## MINISYMPOSIUM ON THE SPEED OF LIGHT—PART III

# ON SMALL CURVED-SPACE MODELS OF THE UNIVERSE

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**Abstract**

*Moon and Spencer's model of the universe does have serious deficiencies. However, it is possible to construct alternative small, curved-space models of the universe that avoid these shortcomings. Thus a more sophisticated analysis is required before such models can be definitely eliminated.*

### Introduction

Many creationists have wrestled with the problem generated by the apparently large size of the universe: if the distant galaxies are really billions of light years away, does this not imply that their light must have traveled for billions of years to reach us now? And how is this to be reconciled with the notion of a young universe?

The implied large age of the universe rests essentially upon these main assumptions: 1. The large distances of the galaxies are (at least roughly) correct. 2. The speed of light is constant in time and space. 3. The light we see has actually traveled from the stars where it appears to originate. Attempts to "save" the traditional Biblical chronology have generally been based on challenging one or more of these assumptions.

In 1953 Moon and Spencer proposed a cosmological model that postulated much smaller distances for the galaxies. Many creationists have since cited this paper in support of a young universe. Recently the Moon and Spencer model has been severely criticized (Akridge, 1984; Phillips, 1988). In this paper we shall see that while this model has serious shortcomings, it is possible to construct a more viable alternative.

### Elliptic Space

Moon and Spencer (1953) assumed that space remains Euclidean for material objects but is elliptic for light. Thus they accept the astronomical distances for galaxies but, upon assuming a constant positive curvature of five light years, the maximum light travel time is at most about 15 years. In essence this model postulates that light covers the distance from the distant galaxies at a speed much greater than the local speed of light.

The theory raises a few problems. In the first place it does not seem physically realistic to have Euclidean space for material objects while having elliptic space for light. Furthermore, if light were to travel in elliptic space we would expect to see other observational consequences. For example, the apparent luminosity distance L would be given by*

$$L = R \sin(r/R) \tag{1}$$

where R is the radius of curvature and r is the "actual" or radar distance. For small values of r/R this yields an L almost equal to r, but as r increases it becomes much larger than L. Thus the apparent distances of the galaxies based on their luminosity (implicitly assuming the Euclidean inverse square law) yield an **underestimate** of the actual distances. It follows that all astronomical objects should, in this theory, have apparent luminosity distances of less than R, or 15 light years. Since this is not observed the Moon and Spencer model must be rejected, or at least drastically modified. Moon and Spencer do refer to a further paper, entitled "Riemannian Space for Astronomy," where some of these difficulties would presumably be overcome. However, I have searched the literature without having been able to find this paper. I doubt that it was published.

### Hyperbolic Space

It is evident that the model must generate apparent distances that are larger than the actual distances. To do this it is necessary to appeal to hyperbolic, rather than elliptic, space. Generally, distances can be measured by four methods: by radar, by apparent size, by apparent luminosity, and by trigonometric parallax. Radar measurements are feasible only within the solar system. The distances obtained via apparent size and apparent luminosity are both the same for a hyperbolic space of constant curvature and are given by

$$L = R \sinh(r/R) \tag{2}$$

Thus, for example, if the radius of curvature R is 50 light years (ly) then a galaxy at, say, 1000 ly will have an apparent luminosity distance of 12 billion ly. The parallax distance P is

$$P = R \tanh(r/R) \tag{3}$$

However, this is the absolute parallax. In practice only the relative parallax is calculated: parallactic movement is measured with respect to the background stars which are assumed to be at infinity. The relative parallax P' is

$$P' = R \tanh(r/R)/[1 - \tanh(r/R)] \tag{4}$$

The variations of L, P, and P' with r/R are given in Table I.

It is evident that L and P' begin to differ significantly when r/R is about 0.2. Parallax can be measured accurately (to within roughly 10%) only to about 100 ly. For an r of 100 ly and an (r/R) of 0.2, this corresponds to a curvature of 500 ly. Any curvature less than 500 ly should thus be detectible. If the distant stars are to be at most 6000 ly away then R must be a maximum of 320 ly. Since this is less than the critical number it follows that this model can be observationally tested.

*The following formulae can be readily derived from elliptic and hyperbolic trigonometry as found, for example, in M.J. Greenberg. 1980. *Euclidean and Non-Euclidean Geometry* (second edition). W. H. Freeman. New York.

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**Table I. Actual distances versus apparent distances in hyperbolic space.**

| *r/R* | *L/R* | *P/R* | *P'/R* |
|---|---|---|---|
| 0.01 | 0.01 | 0.0099997 | 0.0101 |
| 0.1 | 0.10017 | 0.09967 | 0.111 |
| 0.2 | 0.2013 | 0.197 | 0.246 |
| 0.4 | 0.411 | 0.38 | 0.613 |
| 1.0 | 1.17 | 0.76 | 3.19 |
| 2.0 | 3.6 | 0.964 | 27 |
| 5 | 74 | 0.999 | 11012 |
| 10 | 11013 | 1.0 | ∞ |
| 20 | $2.4 \times 10^8$ | 1.0 | ∞ |

However, I have assumed the curvature to be constant throughout space. One could modify this assumption and postulate a more general situation where the curvature is allowed to vary with distance. One could then obtain a "fit" with the observations by, for example, letting the curvature become appreciable only at distances beyond, say, 100 ly.

### General Relativity

The Moon-Spencer model was criticized by Akridge (1984) because its curvature would require much too high a density, as calculated via general relativity. Akridge also claims that Moon and Spencer "borrowed" their distance formula from general relativity. But this is not the case. Their formula, as well as the ones above, is derived from non-Euclidean geometry on the assumption of constant curvature. It is true that these formulae are also used by general relativity. However, the distinctive feature of general relativity is the further assumption that the curvature is entirely due to the matter-energy content of the universe and that an empty universe would have zero curvature.

It is evident that Moon and Spencer did not accept this general relativistic origin of the space curvature. Indeed, one could ask why the curvature of empty space should necessarily be zero; it can as well be assumed that empty space has an inherent non-zero curvature. Since the proposed curvature is very small it cannot be tested in the laboratory but only via very large-scale effects. In following this approach one need not completely reject general relativity. It could be modified by postulating that the matter-energy content of the universe superimposes a curvature on the initial (non-zero) curvature of empty space.

In the light of the above comments and the further fact that general relativity is merely one of a number of competing dynamical theories, it must be concluded Akridge's general relativistic criticism of curved-space models is inadequate.

### The Red Shift

Thus far I have implicitly assumed the universe to be static. If the red shifts of distant galaxies are accepted as reflective of actual radial motion then the equations for distances from apparent luminosity and apparent size will have to be corrected by factors of (1 + z) and 1/(1 + z) respectively*, where z is the fractional red-shift. Then the most distant galaxies are receding from us at close to the speed of light. For a universe of age 6000 years this implies that, assuming the speeds to be constant, the most distant galaxies must be at a distance of at least 6000 ly. Otherwise we get a singularity after creation. Taking into account the travel time for light it follows that the most distant galaxies currently observed must have been at least 3000 ly distant at the time of light emission.

Note that in this model the red shift is proportional, not to the actual distance, but to the apparent distance. Hence, upon extrapolation into the past, we do not obtain a big-bang situation where all the material was at one point at one time. It should be possible to test this case by observing the variation of the apparent distances of distant galaxies. If they really are fairly close then their apparent magnitudes should decrease significantly over a relatively short timespan.

However, one could also consider the possibility that the redshift is caused by something other than recessional motion. Various alternatives have been proposed: (1) "tired-light" theories (La Violette, 1986), (2) photon decay due to space curvature (Crawford, 1979), or (3) gravitational redshifts due to a massive second center of the universe (Ellis, 1978). In the latter case the curvature would vary with distance in such a way that space would initially be hyperbolic but would become elliptic as we approach the second center at the most distant part of the universe.

### Isotropy and Homogeneity

In this model the distant galaxies are much more closely packed than the near ones. This is directly contrary to the Cosmological Principle that underlies most modern cosmologies (e.g. the Robertson-Walker models). The Cosmological Principle asserts that the universe is spatially homogeneous (i.e. it is roughly the same everywhere in space).

The observations, however, yield direct evidence only for isotropy (i.e. as seen from the earth the universe appears to be spherically symmetric). The concept of homogeneity is based more on philosophical presuppositions than on empirical considerations. According to cosmologist G.F.R. Ellis (1975, pp. 249-50) it is fundamentally due to the Copernican-Darwinian revolution in our understanding of the nature of man and his position in the universe. He notes that:

> It would certainly be consistent with the present observations that we were at the centre of the universe, and that, for example, radio sources were distributed spherically symmetrically about us in shells characterized by increasing source density and brightness as their distance from us increased. Although mathematical models for such Earth-centered cosmologies have occasionally been investigated, they have not been taken seriously; in fact the most striking feature of the radio source counts is how this obvious possibility has been completely discounted. The assumption of spatial homogeneity has inevitably been made, and has led to the conclusion that the population of radio sources evolves extremely rapidly. What has therefore happened is that an unproven cosmological assumption has been completely accepted and used to obtain rather unexpected information about astrophysical processes.

*See, for example, Steven Weinberg. 1975. Gravitation and Cosmology. John Wiley. New York. p. 423.

In the big-bang cosmologies philosophical considerations lead to the assumption of spatial homogeneity, which is "saved" from observational falsification by purely *ad hoc* assumptions regarding the rapid evolution of radio sources. In the curved-space model this assumption is not needed and we retain only the observed spherical symmetry of the universe.

Ellis refers to "earth"-centered models of the universe. But this does not necessarily mean that we have to limit ourselves to strictly geocentric models. The observationally determined spherical symmetry would be viable also if we choose the center to be at the Sun or some other relatively near position.

### Conclusion

I have given a rough sketch of how a curved-space cosmology could be modified so as to explain the observational evidence in terms of a relatively small universe. The prime motivation has been to demonstrate that it is possible to explain the empirical data in more than one way. It may be argued that the curved-space model can be "saved" only via a number of *ad hoc* assumptions. However, the same consideration applies also for the big-bang cosmologies. The difficulty faced in cosmology is that we can directly observe only a minute portion of space-time. To draw cosmological conclusions from these limited observations requires drastic simplifying assumptions and extrapolations. Since more than one model can account for the observations it is crucial that objective criteria be established that enable us to choose the "best" theory. But even the establishment of such criteria is a very subjective process in which we are strongly guided by our prior philosophical and religious commitments.

Thus I conclude that the possibility of constructing viable, small curved-space models of the universe has been too easily dismissed. A more detailed analysis of the various observational implications of such models and an assessment in the light of clearly expressed theory selection criteria are necessary before they can be definitely invalidated.

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# CRITICAL THOUGHTS AND CONJECTURES CONCERNING THE DOPPLER EFFECT AND THE CONCEPT OF AN EXPANDING UNIVERSE—PART I

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### Abstract

*The main evidence for the various "expanding universe" cosmologies is drawn from the red shifting of the spectral lines in the light emitted by galaxies, quasars, and other extraterrestrial objects. It is demonstrated that there are many mechanisms which can cause red shifts, and that the current interpretation of these red shifts yields absurd conclusions concerning the nature of the universe. The result is that the basic evidence for the "expanding universe" cosmologies is shown to be the result of misinterpretation of these red shifts, thereby undermining the concept that the universe originated in some primordial explosion.*

### Introduction

The nature of red shifts in the line spectra of extragalactic objects, such as galaxies, quasars, and radio stars will be examined and it will be demonstrated that these shifts are not necessarily Doppler effects. Other mechanisms will be offered as explanation for these line shifts. Consequently, the evidence usually offered as proof that the universe resulted from some primordial "big bang" will be shown to be inconclusive and largely subjective.[a]

### The Nature of the Doppler Effect— The Basic Premise of an Expanding Universe

Light, indeed all electromagnetic radiation, consists of transverse waves. If light is formed by the excitation of the electrons of an element the spectra of that light will appear as bright lines. The position of these lines is predictable and distinct for every element, that is, they always appear in the same place on the spectrum. Often the light from a star will contain dark lines. These are formed as the radiation from the star's surface passes through its atmosphere, which will absorb different frequencies of the light, blanking those frequencies from the star's spectrum, causing them to appear as dark lines. (Figure 1)

If a light source approaches an observer at high speeds, these dark and bright lines will change their position in the spectrum and be displaced towards the blue end of the spectrum (i.e. they will become blue shifted). If the light source is receding, the lines will be displaced toward the red end of the spectrum (red shifted). This shifting effect, as caused by the recession

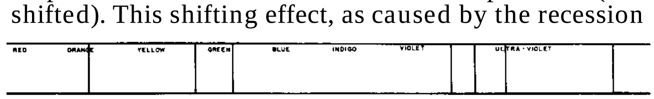


**Figure 1. Typical line spectra for an element.**

[a]Other problems concerning the big bang hypothesis have been detailed in past CRSQ articles and more recently in the CRS Monograph No. 2, *Design and Origins in Astronomy* (The Editor).

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