THE UNIVERSE IS BIGGER THAN 15.71 LIGHT YEARS

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Moon and Spencer's 15.71 light year model universe does not approximate the real universe. Their model universe is far too dense, and far too short-lived. Such a model for the universe should not be used in support of a short travel time for light from the distant stars as a solution for the light from the distant stars paradox.

Introduction

How did the light from the distant stars arrive here on earth, if the universe is only 6,000 to 10,000 years old? Some Creationists[1, 2] have looked to a 1953 paper by Moon and Spencer[3] for an answer.

Moon and Spencer supported an unpopular idea about the effect of motion on the speed of light. Their idea was unpopular, because it was at odds with the theory of relativity. The effect, if it were true, would have nothing to do directly with the light from distant stars paradox.

However, the model of the universe that Moon and Spencer used to support their ideas is the model of the universe some creationists have used to explain the travel time of light paradox. Creationists, and Moon and Spencer are joined by a common model of the universe. However, the two deal with very different issues.

How did Moon and Spencer arrive at their model of the universe? What evidence did they put forth in support of their model? These questions must be answered now, because this article contends that the Moon and Spencer model is incorrect.

Moon and Spencer Universe

A stationary star emits light that travels at a speed of 186,000 miles per second toward the earth. Moon and Spencer theorized that a star already moving toward the earth at 1,000 miles per second would emit light that travels toward the earth at 186,000 + 1,000 = 187,000 miles per second. This proposition is at odds with special relativity. Relativity predicts that the speed of light through empty space is 186,000 miles per second, whether or not the source of the light is in motion.

Moon and Spencer were aware of the classic test that seems to disprove their theory. The thrust of their paper was to present a model universe in which this test is indecisive.

The test measures light observed from binary stars. For simplicity, let us assume that one star of the pair is very massive and that the other star has relatively small mass. Then the massive star essentially remains fixed, while the less massive one rotates about it. Suppose that the earth lies in the orbital plane of this pair.

According to Moon and Spencer, the less massive star should emit light that travels toward the earth faster than 186,000 miles per second, during the part of its orbit when it approaches the earth. It should emit light that travels toward the earth slower than 186,000 miles per second during the part of its orbit when it travels away from the earth.

Suppose, for example, that the orbiting star of the pair is one AU (the distance from the earth to the sun) from the central star. Suppose its orbital speed is 120 km/sec = 0.0004c, where c = 300,000 km/sec. Its orbital period would be about 90 days.

Moon and Spencer would predict that this star emits light which travels toward the earth with speed $c + v = 1.0004c$ when the star moves toward the earth, and it emits light that travels toward the earth with speed $c - v = 0.9996c$ when it travels directly away from the earth. The slow light leaves the binary system one-half period ($T/2 = 45$ days) before the fast light, but the separation between the two light signals becomes less and less as the fast light gradually overtakes the slow light.

The fast light would reach an observer one light year away in about $1 - (v/c)$ years or 0.9996 years, while the slow light would reach him in about $1 + (v/c)$ years or 1.0004 years. The time difference between the travel time of the fast light and the slow light is $2v/c$ or 0.0008 years. This time difference is about seven hours. For an observer 15 light years away, the amount of catching up done en route is 15 times as much or about 4.5 days. For an observer 150 light years away, the amount of catching up done in route is 45 days. For this observer, the fast light emitted 45 days behind the slow light has caught up with the slow light that began with a 45 day head start.

The observer 150 light years distant would notice in a remarkable way the two light signals, which reach him simultaneously. This observer would seem to see two identical stars in orbit about the central massive star. Actually, the fast light emitted by the orbiting star on the part of its orbit when it moved toward the earth, caught up with the slow light this same star emitted one-half period earlier on the part of its orbit when it was traveling away from the earth. Several weeks later, the same astronomer looking at the same system might see only one orbiting star or maybe no orbiting stars at all. He would be between two pairs of slow light-fast light signals that have caught up with one another. If such observations of multiple identical stars appearing and disappearing were ever made, those observations would be direct evidence that the object emitting light adds its own speed to the speed of the light it emits, just as Moon and Spencer thought. The effect would be more noticeable for more distant observers. More catching up occurs over greater distances of travel.

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No such effect has ever been observed. It would be observed easily, if the speed of light depended on the speed of the emitter, and if the distance of travel were large enough for "catch-up" to accumulate. Moon and Spencer believed the speed of light depended on the speed of the emitter. They needed some explanation for the lack of odd effects for the binaries. Hence, they proposed that the universe was only a few light years in size. Thus, all observable binaries would be only a few light years away. The catch-up time that would accumulate over that short a distance might be unobservable. In our example, maybe 15 light years would do for the size of the universe. So the maximum time difference of 4.5 days of catch-up time might be unobservable compared to the 45 days difference between the time the two light signals were emitted. If the effect required, say, more than 10% difference to be observable, then a 15 light year universe would be so small that the effect would escape detection, even if the effect were real.

Moon and Spencer appealed to curved space-time to give them a small universe. They chose a model universe that was so curved that the real physical distance corresponding to an apparent distance of infinity would be less than the distance required to produce the catch-up effect of light from binaries. This consideration alone determined for them the size of the curved space-time universe they would use.

They chose $5\pi = 15.71$ light years as the maximum size of the universe, because that distance is small enough so that "catch-up" from the binaries they listed would be unobservable. This particular exact value was selected rather than 15.00 or 20.00 light years, because it was a number that fit conveniently into the mathematics of general relativity.

The distance formula they borrowed from general relativity[4] is

$$L = 2r_0 \tan^{-1}(r/2r_0) \qquad (1)$$

where $r_0 = 5$ light years exactly, r is the coordinate distance to a star and L is the physical distance to the star. The coordinate distance r is the distance Moon and Spencer use for the distance the star *seems* to be. It can be any distance from 4.3 light years for the closest star to several billion light years for the most distant known light sources. Moon and Spencer's physical distance L is the apparent distance, r, corrected for effects of the curvature of space-time.

In the formula, L (physical distance or real distance) and r (coordinate distance or apparent distance) are essentially equal for distances on the order of one light year or less. For instance, an apparent distance of $r = 1$ light year yields:

$$L = 10\tan^{-1}(0.1) = 0.997 \text{ light years.}$$

That's a difference of only three tenths of one per cent.

The difference between the two distances becomes enormous for larger r values.

Table I. r vs. L in Moon-Spencer Universe.

r (light years)	L (light years)
10.0	7.9
100.0	14.7
1,000.0	15.6
∞	15.71

Moon and Spencer adopt a universe of such small radius of curvature, $r_0 = 5$ light years, that the most distant object is only 15.71 light years of physical distance away. For them, that means no binaries are far enough away in terms of physical distance for fast light to catch slow light. Moon and Spencer can therefore still claim the speed of the emitter adds to the speed of light, and at the same time explain away evidence from apparently distant binaries to the contrary. Their solution is that the universe is too small for the effects to accumulate.

If the universe really is that small, light from even the most distant objects would seem to require only 15.71 light years to reach us. Such a universe would not have a paradox of the travel time of light.

How did light from the Andromeda Galaxy, whose apparent distance is $r = 2$ million light years, get here if the universe was created no more than 10,000 years ago? A candidate answer, using Moon and Spencer's paper, is that it would only take 15.71 years for all light to get here from even the most distant stars. The entire universe has a physical size of $L_{max} = 15.71$ light years. Strangely, a universe in which the most distant object is $5\pi = 15.71$ light years is a universe with a radius of curvature of $r_0 = 5$ light years.

Now consider general relativity to investigate a possible solution for the travel time of light based on Moon and Spencer's 15.71 light year physical size universe.

General Relativity — Static Model

Let us assume the matter in the universe is more or less evenly distributed on a sufficiently large scale, and that the universe as a whole is not expanding, contracting, or rotating. Then we have the static model of the universe.

The standard axiom of general relativity is that curved space-time "tells" matter and light how to travel, and that matter-energy "tells" space-time how to curve. The two parts of this axiom are inseparable in general relativity. The static model[5] yields the average density ρ_{static} that is necessary to produce a universe with a radius of curvature r_0,

$$\rho_{static} = (3/8\pi G)(c/r_0)^2, \qquad (2)$$

where $G = 6.67 \times 10^{-11}$ and $c = 3 \times 10^8$ in SI units. For a five light year r_0 we have

$$\rho_{static} = 7.2 \times 10^{-8} \text{ kg/m}^3. \qquad (3)$$

This is billions of billions of times greater than the observed average density (about 2×10^{-28} kg/m^3),[6] of matter in the universe. This observed density would give the universe a radius of 95 billion light years, if the universe was adequately described by the static model.

As an illustration, consider how much matter there would have to be in a sphere of radius one light year around us. This mass would be $M = (4\pi/3)\rho_{static}r^3 = 2.6 \times 10^{41}$ kg, which is the mass of 130 *billion* suns. There should be a whole galaxy of stars within one light year of us! It would take that much distributed mass to curve the universe so that the farthest distance is $5\pi = 15.71$ light years away from us.[7]

Within the orbit of Pluto, at that rate there would have to be the mass of 33 suns. This great extra mass within our own solar system would have an enormous effect on the motions of the planets. We would easily observe it with the naked eye.

There is not enough matter per unit volume in the universe to produce the 15.71 light year universe in the static model of general relativity.

Non-Static Models of the Universe

Models of the universe in which its large scale structure is changing can be classified into three groups according to density. The Robertson-Walker metric[8]

$$ds^2 = c^2dt^2 - R^2(t)\frac{[dr^2 + r^2(d\theta^2 + \sin^2\theta d\varnothing^2)]}{[1 + k(r/2r_0)^2]^2} \quad (4)$$

describes a changing universe in which the average mass-density is uniform throughout the universe at a given time, t, but varies as the universe expands (or contracts) with increasing time.

In equation (4) ds is the length of an infinitesimal section of world line in four-dimensional space-time. R(t) is the scale factor by which the universe has expanded or contracted relative to its size in the present epoch. $R = 1$ now. If the universe is expanding, $R < 1$ earlier and $R > 1$ later. The r_0 in the denominator of equation (4) is the radius of the universe in four-dimensional space-time. We will see that it is the same r_0 that appears in the Moon and Spencer equation (1). The constant k in the denominator can take on only one of the three possible values of +1, 0 or −1. This constant k classifies the solutions by density.

$k = +1$ yields a universe in which matter is packed densely enough so that the expansion of the universe will eventually be overcome by gravitational attraction. The universe will reach a maximum size, and then it will begin to contract. Thus $k = +1$ gives a closed universe. The $k = +1$ case will be of greatest interest in this article, since it is the case used by Moon and Spencer.

$k = -1$ gives an open universe. This solution yields a universe in which matter is so thinly spread that its gravitational effect can never overcome the expansion of the universe. The universe expands forever. Even after infinite time, it is still expanding far too fast to stop.

$k = 0$ represents the borderline case between the $k = +1$ and the $k = -1$ solutions. Using $k = 0$ in equation (4) yields a universe in which the matter has exactly the correct density (critical density) so that its gravitational effect slows the expansion, but never quite slows it to a complete stop. Only as infinite time elapses, does the expansion almost slow to a stop.

(A) $k = 0$

In this case equation (4) becomes

$$ds^2 = c^2dt^2 - R^2(t)[dr^2 + r^2(d\theta^2 + \sin^2\theta d\varnothing^2)]. \quad (5)$$

When the physical length is obtained by the usual procedure of setting $dt = 0$ and equating the differential physical length dL to the absolute value of the differential world length ds at that fixed time, we have

$$dL^2 = R^2(t)[dr^2 + r^2(d\theta^2 + \sin^2\theta d\varnothing^2)]. \quad (6)$$

This length is Euclidean. The universe for this case is not curved and the size of the universe is unlimited. Light travels along *straight* lines. This is why the case $k = 0$ is not useful to Moon and Spencer.

(B) $k = +1$

This case of a closed universe *is* the model adopted by Moon and Spencer. We begin with the four-length

$$ds^2 = c^2dt^2 - R^2(t)\frac{[dr^2 + r^2(d\theta^2 + \sin^2\theta d\varnothing^2)]}{[1 + (r/2r_0)^2]^2} \quad (7)$$

from equation (2), and write the differential physical length by setting $|ds| = dL$ when $dt = 0$. We have

$$dL^2 = R^2(t)\frac{[dr^2 + r^2(d\theta^2 + \sin^2\theta d\varnothing^2)]}{[1 + (r/2r_0)^2]^2}. \quad (8)$$

If we consider the earth to be at the center of a spherical coordinate system, then the light coming to the earth from any star travels along a radius, so $d\theta = d\varnothing = 0$ for that light ray. We have, for such a stellar light ray

$$dL = R(t)\frac{dr}{[1 + (r/2r_0)^2]}. \quad (9)$$

Furthermore, if the scale factor R remains constant at $R = 1$ during the travel time of the light ray, equation (9) becomes

$$dL = \frac{dr}{1 + (r/2r_0)^2} \quad (10)$$

which integrates to

$$L = 2r_0\tan^{-1}(r/2r_0). \quad (11)$$

Equation (11) of general relativity relating physical and coordinate distance is the same as Moon and Spencer's equation (1) relating real and apparent distances, both in a closed universe.

The same general relativity that yields (11) under the conditions mentioned above, also requires that the density of the matter in the universe be enough to limit the universe to a radius of space-time curvature in the present epoch to r_0. That density is, from general relativity[9]

$$\rho_0 = \left(\frac{3c^2}{8\pi G r_0^2}\right)k + \left(\frac{3}{8\pi G}\right)\left(\frac{1}{R}\frac{dR}{dt}\right)_0^2. \quad (12)$$

The density at earlier or later times is given by $\rho(t) = \rho_0/R^3(t)$ as the universe expands or contracts. However, comparing equation (12) with ρ_{static} from equation (2) we see that

$$\rho_0 > \rho_{static}. \quad (13)$$

The density required to produce a closed universe as small as Moon and Spencer propose has to be greater than the density to close the static universe model. But we already found that this density is dozens of orders of magnitude greater than the measured density.

Let us examine the mathematics of the model. The universe will expand during the travel time of light from astronomical sources. Therefore R is *not* a constant during the integration of equation (9) as Moon and Spencer must have, so equation (11), the Moon and Spencer equation, does *not* result. The key equation upon which their work is based is gone.

The maximum radius that Moon and Spencer's closed expanding universe eventually reaches can be shown to be[10]

$$r_{max} = r_0[1 + (r/c \times dR/dt)^2{}_0], \qquad (14)$$

and the total time it takes such a universe to expand to its maximum size, if it began its expansion from a point is[11]

$$t_{max} = \pi/2 \cdot r_{max}/c = \pi r_0/2c[1 + (r/c \cdot dR/dt)^2{}_0]. \qquad (15)$$

A zero subscript means the quantity is to be evaluated in the present epoch. Let us classify this expansion time according to the magnitude of the last term in brackets in equation (15).

If $(r_0/c) \cdot (dR/dt)_0 \leqslant 1$, then t_{max} is $r_0/2c = 15.71/2$ years. The universe of Moon and Spencer would expand to its maximum size in less than eight years, even if the expansion started from the smallest possible dimension, a point. From symmetry, the contraction phase would last the same time. In that time, the Moon and Spencer universe would contract back to a point.

Moon and Spencer did not propose that the universe began expanding from a point eight years ago, and neither do creationists who use their distance formula (1). However, such a universe really would have a lifetime of only 15.71 years—about eight years for expansion plus eight years for contraction. If the universe was not created as a point, but was created with finite size, its lifetime would be less. Thus, 15.71 years represents the upper limit on the lifetime of Moon and Spencer's universe. We do not have to add the expansion effect onto the model universe; it *is* the model. Moon and Spencer's 15.71 light years in size lasts only 15.71 years of time, and that is 15.71 years of physical time, our time, real time. Thus we can exclude the case $(r_0/c) \cdot (dR/dt)_0 \leqslant 1$.

If $(r_0/c) \cdot (dR/dt)_0 > 1$, then $(dR/dt)_0 \geqslant c/r_0 = 1/5$ or 20% per year. This rate of expansion would mean the universe is presently expanding at the rate of 20% per year. This rocketing expansion is *not* observed. Such expansion would be even greater earlier, so the universe would be no more than 1/20% = 5 years old at present, even if it began its expansion from the smallest possible size, a point!

The physical content of the above inequalities is clear. A universe with matter packed densely enough to produce a 15.71 light year size for that universe will have to be expanding very rapidly to overcome the tremendous gravitational attraction. One would have to go back in time only a few years to find it the size of a point.

We must also note that in such a dense, small universe as the Moon and Spencer universe, the physical speed of light is *not* constant. Light travels along a null geodesic, ds = 0, so from the Robertson-Walker metric of equation (4)

$$c\,dt/R(t) = dr/[1 + (r/2r_0)^2] = dL$$

or

$$dL/dt = c/R(t). \qquad (16)$$

Hence, the physical speed of light, dL/dt, changes, where L is the Moon and Spencer physical distance as given by their equation (1). Thus, the travel time of light from the distant stars in Moon and Spencer's universe is *not* equal to their physical distance in light years. Of course, the maximum time of travel for light from the most distant star can be no greater than the 15.71 year lifetime of the Moon and Spencer universe, but that is little comfort to anyone.

This speed of light consideration would go in favor of creationists if R = 1 = constant, if somehow there could be a universe with our average mass density whose expansion was small or zero. However, such a universe *cannot exist* according to the theory of general relativity (curved Riemann space-time) whose physical distance formula Moon and Spencer looked to for their model universe.

A final criticism of the Moon and Spencer model universe will be presented here, although it holds equally for all of the model universes discussed. That criticism centers on the interpretaton of the lengths L and r in the key Moon and Spencer equation (1). Creationists[12] have interpreted Moon and Spencer's distance r in that equation to mean the actual distance to a star that an astronomer determines when he makes his best measurement. The astronomer could make a perfect measurement if he would simply stack meter sticks end to end from the earth to the star. In that case, the distance to the star would be r, the apparent distance, the distance we think it is to the star. Creationists interpret the true distance—different from the number of meter sticks from here to there—as th eapparent distance somehow altered by the curvature of space-time. This altered distance is the L in the Moon and Spencer equation (1).

General relativity, which provides equation (1), contrasts sharply in the interpretation of these symbols. According to general relativity, r in equation (1) is only a numerical parameter called the coordinate distance, and L is the physical distance.[13]

Moon and Spencer make the non-physical r in equation (1) bear the role of the distance to the star, while this distance is actually the L of that equation. They make the physical distance L of equation (1) play the role of some non-physical equivalent distance distorted by the curvature of space-time.

(C) k = −1

In this case equation (4) yields for the physical distance

$$L = 2r_0 \tanh^{-1}(r/2r_0) \qquad (17)$$

and there is no maximum distance. There is no finite radius to the universe. It goes on forever in both space and time. It is expanding so fast that it will never stop. This model universe has no relation to Moon and Spencer's work.

Conclusion

Moon and Spencer's 15.71 light year model universe is not compatible with the real universe. Their model universe is far too dense, and far too short-lived to be real. Creationists should not use such a bad model for the universe in support of a short travel time for the speed of light from the distant stars as a solution for the light from the distant stars paradox.

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4. *Ibid.*, equation (11).
5. Adler, Ronald J., Maurice J. Bazin, and Menahem Schiffer, Introduction to general relativity, 1975. McGraw-Hill, New York, p. 430.
6. *Ibid.*, p. 393.
7. The curvature of space-time cannot be relied upon to cancel out this result. The curvature effect is negligible over distances of only one light year. Therefore, it does not matter whether one uses straight or curved distances within the nearest light year to calculate the local mass density of the universe.
8. Adler, Bazin, and Schiffer, *Op. cit.*, p. 406.
9. *Ibid.*, p. 432, equation (13.18c).
10. *Ibid.*, section 13.3.
11. *Ibid.*
12. Slusher, *Op. cit.*, Niessen, *Op. cit.*
13. Adler, Bazin, and Schiffer, *Op. cit.*, p. 187.

PANORAMA OF SCIENCE

Ultraviolet Light Thrown onto Origins?

Recent reports of research by Joel S. Levine and others at the Langley Research Center and by V. M. Canuto and C. Imhoff at the Goddard Institute for Space Studies into ultraviolet radiation from the Sun contain evidence which could be devastating to the old reductionist model of the Earth's early atmosphere.[1]

Levine reported: ". . . the overwhelming majority of chemical evolution experiments since the first in 1952 may have been conducted with the wrong atmospheric mixture." This is a strong statement that cannot have been made lightly. It is backed by C. Imhoff's measurements of ultraviolet radiation from a half-dozen young sun-like stars. Imhoff found that these stars were emitting orders of magnitude more ultraviolet than was previously supposed. Therefore: ". . . ultraviolet radiation at the Earth from the young Sun may have been up to 100,000 times greater than today. The previous (uniformitarian) assumption was that the ultraviolet radiation from the young Sun was roughly comparable to today's level. Oxygen in the Earth's atmosphere may have been at least 1 million times greater than anyone ever thought . . . (however) calculations indicate that levels of ozone in the early atmosphere were insufficient to protect the surface of the Earth from enhanced levels of solar ultraviolet radiation."

Recent photochemical calculations by Levine and others at Langley have the Earth's early atmosphere composed of carbon dioxide, nitrogen, and water vapor (all of volcanic origin) at the time when the (supposed) "precursors of living systems" were first formed. Moreover, both methane and ammonia would have been extremely short-lived. Thus the atmosphere of methane, ammonia, and hydrogen, previously supposed to have existed, "was photo-chemically unstable if it existed at all."

A quotation from Levine is of especial interest here. "In the case of our calculated oxygen levels, one bit of evidence from the early geological record supports our conclusions. It was puzzling (to geologists who accepted the reducing atmosphere which Oparin[2] suggested existed at first); but geologists know from their analyses of the earliest known rocks that the oxygen level of the early atmosphere had to be much higher than was previously supposed. Analyses of these rocks, estimated to be more than 3.5 billion years old, found oxidized iron in amounts that called for atmospheric oxygen levels to be at least 100 times greater and perhaps up to 1 billion times greater than otherwise accepted. . . . High levels of ultraviolet radiation must have had a very important impact on the origin and evolution of life."

Moreover, seeing that determination of age by radioisotopes is not as accurate as it is often claimed to be,[3] perhaps the oldest PreCambrian red beds, which are composed of hematite, are of sufficient age to provide support for Levine's hypothesis.

It appears as if echoes of Yockey continually return to haunt us with increasing vigor. As he said: "The 'warm little pond' scenario was invented *ad hoc* to serve as a materialistic reductionist explanation of the origin of life. It is unsupported by any other evidence, and it will remain *ad hoc* until such evidence is found. Even if it existed, as described in the scenario, it nevertheless falls very far short indeed of achieving the purpose of its authors even with the aid of a *deus ex machina*. One must conclude that, contrary to the established and current wisdom, a scenario describing the genesis of life on Earth by chance and natural causes which can be accepted on the basis of fact and not faith has not yet been written."[4]

Robert H. Dott, Jr., speaking as President of the Society of Economic Paleontologists and Mineralogists in a recent address re-defined the notion of uniformitarianism, apparently for the benefit of the scientific creationists.[5] He made at least two references to creationists, indicating that the "neocatastrophist-creationist cause" is definitely influencing the thinking of at least a few open-minded scientists.

I suggest that a challenge to the scientific establishment offered by the scientific creationists has done much to reopen long-closed doors of scientific inquiry. Perhaps now a greater percentage of scientists will be less intimidated by the unscientific (in the true sense of the word) attitude displayed by certain members of the academic community, so that science may once again make the bold strides characterisitc of nineteenth-century science at its best.

Contributed by Mr. R. L. Mandock

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