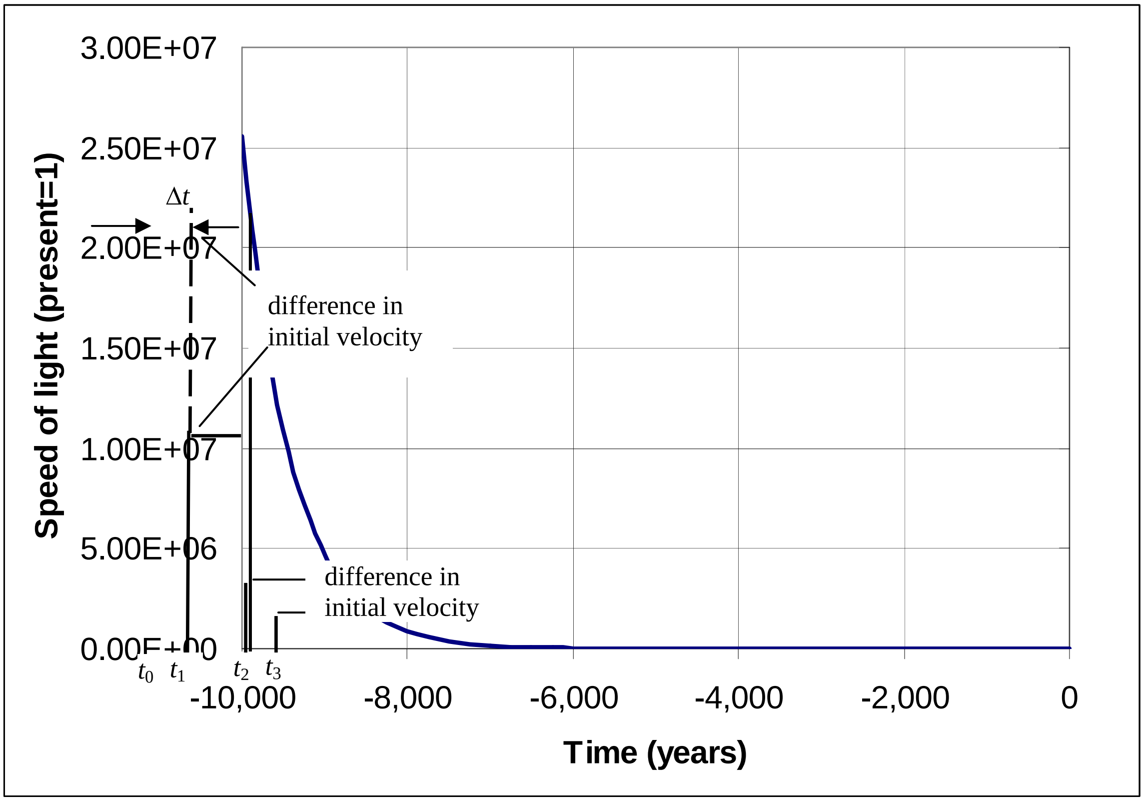

Figure C-4. Illustration of time dilation effect of drop in speed of light over time. A larger difference in initial velocity for the same Δt will of course mean a larger difference in arrival time, thus leading to time dilation.

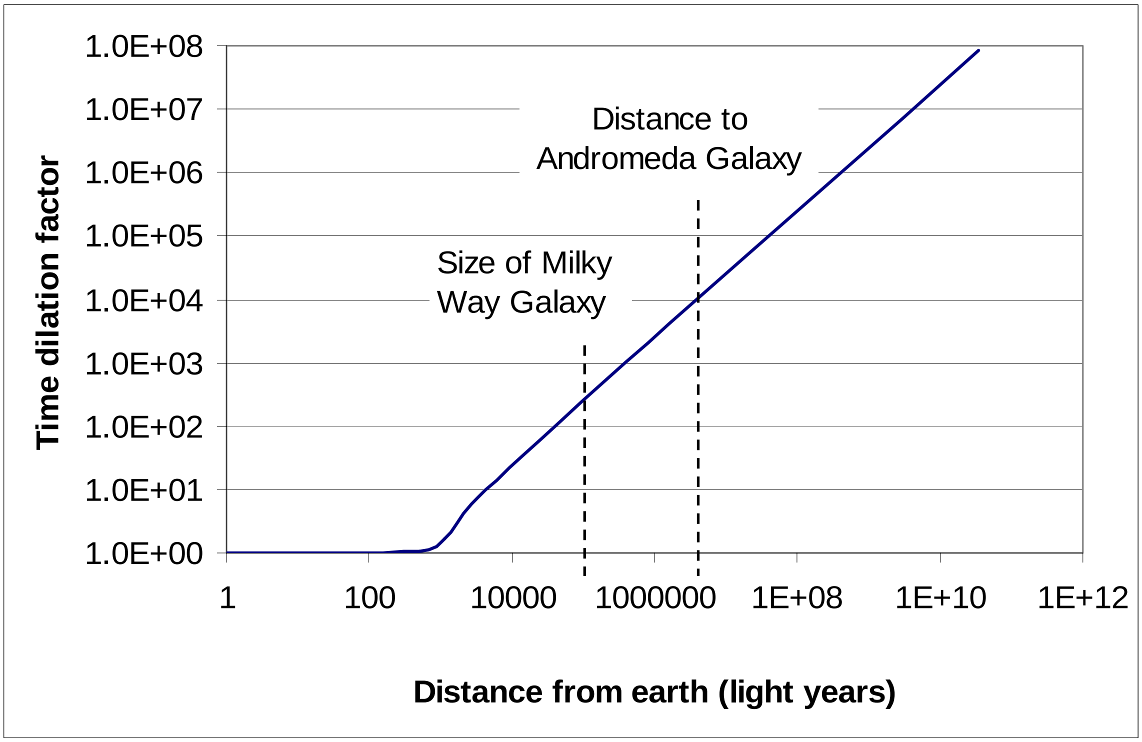

Figure C-5. Magnitude of time dilation effect as function of distance from earth in light years.