The Age of the Astronomical Universe

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One of the major points of disagreement on scientific matters among Christians who reject the general theory[1] of biological evolution as scientifically untenable is to be found in the differing views they hold concerning the age of the universe. For some time American creationists[2] in such organisations as the Creation Research Society and the Institute for Creation Research have argued very vigorously for the young universe view in which Genesis 1 is interpreted as stating that the entire universe, including on the one hand all stars and galaxies and on the other hand man, was formed by God in a series of purely miraculous acts in the time span of six successive 24-hour days. More recently this interpretation has been adopted by some members of the Australian based Creation Science Association. When this interpretation is coupled with the belief that the genealogies of Genesis are complete it follows that the entire creation is younger than 10,000 years. Such a viewpoint of necessity requires a radical re-interpretation of astronomical data and theory, since it is not possible to hold to the idea that the universe is young and to assert in a straightforward way that for example, the Andromeda galaxy is distant two million light-years from the solar system. In the first part of this article I shall examine some of the ways by which adherents of mature creationism[3] have endeavoured to re-interpret astronomy in order to be able to hold to their young universe view. In the second part I shall discuss the relevance of the isochron method of radioactive dating of astronomical objects, particularly meteorites, for the determination of the age of the universe. In both parts I shall be particularly concerned with the views of Barry Setterfield, who in a series of articles published in **Ex Nihilo,** the journal of the Creation Science Association, claims to have discovered empirical evidence that would enable the young universe view to be reconciled with the astronomical distance scale and also with the data used as the starting point for the 4.6 billion year estimate of the age of the solar system by the method of radioactive decay.

THE CONFLICT BETWEEN ASTRONOMY AND THE YOUNG UNIVERSE THEORY

The conflict between conventional astronomy and the young universe theory may be stated very clearly in the following way. If (i) current ideas concerning the propagation of light are correct, in particular that light travels with uniform speed in the same universe in which material particles move; if (ii) some astronomical objects are at distances of the order of millions or even billions of light years from our galaxy and (iii) if the light that we see on looking into the night sky actually came from the objects in question, then the universe must be thousands of millions of years old. The force of this argument is admitted by those who hold to the idea that the universe is less than 10,000 years old, and they have sought to evade its consequence by asserting that one or more of these three premises is wrong. Even though everybody acknowledges that estimates of big astronomical distances may be in error by factors greater than two, very few people who hold to the young universe view have sought to overcome the conflict by denying the large distance scales.

Consequently, the usual way that the conflict between astronomy and the young universe theory is resolved by those who hold the young universe view is either (a) to assert that the light we see apparently from distant galaxies was created with the appearance of age or (b) to assert that current ideas concerning the propagation of light are incorrect.

LIGHT CREATED WITH THE APPEARANCE OF AGE

Whitcomb and Morris, in their book **The Genesis Flood**[4], argue that of necessity the photons of light energy were created at the same instant as the stars from which they were apparently derived.[5] Whitcomb and Morris fail to see that their viewpoint entails that the exciting sequences of events such as explosions in galaxies, systematic variation of light from variable stars in the Magellanic Clouds and out-

bursts in quasars that are seen by astronomers in fact never happened at all on the objects from which this light appeared to come. The idea of light being created with the appearance of coming from the distant galaxies is in fact another way of saying that this light did not originate from the apparent sources. Such a view of necessity involves God as presenting us with data that are deceptive and as such is in direct conflict with the Biblical data that emphasizes the faithfulness and reliability of God.[6] It has been my experience that some people who believe in creation of light with the appearance of age are quite unable to face up to this matter, so let me give a concrete example of what is involved. On 5th March, 1979, Russian astronomers[7] detected a significant burst of gamma rays that apparently had their origin in the Large Magellanic Cloud. Photographs taken by optical astronomers revealed an unusually large event in this Magellanic Cloud. However, since the Magellanic Clouds are more than 100,000 light years from the earth, those people who use the argument that light is created apparently coming from the stars will have to say that no such event really took place in the Large Magellanic Cloud, for otherwise they would be asserting that the event took place there over 100,000 years ago. They are thus saying that the gamma ray burst was not a real event in the Large Magellanic Cloud, in other words that it is only an appearance, not a reality.

It is encouraging that an increasing number of people who hold to the young universe view have recognized that the hypothesis of light being created with the appearance of age is inconsistent with the scriptural idea of the faithfulness of God and have therefore rejected this hypothesis. Paul M. Steidl writes: —

Some Christians maintain that since by this reasoning we could never know that other galaxies existed, God made special provision for us so that man could see them, by creating the universe with the appearance of having been running for a long time. This much I agree with. But they then say that this includes the light from distant objects as well, that is, the light from astronomical objects was created en route to earth already, never having really been at the object from which it is supposed to have come. If we see an event in a distant galaxy, for example, a supernova, the light from that supernova was actually created fairly near the earth and was never really at the supernova. In fact, the supernova would have to have happened before the beginning of the universe! It never really happened. This is the conclusion we are forced to if we assume that light was created en route to earth instead of actually having originated at the luminous object. If the events never really happened, maybe the galaxies don't even exist,

only their light. Maybe God is fooling us into believing there is something there when there really isn't.[8]

Steidl goes on to say: — *Obviously we must reject this hypothesis. First, God would not* deceive *us in this way; it is contrary to his nature.*[9]

If the idea of light being created with the appearance of age is rejected, there only remains the possibility that conventional ideas concerning the propagation of light are incorrect.

MOON AND SPENCER S IDEA OF LIGHT PROPAGATING IN A RIEMANNIAN SPACE

Many people who hold to the young universe view have found it convenient to take up the idea propounded by Moon and Spencer[10] that while astronomical space remains Euclidean for material particles (the purpose of Moon and Spencer's paper was to oppose Einstein's theory of relativity), light is considered to travel in a Riemannian space with constant curvature of 5 light years so that light from the most distant galaxies would reach us in 15.71 years. Moon and Spencer promised another paper which would deal with the mathematics of this assumption. An exhaustive search with the aid of the **Science Citation Index** revealed that no such paper was ever published. The reason for this is hardly surprising: the very able mathematical physicist[11] who reviewed Moon and Spencer's paper for **Mathematical Reviews** confessed that he was completely unable to understand what Moon and Spencer were talking about. Moon and Spencer in fact overlooked a whole host of difficulties with their idea. For example, light would in fact travel to us in two opposite directions so that we should see everything duplicated. This is certainly not observed and so we may safely reject the view of Moon and Spencer.

SETTERFIELD'S VIEW THAT THE SPEED OF LIGHT HAS BEEN DECREASING

The only possibility really left open for anyone who holds to the young universe view is that the speed of light has not been constant and was in fact greater in the past. From time to time various authors have claimed to have detected a systematic variation in the measured value of the speed of light, but for the most part such claims have not been taken very seriously in view of the fact that until just after the second world war, when the radar method became available, the errors in the measurement of speed of light were too big to permit anything much to be said about systematic trends. Nevertheless, in a series of articles published in **Ex Nihilo,**[12] the publication of the Creation Science Association of

Australia, Mr Barry Setterfield claims to have detected a systematic decrease in the value of the speed of light obtained from the earliest measurements by Roemer and Picard in the late seventeenth century. Moreover, Setterfield claims that the data fit almost perfectly to only one theoretical curve and that no other theoretical curve fits the data as well. On this basis Setterfield has used his theoretical curve to extrapolate backwards in time and he claims that the speed of light six thousand years ago was five hundred thousand million times faster than the current value of the speed of light. If this were true, light from the furthest part of the galaxy would have been able to reach the earth within twenty-four hours, and light from the furthest part of the universe would reach us in six thousand years.

Moreover, because the speed of light is such a fundamental physical quantity, a number of other physical quantities, in particular, radioactive decay rates, would also have to vary. Radioactive decay rates would, according to Setterfield, vary in the same way as the speed of light (although the energy released in any such decay would be a constant independent of time). This would then have the consequence that the ages of rocks or meteorites or lunar rock samples would come out very high to anyone who calculates ages on the basis of constant decay rates. Thus Setterfield claims to have found a fundamentally new physical phenomenon which has as its consequence a complete harmonization of the young universe view with all existing physical data that have been thought to require a long time scale for the universe.

EXAMINATION OF SETTERFIELD'S CLAIMS

It it therefore of considerable importance to examine Setterfield's claims very carefully. If true, they would have revolutionary consequences for currently held physical theory. Originally[13] the heart of Setterfield's view was his claim that the coefficient of determination for the fit of the light velocity data to his theoretical curve is one to nine decimal places. The coefficient of determination is a number between zero and one which is calculated from the observed data and the form of the theoretical curve. A value of one indicates a perfect fit with every observed point lying exactly on the theoretical curve, whereas a value near zero indicates a very poor fit. Thus a value of one to nine decimal places indicates a near perfect fit.

For some time I simply accepted Setterfield's claim (repeated several times in his articles and in his replies to letters sent to **Ex Nihilo** in response to his articles) concerning the value of the coefficient of

determination for the fit of the data that he used to his theoretical curve. However, on looking more carefully at the graphs that he published showing both the data points and the theoretical curve, I became suspicious that his coefficient of determination could not be so close to one since there was quite an amount of scatter shown in these curves. I therefore calculated the coefficient of determination for the fit of his curve to the data he gave for the speed of light before 1960, since this is the period for which Setterfield claims the speed of light has varied (he in fact claims that the speed of light has been constant since 1960 and this has the interesting effect that an infinite number of derivatives of his theoretical curve of fit are discontinuous at 1960). My first calculation was carried out on a Hewlett-Packard HP-65 programmable pocket calculator which displays ten significant digits but which works internally to fourteen digits. To my surprise I found that the coefficient of determination was only 0.98634. I noted that in order to carry out the computation by a direct application of the standard formula it was necessary to subtract numbers that were very close to one another, causing a substantial loss of significant digits. In order to check this calculation I programmed it on the Cyber machine at the University of Sydney Computer Centre (the Cyber works to fourteen decimal digit accuracy in single precision). The result from this calculation was again 0.98634. The accuracy of my calculation can be checked easily by anyone who has access to a scientific calculator or a computer which works to fourteen or more significant decimal digits. Indeed by an application of the rules for the shift to the mean this calculation can be checked with an ordinary scientific calculator. I therefore conclude that Setterfield and his colleague who did the calculation made a computing error.

In a later issue of **Ex Nihilo**[14] Setterfield has admitted that a mistake was made in his original calculation of the coefficient of determination of his theoretical curve, a log sine curve. In this new paper he has given more details of how he fitted the light speed data to his curve, in particular, how he determined the time at which his postulated decay in the speed of light began. This he did by varying the time of the beginning of the decay and choosing the time which gave the highest value for the coefficient of determination. On this basis Setterfield then claimed that the correct value of the coefficient of determination is 0.998 based on a data of 4082 BC for the beginning of the decay. He also continued to claim that the log sine curve gives a higher value for the coefficient of determination than any other curve. Both of these claims are false.

In the first place I recalculated the coefficient of

determination for Setterfield's data prior to 1960 for his log sine curve based on 4082 BC as the beginning of his postulated time of decay. Note carefully that inclusion of data beyond 1960, the time at which Setterfield admits that the speed of light is measured to be constant, would have the effect of decreasing the coefficient of determination, because in order to get one straight line on a log sine basis the speed of light would have to increase again after 1960. This calculation was also carried out on the Cyber at the University of Sydney. I found that the coefficient of determination was again 0.98634, in other words, that the different decay origin time made no noticeable difference to the coefficient of determination.

With regard to the second claim, there is a curve which gives a higher value for the coefficient of determination for the pre-1960 data than the log sine curve, namely, a simple parabola originally proposed in letter to **Ex Nihilo**[15] by Dr Peter Cadusch of the Applied Physics Department, Swinburne Institute of Technology. Dr Cadusch suggested that the light speed data before 1960 would be fitted just as well by the simple parabolic curve

$$c(T) = c(1960) + b(1960 - T)^2$$

where b is a constant, T is the date in years A.D. and c(T) is the speed of light measured at time T. It is apparent from Setterfield's latest paper that he has never examined the fit of his data for this curve. When I calculated the coefficient of determination for Dr Cadusch's parabola I obtained a value of 0.98644 which is marginally higher than the 0.98634 obtained for the log sine curve.

On Setterfield's original basis one should use the curve with the higher coefficient of determination. However, if the parabolic curve is used one obtains nowhere the increase in the speed of light 6000 years ago that Setterfield claims. An increase of only 220 times is obtained, which is insufficient to be able to reconcile a young universe with the observations.

In Table **2** on p. **43** of **Ex Nihilo,** vol. **5** no. **3, 1983,** Setterfield has a table of values of r^2 as a function of the origin data B.C. It is necessary to point out that **every single value of r^2 given here is wrong!** In fact, every single value of r^2 for this data is **0.98634,** correct to **5** decimal places (the sixth and seventh digits increase linearly from **29** at **4002** B.C. to **47** at **4200** B.C.). I have sent the Editor of **Ex Nihilo** a copy of my computer programs so that he can verify this. Consequently, Setterfield's claims that there are peaks in the r^2 values is completely incorrect.

There are some other false claims that Setterfield has made. In a letter to the Editor of **New Life** (May 4, 1984) he stated that "the data from the post 1870 A.D. plainly shows the drop in c with time." It is interesting that Setterfield has failed to quote the most eminent authority in this field, namely R.T. Birge, who discussed <u>this</u> very issue in his 1941 paper "The General Physical Constants as of August 1941 with details on the velocity of light only", **Reports on Progress in Physics,** vol. 8, pp. 90-134, 1941. In Section A, pp. 92-101, Birge gave a thorough discussion of the view of de Bray (cited favourably by Setterfield) that the speed of light had been decreasing. Birge's final conclusion (based on extensive discussion) is ". . .the assumption of a **constant** value of c (for the period 1875 to 1940) **is** consistent with all the experimental evidence, when the probable error of each result is taken into account" (p. 100, emphasis by Birge).

Another claim by Setterfield that I suspect to be false is that the log sine curve occurs in the behaviour of some spinning tops. I have searched in the relevant literature and I have not been able to find anything of this nature. I would be most interested to see the reference Setterfield has in mind here.

Up to this point I have simply assumed for the sake of discussion that the data on light velocities used by Setterfield are correct. However, there is serious reason to question this assumption. A comprehensive discussion of Setterfield's data has been given by Bounds,[26] who points out that inter alia the value of the speed of light attributed by Setterfield to Roemer in 1675 is seriously in error. Setterfield claims that the value is 301300 km per second plus or minus 200 km per second. The authority given for this figure was the popular astronomy journal **Sky and Telescope** of June, 1973 (p. 353), and Setterfield presents the reference in such a way as to imply that the author of the **Sky and Telescope** article reworked a selection of Roemer's data. In point of fact the **Sky and Telescope** item was nothing more than a reference to the paper 'On the velocity of light three centuries ago' by S.J. Goldstein Jr., J.D. Trasco and T.J. Ogburn III published in the **Astronomical Journal,** vol. 78, no. 1, February 1973 (pp. 122-125). Goldstein, Trasco and Ogburn analysed a series of forty observations of the times of ingress or egress of Jupiter's satellite Io into or from Jupiter's shadow made by Roemer and Picard at Paris Observatory from 1668 to 1678. The method used by Goldstein, Trasco and Ogburn was to compare each of these observations with predictions based on modern orbits for Io, the Earth and Jupiter, using a modern (radar determined) radius for Jupiter. The speed of light was then determined by a least squares fit between the observed and predicted eclipses. A byproduct of this analysis is an estimate of the accuracy of Picard and Roemer's observations by the

value of the root-mean-square (r.m.s.) deviations between prediction and observation.

Goldstein, Trasco and Ogburn plotted the graph of the r.m.s. residuals versus the light travel time across the diameter of the Earth's orbit. What is immediately obvious from this graph is that the best fit (least residuals) 'occurs at zero where the light travel time is identical to the currently accepted value'.[17] A little later in the last paragraph of their paper Goldstein, Trasco and Ogburn state[18] 'We conclude that the velocity of light did not differ by 0.5% in 1668 to 1678 from the current value'. Unfortunately Setterfield, entirely without any justification, has changed these two statements into a claim that the speed of light in 1675 was 0.5% higher than the present value. This completely distorts the conclusion of Goldstein, Trasco and Ogburn that the best value is in fact identical to the current value. The value of the coefficient of determination for the log sine curve with the current value of the speed of light at 1675 is only 0.266 which is quite low. This by the way contradicts the implicit claim by Setterfield in his letter to the Editor of **New Life** that one disputed value (the '1675' value of c) doesn't alter the validity of his conclusions. Long ago Einstein said, correctly, that no amount of observational agreement with his theory could prove him right, but a single observation could prove him wrong. Now in the first place the correct value for c in '1675', namely, the same as today, makes a dramatic reduction in the value of r^2, indicating that a single changed value has the ability to invalidate the conclusions Setterfield has drawn. In the second place, the '1675' value is quite crucial, since this is the earliest measured value of c. If there was no variation from the current value of c back in 1668 to 1678, when the deviation from the current value would have been largest, then there are very good grounds for rejecting the theory.

In point of fact, the only way that Setterfield can maintain his view is to reject the correctness of the Goldstein, Trasco and Ogburn paper. The only way he can do this is to refer to the work of earlier authors, notably Froome and Essen, who are claimed by Setterfield in his original paper to have reworked Roemer's data and to have obtained a value higher than 301,300 km/sec, thus implying that Froome and Essen used just as detailed and careful an approach as that used by Goldstein, Trasco and Ogburn and that their different value for c makes Goldstein, Trasco and Ogburn's work 'disputed'. In actual fact, as Vivian Bounds has pointed out over two years ago, it is not correct to say that Froome and Essen used a careful detailed approach on the Roemer-Picard data. What Froome and Essen actually wrote was "Delambre (1790) and Glasenapp (1874) obtained values of 986 sec. and 1001.6 sec. for the time lag

and the mean of these values together with the present day value for the diameter of the earth's orbit (2.99 x 10⁸ km) gives a value for c of 303,000 km/sec with an uncertainty of about 2,000 km/sec" (p. 1 of their book **The Velocity of Light and Radio Waves,** London, Academic Press, 1969). Thus in fact Froome and Essen didn't use any of the Roemer-Picard data. In the second place, they made a careless error, since 2.99 x 10⁸ km divided by the mean of 986 sec and 1001.6 sec is not 303,000 km/sec, but in fact 300,865 km/sec, which is in fact lower than the value (301,300 km/sec) that Setterfield used for the '1675' value of the speed of light. Thus since Froome and Essen did not in fact use the Roemer-Picard data and since they made an elementary blunder in the trivial calculation that they did do, they can hardly be claimed to have caused the Goldstein, Frasco and Ogburn work to be 'disputed'.

Because Mr Setterfield's views have been so widely accepted in Christian circles, I believe that it has to be stated clearly that he has been extremely careless in his citations from published work. As noted earlier, he completely reversed the actual conclusions of Goldstein, Trasco and Ogburn, and by attaching the word 'disputed' to their real conclusions he has cast doubt over their scientific accuracy, when in fact the work that he uses to dispute their results has an obvious serious error of calculation.

THE PHYSICAL AND BIOLOGICAL CONSEQUENCES OF SETTERFIELD'S VIEW

Setterfield claims that there are three other means whereby his hypothesis can be tested, namely, variations in other physical constants, changes in radioactive decay rates, and the red-shifts of spectral lines. In the first place, none of the other physical constants are presently able to be measured with the same accuracy as the speed of light, especially before 1960, and so Birge's remarks that I quoted earlier are relevant here, namely, that in view of the probable errors involved, the observations are consistent with the hypothesis that the values of the physical quantities have been in fact really constant. The third reason, the red-shift of light from distant galaxies, is capable of many explanations and is therefore hardly a proof of Setterfield's hypothesis.

The second point, namely, the prediction that radioactive rates were higher in the past, is in fact a very strong reason for rejecting Setterfield's views. In the first place, since he maintains the radioactive decay rates are proportional to the speed of light and since he also claims that the energy carried off in each decay is independent of the speed of light, he cannot allow any radioactive material to be on the

earth's surface at the time of creation of living beings, since the consequent enormous flux of radioactive particles would have completely destroyed the DNA in the cells of living beings. Consequently, he must postulate that all radioactive material was originally deep inside the earth's crust. But this hypothesis has even graver consequences, since it concentrates the distribution of radioactive material. This in turn would lead, through the enormous energy released in less than 6000 years, to the melting of the whole of the earth. Even when released over a thousand million years, this energy from radioactive decay has the ability to melt part of the interior of the earth. I strongly suspect that a 6000 year time span **for the same amount of energy released** would have catastrophic effects on the suitability of the earth's environment for biological organisms (there is a real possibility that this release of energy could vaporize part of the earth).

The naturally occurring fission reactor that existed at Oklo in Gabon, West Africa, places very stringent limits on the variation that could have occurred in the past in the fundamental constants of physics (for example see the paper ''Limits on the variability of coupling constants from the Oklo natural reactor'' by J.M. Irvine, **Phil. Trans. Roy. Soc. London A,** vol. 310, pp. 239-243, 1983. A more general paper on the Oklo natural reactor is the article "A natural fission reactor", by G.A. Cowan, **Scientific American,** vol. 235, no. 1, pp. 36-47, 1976). The main effect of enhanced nuclear reaction rates would be in fact to turn a slow reactor into a bomb (remember that this is the essential significance of a reactor going 'critical') since the same energy is released in a very much shorter time. This in fact did not happen at Oklo, so the existence of the natural fission reactor at Oklo is strong evidence against Setterfield's hypothesis.

SETTERFIELD'S HYPOTHESIS IS WITHOUT FOUNDATION

Because the correct value of the coefficient of determination for the fit of the data to his theoretical curve is 0.98634 and not 0.999999999, because a simple parabolic curve yields a higher coefficient of determination, and in any case because the value that should be used for the speed of light in 1675 is identical to the current value, Setterfield's hypothesis that the speed of light was five hundred thousand million times its present value six thousand years ago is entirely without foundation. Such an extrapolation through nearly twelve orders of magnitude for the value of the speed of light is completely unwarranted. My conclusion therefore is that Christians will have to take seriously the indications

for a very large age of the universe that come from the argument based on the time that light takes to travel from the distant parts of the universe.

RADIOMETRIC DETERMINATION OF THE AGE OF THE SOLAR SYSTEM

In the last part of this article I wish to examine the validity of another method of obtaining an estimate of the age of the solar system, namely, the radiometric method. Before 1968 when I worked for two years on relativistic astrophysics in a low energy nuclear physics laboratory at the California Institute of Technology, I was highly sceptical of radiometric determinations of age because of the difficulty of establishing the initial conditions from which the radioactive rock sample had undergone decay. An example[19] which points up this difficulty is provided by the fact that lava rocks formed in 1800 and 1801 in Hualalai, Hawaii give ages between 169 million years and three billion years by the potassium-argon dating method, whereas the age of the rocks from their laying down is even now only 183 years. Clearly radiometric ages need have nothing to do with the time at which the rock was laid down. This fact is of considerable relevance for the assessment of ages ascribed to fossil bones from East Africa since in many cases an age is assigned to the bones from the radiometric age of the strata in which the fossils were found.

However I found out at Caltech that a rather different situation holds for the dating of meteorites by the rubidium-strontium method, since this method includes a built-in check on the validity of assumptions concerning initial conditions. Donald S. Burnett and Gerald J. Wasserburg have summarized this method as follows (where Rb^{87} st<u>an</u>ds for the isotope of rubidium with atomic weight 87, Sr^{86} the isotope of strontium with atomic weight 86, etc.)

'Generally speaking, Rb and Sr are inhomogeneously distributed in *a meteorite, either due to the fact that a meteorite is a mixture of minerals of different chemical* composition or, for more obscure *reasons, due to variations in composition from one portion of the sample to another. Consider three parts of a meteorite which are formed with different ratios of* Rb^{87}/Sr^{86}*. However, the* isotopic *composition of the Sr (measured as* Sr^{87}/Sr^{86}*) will initially be the same in all three parts.* Sr^{86} is *a stable isotope of Sr, and barring chemical or thermal alteration, its concentration does not change with time. However, as time passes, the* Sr^{87}/Sr^{86} *ratio will increase as* a *result of the decay of* Rb^{87} *into* Sr^{87} *with* larger *increases occurring in* those parts *having higher* Rb^{87}/Sr^{86} ratio. *Today, a plot of the measured* Sr^{87}/Sr^{86} *ratio vs the* measured Rb^{87}/Sr^{86} in *each sample will give a straight*

line. *The age can be calculated from the slope of this line, and the initial* Sr^{87}/Sr^{86} *ratio is given by the* intercept.'[20]

Burnett and Wasserburg go on to point out that this simple model does in fact apply to many meteorites, since very good straight-line fits are obtained. One such example is the Norton County meteorite, which has an excellent straight line fit and yields an age of formation of 4.7 thousand million years. Occasionally a meteorite gives an age of 3.8 thousand million years, pointing to the fact that other planets beside the Earth have been subject to reformation since they were first made. It should be noted that, unlike terrestrial material, meteorites are not subject to chemical and physical processes as melting, recrystallisation, weathering or mixing.

Harold Slusher subjects the rubidium-strontium method of determining ages to considerable criticism in his booklet **Critique of Radiometric Dating.** However, it appears to me that Slusher's criticisms are not valid either in the case of meteoritic samples or in the case of moon rock samples, for the following reason. If even only some of Slusher's criticisms were valid it would not be possible to obtain a straight-line fit for values of Sr^{87}/Sr^{86} vs Rb^{87}/Sr^{86} taken from different parts of a meteorite or a moon rock, yet the simple fact of the matter is that extraordinarily good straight-line fits are found for both meteorites and rocks.[21] Occasionally there are some discrepant values, such as the CF1-F/G1 glass and the II AB-J2 pyroxene in the Colomera iron meteorite, but as Sanz, Burnett and Wasserburg note,[22] the great majority of samples meet the conditions for a simple closed system model since they yield a well-defined straight line. An important difference between conditions on the earth on the one hand and conditions on meteorites and moon rocks on the other hand is that moon rocks are not subject to the action of water, and meteorites are only subject to such action when they arrive at the earth. Indeed, Sanz, Burnett and Wasserburg point out that there is some evidence that the discrepant samples in the Colomera meteorite may be due to terrestrial hydration.[23] I think that it is very significant that Slusher does not discuss the fact that the great majority of samples from moon rocks and meteorites give rise to excellent straight-line fits for rubidium-strontium dating, and these different samples all give ages of the order of 4 billion years.

A detailed critique of Slusher's objections to the rubidium-strontium method has been given by Davis A. Young in his recent book **Christianity and the Age of the Earth**[24] and the interested reader is referred to this careful book for a fuller treatment of this topic.

CONCLUSIONS

It appears to me that there is no adequate evidence to support the idea that the speed of light was thousands of millions of times faster in the past than it is now, and indeed there is strong evidence against such an idea. Consequently the great distances of the furthest galaxies from our galaxy is strong evidence that the universe is of the order of ten billion years old. Furthermore, the rubidium-strontium radioactive decay method of measuring the ages of meteorites and lunar rocks gives consistent results of the order of 4.6 billion years for the ages of these objects, and the internal check of the model used gives a clear indication of the validity of the method.

FOOTNOTES

1. This term was introduced by G.A. Kerkut in his book **Implications of Evolution,** Pergamon, Oxford, 1960, where he wrote 'On the other hand there is the theory that all the living forms in the world have arisen from a single source which itself came from an inorganic form. This theory can be called the "General Theory of Evolution'' and the evidence that supports it is not sufficiently strong to allow us to consider it as anything more than a working hypothesis.' (op. cit. p. 157).

2. I would prefer to be able to use the term 'creationist' to refer to anyone who holds that matter, the various forms of life and the world were created by the transcendent God out of nothing (cf. Webster's **Third New International Dictionary).** Unfortunately the term 'creationist' now seems to be used in the much narrower sense of those who hold to the young universe view.

3. David A. Young uses the term 'mature creationism' in his book **Creation and the Flood: An Alternative to Flood Geology and Theistic Evolution,** Baker Book House, Grand Rapids, 1977, to denote the interpretation of Genesis 1 which 'envisages the formation of the entire universe by a series of purely miraculous acts of God in the time span of six successive 24 hour days' (p. 44).

4. John C. Whitcomb Jr. and Henry M. Morris **The Genesis Flood,** Baker Book House, Grand Rapids, 1961.

5. op. cit. p. 369.

6. For example Ps. 33:4-6; Ps. 36:5; Ps. 89:1-2,5,8,14; Ps. 119:39-91. Any exhaustive concordance will show that there are many references in Scripture to God's faithfulness.

7. E.P. Mazets, S.V. Golenetskii, V.N. Il'inskii, R.L. Aptekar' and Yu. A. Guryan: 'Observations of a flaring x-ray pulsar in Dorado', **Nature,** vol. 282, p. 587, 1979.

8. M. Steidl **The Earth, The Stars and The Bible,** Presbyterian and Reformed, Phillipsburg, 1979, p. 222f.

9. ibid.

10. Parry Moon and Domina Eberle Spencer: 'Binary stars and the velocity of light', **Journal of the Optical Society of America,** vol. 43, p. 639, 1953.

11. John L. Synge reviewed the Moon and Spencer paper in **Mathematical Reviews,** vol. 15, p. 170, 1954.

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