solution to the problem of Genesis 49:26 in AE 163, but it does seem far preferable to the solution "Swedenborg made a mistake." The object has been to show that fairly compelling answers can exist for what seem to be almost certain cases of error. If one adds to this the instances in the Old and New Testaments where apparent errors in fact convey Divine secrets, if properly understood,[5] then a strong case exists that mere man should never presume to identify anything in Divine revelation as an error. ■

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[4] E.g. AE 365:38, where the basic subject being explained is peace. From peace the treatment turns more specifically to a passage about Salem (which means peace), then to Melchizedek, King of Salem, and finally a passage is quoted relating to Melchizedek without any reference at all to peace.

[5] E.g. Genesis 35:26: "These are the sons of Jacob, who *was* born to him in Paddan-Aram," and its explanation in AC 4610.

TOWARD THE BEGINNING OF TIME

Gregory L. Baker*

IV Big Bang via General Relativity

Clearly our view of the first moments of creation will be strongly shaped by the mode with which it is described. This mode is the local description prescribed by Einstein's 1916 general theory of relativity, a theory which is classical in the sense that it does not describe quantum phenomena, but nevertheless is very radical in that it provides a hitherto unknown connection between space and time.

> Henceforth space by itself, and time by itself, are doomed to fade away into mere shadows, and only a kind of union of the two will preserve an independent reality.[12]

1) *Spacetime Intervals and Curvature*

In Newtonian physics, space and time are considered to be quite separate entities. Mathematically they are described by "small"

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* Continued from January-March, 1980 issue.

[12] H. Minkowski, "Space and Time," in *The Principle of Relativity*, annotated by A. Sommerfeld (New York: Dover Pub. Inc., 1923).

intervals: $dl^2 = dx^2 + dy^2 + dz^2$ for space, and for time. (In polar coordinates: $dl^2 = dr^2 + r^2d\theta^2 + r^2\sin^2\theta d\phi^2$). For relativity physics, space and time are combined into a single interval: $ds^2 = c^2dt^2 - (dx^2 + dy^2 + dx^2)$ or, in polar coordinates: $ds^2 = c^2dt^2 - (dr^2 + r^2d\theta^2 + r^2\sin^2\theta d\phi^2)$.

Intervals for both Newtonian and relativity physics are considered "invariant" or observer independent under certain respective coordinate transformations. In other words, the interval is a local property of space and time in Newtonian physics and a local property of spacetime in relativity physics. The spacetime interval is central to the development of a relativistic description of the universe.

Now, the specific interval $ds^2 = c^2dt^2 - (dr^2 + r^2d\theta^2 + r^2\sin^2\theta d\phi^2)$ refers to flat spacetime, whereas the universe may not be flat. Consider the observed phenomenon of the slight bending of light around the sun. One may take the view that the light travels in a curved path around the sun or, it may be supposed that the geometry of spacetime is curved near the sun and that, in fact, the light is travelling in a straight line through a curved geometry. General relativity is based on the latter view and it is therefore convenient to express particle motion in this curved spacetime. The origin of curvature of spacetime is the presence of mass-energy, and this relationship is expressed in the so-called Einstein field equations. These equations essentially convert physics to geometry.

The application of these notions to the universe as a whole (at least an idealized smooth model) would suggest that the curvature of spacetime is provided by the mass-energy of the cosmological "fluid." While the details of the "fluid" may not be at hand, it is possible to suggest a reasonable expression for an interval of spacetime. One notes that the universe is isotropic or the same in all directions (recall the isotropic microwave radiation) and further, that the universe seems to be homogeneous or of uniform density. These facts, together with the radial expansion (recall the red shift) lead to the use of polar coordinates and the interval

$$ds^2 = c^2dt^2 - a(t)^2\,[dr^2/(1 - kr^2) + r^2d\theta^2 + r^2\sin^2\theta d\phi^2]$$

which defines the so-called Robertson-Walker model. A comparison with the flat space-time interval will indicate some differences. First, the coefficient of the term dr^2 has been modified to account for the curvature of space along the radial direction, and the constant k will take values of -1, 0 and +1 depending upon whether the curvature is negative, zero (flat), or positive, respectively. (In two dimensions, positive curvature could be represented by the surface of a sphere and negative curvature by the surface of a smooth funnel.) Secondly, the term a(t) sets the scale of the geometry as the universe expands from the Big-Bang creation and this factor is called the "cosmic scale factor." This theoretical parameter is related to an experimental parameter called the Hubble constant. Only in the case of positive curvature (k = +1) does the factor a(t) have the physical interpretation of being proportional to the radius of the universe.

The Robertson-Walker metric is appropriate to an observer who is stationary with respect to the "comoving" coordinate system. The comoving system is stationary with respect to particles whose motion is the "free-fall" expansion of the universe. An analogy is often made with a grid drawn on a balloon which will be inflated. As the balloon increases in size, the grid will expand and all points on the balloon will recede from an observer who is located at some grid-point on the balloon. Similarly during the expansion of the universe, an observer placed on a galaxy which is participating in the expansion is said to be stationary with respect to the comoving coordinate system. Now, if the observer had somehow been present at the Big-Bang he would measure a history or time until the present of 10 to 15 billion years. The time interval measured in this way is called the "proper time." (In section V:4 the measurement of proper time will be treated in more detail.)

2) *The First Moment*

It is very important to understand that the method of space-time intervals is one which depends only on the *local* properties of space-time. Hence the conclusions drawn must relate only to an observer's neighborhood. Now the Robertson-Walker metric is unchanged from point to point in the comoving system, yet all one can really say must be based upon the sum of the observations of all observers of their local neighborhoods. And which observer is in a position to make that summation, except possibly with the mind's eye? Therefore, if one goes backward in time via the Robertson-Walker metric to the point of the primeval explosion, one can only say that all observers, everywhere (whatever that means), would see the same Big-Bang. The following quotations express a similar view:

> The fireball should not be thought of as having been located at some preferred position in the universe; rather, it filled the entire universe.[13]

> It is not really meaningful...to ask where it was in our universe that the big-bang took place, since when it took place there was only one point in space. That is, the big-bang took place everywhere.[14]

One might represent the situation by the following diagram

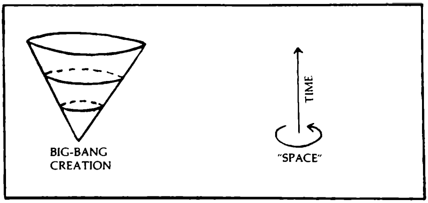

Figure 2

Clearly there are conceptual difficulties in attempting to escape the confines of the local view. There is no "outside" for the overall observer to locate in, to make his "comprehensive" measurements of space-time. Yet despite these difficulties, a start has been made at a so-called global approach.[15] One important result of the new global methods is the conclusion that, if certain very general conditions hold in the universe, then there must have been a singularity of space-time in the past. By singularity is meant a kind of infinite wrapping up of space-time such as the Big-Bang concept suggests. Therefore the local and global methods both point strongly to a Big-Bang creation.[16]

3) *Entropy and the Big-Bang*

It may be recalled that the increase of entropy provided a directionality property for time. Therefore it is of interest to calculate the entropy for the expanding universe to observe a possible connection between expansion and entropy increase. It

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[13] H. C. Ohanian, *Gravitation and Spacetime* (New York: Norton Press, 1976), p. 372.

[14] Rudolf Rucker, *Geometry, Relativity and the Fourth Dimension* (New York: Dover, 1977), p. 102.

[15] Charles W. Misner, Kip S. Thorne, John Archibald Wheeler, *Gravitation* (San Francisco: W. H. Freeman and Co., © 1973), Chapt. 34.

[16] Fernando Caracena has pointed out the analogy of the initial point-like containment of all spacetime to the first natural point developed in Swedenborg's *Principia*. Both objects form a kind of logical nexus between the natural and the spiritual.

turns out that the calculated entropy for the smoothed out universe under discussion is, in fact, a constant having the seemingly large value of about 10^9 bits per baryon or elementary particle.[17] (A bit is a single unit of missing information corresponding to a single "yes" or "no" decision). This result seems remarkable on two counts: first, the fact that the entropy is constant is difficult to explain assuming a passage of time with expansion. However, it turns out that the model is really too simplified to generate entropy beyond the initial amount. In reality, the radiating stars provided the entropy producing mechanisms, and therefore the direction of time is not really in doubt. The second interesting point of the calculation is that an initial entropy of 10^9 bits per baryon seems to be very large. From a philosophical viewpoint, this large entropy seems not unreasonable in that each particle is given a great deal of freedom in the possible uses to which it may be put. On the other hand, one can reasonably enquire as to the mechanism which produced this large entropy. One suggested mechanism arises from the possibility that the universe may *not* have been isotropic (same in all directions) in the earliest moments.

4) *Possible Anisotropic Origins*

Up to this point it was assumed that the Robertson-Walker metric, representing a completely isotropic and homogeneous (uniform composition) universe was sufficient for the discussion. Based upon the observed high degree of isotropy of the background 2.7° K microwave radiation, this assumption seems well founded. However, it has been suggested that during the first moments of creation the universe may have been highly anisotropic, and that some mechanism existed whereby this anisotropy was damped out, leaving the isotropic universe we observe.

There are two reasons for suggesting the early anisotropic universe. The first seems to be the aesthetic argument that the high degree of isotropy of the radiation field is a key piece of cosmological data and, "As such it surely deserves a better explanation than is provided by the postulate that the universe, from the beginning, was remarkably symmetric."[18] Perhaps this is a matter of taste.

The second, more practical reason, is that an initially anisotropic metric may provide mechanisms for particle creation and may also help to explain the origin of the large amount of entropy per baryon

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[17] Steven Weinbert, *Gravitation and Cosmology*, (New York: John Wiley and Sons, 1972), p. 509.

[18] C. W. Misner, *Astro. Phys. Journ.* 151, 431 (1968).

(about 10^9 bits) which appears in the uniformly and adiabatically expanding universe evident at temperatures below 10^{10}°K.[19]

The usual starting point is the anisotropic metric first stated by E. Kasner in 1921:

$$s^2 = dt^2 - (t^{2p_1}dx + t^{2p_2}dy^2 + t^{2p_3}dz^2) \quad \text{(units such that } c = 1)$$

Like the Robertson-Walker metric, the spatial grid changes with time, but whether it expands or contracts in a given direction depends on whether individual p_i values are positive or negative. To ensure variety the conditions

$$p_1 + p_2 + p_3 = 1 \text{ and } p_1^2 + p_2^2 + p_3^2 = 1$$

are given. The example $p_1 = -1/3$, $p_2 = 2/3$, $p_3 = 2/3$ is often used. In this case the metric is expanding along the y and z directions and contracting along the x direction. If a radiation field were present it would be cooling in the y and z directions and heating along the x direction; or equivalently, the y and z directions would show redshifts and x direction would produce blueshifts.

Of the various mechanisms to be operating in an anisotropic universe, perhaps the most interesting is the particle creation (a quantum effect) occurring for $t > T^* = 10^{-44}$ seconds, the time associated with the Planck length (a quantum length related to gravity). Vacuum fluctuations (via the uncertainty principle) produce virtual quanta which, if given sufficient energy, can produce particle-antiparticle pairs. The virtual quanta may gain energy by being blueshifted along the x-direction, and therefore the gravitational field helps to produce more energetic particles. Furthermore, because gravity interacts with all types of particles, there appears to be an entire spectrum of particles created.

Once the particle-antiparticle pair is produced, the gravitational expansion acting along the y and z directions helps to separate the particles and therefore inhibit recombination which means annihilation of the particle.

The question of entropy enters when, in the creation of the particle-antiparticle pair, correlations between the members of the pair are lost through decays, scattering or just large spatial separations, each mechanism being entropy producing. Furthermore, interactions between the radiation fields in the different directions (hot for the x-direction and cold for the y, z directions) will also generate entropy. To quote the paper by Parker:

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[19] Leonard Parker, "The Production of elementary Particles by Strong Gravitational Fields," in *Asymptotic Structure of Space-Time*, edited by F. P. Esposito and L. Witten, (New York: Plenum Press, 1977), p. 108.

> The entropy produced is consistent with the requirements of the Einstein equations, and of the observed 3°K radiation. Thus, the particle creation process occurring near T^* seems to offer a natural explanation for the origin of the entropy now observed in the 3°K black-body radiation.[20]

5) *From First to Lasts*

Before leaving what is primarily a classical, relativistic discussion of the beginning of time, perhaps a nod should be given to the question of an end of time.

The answer to the question "Is there an end of time?" can become rather involved as one considers various cosmological models and astronomical data. Nevertheless it may not be too much of an oversimplification to say that the question is really one of mass density. If the average density of the universe is sufficiently large then the gravitational effect will eventually overcome the explosive effect of the Big-Bang and the universe should start to contract toward a final state—a kind of super black hole. Following this plunge into a space-time singularity, some think the universe will re-explode in a Big-Bang and go through another cycle of expansion and contraction. The process is repeated ad infinitum implying no end of time, and, assuming our present universe was generated by this method, there is no beginning of time either. A kind of pulsating steady-state universe (with its attendant philosophical problems) results. In the conclusion to this paper, some of these difficulties for the cyclic model will be demonstrated.

On the other hand, if the average density is below a certain critical figure, then gravitation will never dominate over expansion and the universe will expand, presumably forever. There is no end of time in this model. At the moment the experimental evidence seems to support a density which is less than the critical figure, although the question is still unresolved.[21]

V Toward the Beginning of Time

1) *Limitation of Classical Relativity*

As we look back in time to the moment of creation, we note (Figure 1) that the universe is heating up considerably, both the radiation field and the matter field; and we also note the compression of the comoving coordinates as space-time becomes

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[20] Parker, 1977, p. 117.

[21] Rucker, 1977, p. 416.

more tightly curved progressing inexorably toward the initial singularity. And yet there may be an instant when the curvature of space-time is so large and the just-born universe in such a tremendously energetic state that ordinary rules of curved space-time, derived from Einstein's general theory of relativity do not hold, or at least must undergo modification.

For example, if the universe is wound up very tightly at some instant, then the mass density and therefore the gravitational potential energy will be superastronomical. This confinement of energy in a small space (at this point the universe, all of space, is very small) would probably be within the realm of the uncertainty principle of quantum physics. This uncertainty principle rules against confinement of arbitrary energies in too small an interval of space-time. Exactly what the limiting radius of curvature should be is not clear. High energy experiments seem to indicate that ordinary curved space-time is valid down to distances of 10^{-15} cm, less than the size of a proton. In fact, quantum theory indicates that the uncertainty argument does not seem to bear strongly until one reaches a radius of curvature corresponding to the Planck length $L^* = (hG/2\pi c^3)^{1/2} = 1.6 \times 10^{-33}$ cm. (However, there is no experimental evidence to say that Euclidean curved space-time is valid between curvatures corresponding to lengths of 10^{-15} cm and 10^{-33} cm.) Assuming the quantum prediction is correct, curved space-time with the well defined metric would vanish when the radius of curvature is of the order of L^*; and the topology would start to fluctuate causing $g_{\mu\nu}$, the metric tensor[22], to be poorly defined, probably becoming a stochastic function or the variable of a complicated quantum mechanical wave function, $\psi(g_{\mu\nu})$. In other words, the classical theory of gravitation ceases to be valid, and a quantum theory of gravitation is required. Unfortunately a complete quantum theory is not available, and this lack represents a significant barrier to the approach toward the beginning of time. (Nevertheless the time, $T^* = (hG/c^5)^{1/2} = 5.4 \times 10^{-44}$ seconds, associated with the Planck length is tantalizingly close to the beginning; the still-to-be resolved question is whether this represents a final limitation in our knowledge of the universal history.)

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[22] The symbol $g_{\mu\nu}$ stands for the coefficients of the various differentials appearing in the expression for the interval of curved space-time. That is, $ds^2 = \Sigma\Sigma g_{\mu\nu} dx^{\mu} dx^{\nu}$.

2) *Freezing of Quantum Levels*

However there will be significant activity at curvatures whose radii are larger than the Planck length and when temperatures are greater than the 10^{12}°K indicated on the left side of Figure 1 shown at the end of Section III. As a general phenomenon, the presence of a temperature bath of T degrees Kelvin scale allows processes to occur whose energy requirement is $E \leq kT$, where k is Boltzmann's constant. Furthermore, since energy and mass are interconvertible according to $E = mc^2$, actual particles may be generated if the temperature is high enough, the mass of each such particle being $m \leq kT/c^2$.

In fact, to generate a given particle it is necessary to have twice the required temperature since particles are generated in particle-antiparticle pairs. For example, to create an electron-positron pair requires a temperature of about 10^{11}°K. Since electrons belong to a class of particles called Leptons (light particles), it is clear that the Lepton era shown on the chart represents that period when quantities of electrons were generated.

To produce the heavier particles called baryons (a familiar example is the proton) would require temperatures three or four orders of magnitude greater, possibly $T = 10^{15}$K. But this era is not shown on the chart because the production of baryons is not a straightforward situation, and depends on the nature of the forces in the universe.

In general, the higher the temperature, the more massive are the particles generated. Therefore as the universe expands and cools, these levels of massive particle creation are no longer available and are said to be frozen out, thereby eliminating some of the more exotic physical processes. For this reason, it is especially difficult to develop a firm picture of the very first moments. Yet, some very interesting tentative notions are emerging which, if true, may considerably unify some of the present divergent threads of physics.

3) *Unified Field Theories and Symmetry Breaking*

To enter into this speculation, a slight historical digression is required.[23]

Until a couple of decades ago, the forces of nature were considered to be four in number:

1. *Gravity:* a long range force which affects everything, but very weakly compared to other forces.

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[23] Steven Weinberg, "The Forces of Nature," *American Scientist*, **65**, 171-176, 1977.

2. *Electromagnetism:* a long range force which is much stronger than gravity, but because positive and negative charges balance each other this force operates only on the molecular and atomic scale. This force is responsible for biological activity.
3. *Strong Nuclear force:* a force about 100 times stronger than electricity which can maintain a group of positively charged protons in a nuclear structure despite the electrostatic repulsion between them. This force is never experienced directly as it has a very short range, about 10^{-13}cm.
4. *Weak Nuclear force:* also a short range force, about 10^{-15}cm and though much weaker than electromagnetism still plays a significant role in the universe. This force is responsible for radioactivity decay.

One of the most exciting challenges to physics is to find some view which would unify or bring into the same conceptual framework all or some of these forces. Einstein spent much of his life trying to bring together gravity and electromagnetism, and failed. But current efforts with some of the forces show considerably more promise of success.

To get some slight feeling for the difficulties in the unification attempt, let us examine one aspect of these forces, namely the exchange particle. The purpose of the exchange particle for each type of force is to provide the means whereby one particle communicates its presence, and therefore a force, to another particle. This view of the interaction in terms of an exchange particle arises from the very successful theory of quantum electrodynamics, which is the quantum theory of electromagentism. Pictorially this exchange is illustrated by a "Feynman" diagram:

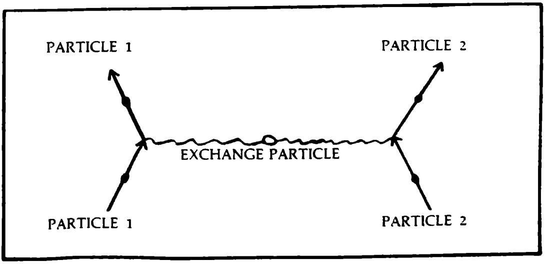

Figure 3

In the diagram, time runs up the page and the exchange particle shown traveling from particle one to particle two alters the paths of the particles. The diagram may represent attractive or repulsive forces. The obvious question is "where does the exchange particle come from?" And the answer lies with the uncertainty principle of quantum physics. According to this principle, energy for the exchange particle comes from an uncertainty in energy which occurs for a very short time Δt, such that $\Delta E \leq h/\Delta t$.

For gravity and electromagnetism, which are long range forces, Δt is long and ΔE must be very small. In these instances the exchange particles have no rest mass and travel at the speed of light. The photon acts as the exchange particle in electromagnetism, and its behavior is well described by the theory of quantum electrodynamics. An interesting property of the photon is, that if it is energetic enough, it can create an electron-positron pair as mentioned earlier. Now in the case of the short range nuclear forces, the exchange particles do have large rest masses, and one of the problems in the unification of these different forces is this discrepancy of mass for the exchange particles.

Beginning in the 1960's, an effort was made to unify the electromagnetic force and weak nuclear force into one so-called Gauge theory. The technicalities of a Gauge theory need not concern us but it turns out that the strong nuclear force may also fit in a similar model, thereby bringing together three of the four forces into one broad framework. The really exciting feature of these developments is the fact that it appears that all these forces *may have been the same* when the universe was at a very high temperature, perhaps greater than 10^{18}°K. The discrepancy in masses of the exchange particles associated with the various forces would have been nonexistent at these very high temperatures. Therefore, during the very first moments of the Big-Bang, nature was simpler, more symmetric than it is now. The differences only appeared as the universe cooled. The analogy is sometimes given of cooling water, which becomes asymmetric when a sheet of ice forms on the top. Similarly, the interactions of nature become asymmetric with cooling, and the effect is known as "symmetry breaking" or "broken symmetry." (It is worth noting that the universe would be a considerably less interesting place if symmetry-breaking had not occurred. For example, biological systems as we know them would be nonexistent.) At any rate, the hoped for unification of the forces of nature only happened, in fact, at the initial moment of creation and may only be reproducible in some future super-powerful particle accelerator. Yet the picture of a unified force at the first instant of creation is, I believe, aesthetically and intuitively pleasing.

4) *Finite Proper Time vs Infinite Event Time*

Perhaps an appropriate way to conclude this section is to discuss briefly the *measurement* of time as one looks backward to the beginning. Consider the question, "Is there an absolute zero of time in the sense that there is an absolute zero of temperature at -273.15° Centigrade (0°K)?"[24]

We have seen that the experimental evidence (red shifts, background microwave radiation, hydrogen to helium ratio, radio source counts, and the night sky itself) and theoretical framework of general relativity (curved space-time) point to a singularity of space-time occurring at a finite proper time (time measured by a suitable clock, stationary in comoving coordinates) in the past. The conventional estimate for the time since the Big-Bang is 10 to 15 billion years. Even the fact that quantum effects in the geometry may occur at curvatures equal to the Planck length, L^*, does not seem to detract from the reality of the singularity.[25] Therefore the problem of an absolute zero of time is not one which can be wished away by invoking quantum effects.

However, another approach may lie in the actual process of measurement of the 10 to 15 billion years. This proper time interval is measured by a hypothetical clock which is stationary with respect to the expanding comoving coordinates. Such clocks could presently be attached to diverging galaxies. The actual composition of the clock is the real point of interest. In our solar system the clock might be a counter which measures revolutions of the earth about the sun—in units of years. Yet the problem with such a clock is that it is only useful in that part of history which runs back to the beginning of the earth. To use this clock for an earlier interval involves an extrapolation of the measuring device which may be unjustified. Therefore one looks for a clock which can measure further back into history, such as the vibrations of interstellar ammonia molecules.

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[24] There is an interesting comparison of the absolute zero of time with the absolute zero of temperature. It is a well known fact of experimental physics that one has to work very hard to get near 0°K. Furthermore, the third law of thermodynamics states that it is impossible in principle by any process, however idealized, to attain the absolute zero in a finite number of steps. Perhaps there is a similar law at work providing a barrier to our knowledge of the beginning of time.

[25] Parker, 1977, p. 117.

These vibrations will give a much smaller unit of time, perhaps something on the order of 10^{-14} seconds. But the molecules themselves will break up as the background radiation temperature climbs to a few thousand degrees, and once again a new clock must be found. One can imagine, at the very high temperatures, clocks which count lifetimes of short-lived elementary particles such as mesons.

Therefore the actual measurement of the finite proper time interval of 10-15 billion years back to the moment of creation involves using more and more sturdy clocks which measure more and more events per second. It seems quite likely that a measurement of the history of the universe would involve measuring an *infinite number of events.* Furthermore, an examination of the Figure 1 shows that the realistic scale of the chronicling of historical events would use the logarithm of time rather than linear proper time. Therefore it may be useful to define an *event time* which is related to the proper time t by $T = \log t$. See Figure 4.

If such were the case, then at the moment of creation ($t = 0$) the event time would be $T = -\infty$.. Therefore from the viewpoint of *events,* the creation of the universe occurred at an infinite past: "The Universe is meaningfully infinitely old because infinitely many things have happened since the beginning."[26]

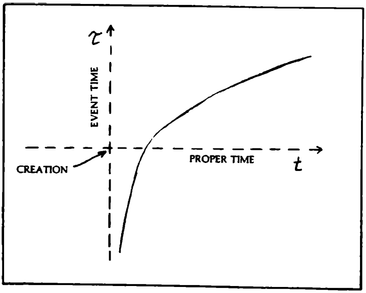

Figure 4

These two views of time measurements are not contradictory; they represent differing aspects of creation. The finite proper time

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[26] C. W. Misner, *Phys. Rev.* **186**, 1328 (1969). Misner suggests this concept in his paper although in a footnote he points out that E. A. Milne had suggested the logarithmic time in his 1948 book, *Kinematic Relativity.*

ensures that creation did have a beginning and that time had a beginning (compare this with TCR 31); and second, the event time with its infinite past fits naturally with a creation that is the work of an Infinite Being.

VI Summary and Concluding Remarks

Following the introduction, this essay began with a consideration of statements from the Writings as to the origin of time with God and the difficulty of treating that which is eternal and out-of-time. Then man's perception of time, especially in the physical science, was outlined, showing both the time reversibility suggested by dynamical equations and the directionality of time imposed by the boundary conditions of creation, manifested by the increase of entropy. Because of these boundary conditions, as well as an abundance of experimental data, a moment of creation (Big-Bang) is a logical and scientific necessity. While the Big-Bang may be adequately described by the theory of General Relativity for times greater than 10^{-5} seconds, certain quantum ideas seem to suggest some very interesting physics, such as the unification of forces prior to symmetry breaking at the very earliest moments. The fact that these earliest times seem so rich with events which are of tremendous significance for the created universe lends some credence to the notion of an event time with its infinite past. Like the absolute zero of temperature, it seems impossible to reach backward to the absolute zero of proper time.

What of the future? In Section IV:5, an allusion was made to the question of the future expansion or contraction of the universe. There are some serious difficulties, logical and theological, for a cyclic universe which periodically explodes and collapses.

First, if the universe is cyclic then the problem of a beginning still remains, since each Big-Bang explosion is not a true beginning. A cyclic universe would then have an infinite past, which seems to contradict the teachings of the Writings that time began with creation. Possibly one could circumvent this aspect of the difficulty by supposing that the cyclical action did have a real beginning or "first" Big-Bang.

Second, the cyclic universe raises problems for the directionality of time as evidenced in the law of increasing entropy. What happens to the entropy law when the universe collapses? Does time reverse itself and the past becomes the future and vice-versa? These questions and the question of net entropy production with each cycle have been considered, but there seems to be no satisfactory resolution of the difficulties. At best, the picture is very confusing.

From a theological perspective, the cyclical universe is very difficult. If the spiritual world needs a natural world populated with humans (humans in the sense of having liberty and rationality) then the periodic disappearances of this natural base would be unacceptable. Furthermore, each man retains a "limbus" formed of the "purest things of nature" in which the corporeal memory is imprinted.[27] While this concept is not clearly explained, it does seem certain that some kind of record in the natural world is required to support the spiritual world. Certainly this record would lose its individuality in the kind of black hole collapse and white hole re-expansion suggested in the cyclical models. (Only charge, mass, and angular momentum are conserved in total gravitational collapse.) For these reasons, if no other, the ever-expanding universe seems most attractive.

It may never be possible to adequately describe the beginning of time; but there is the satisfaction in this subject of seeing the convergence of scientific truth and the truths of the Writings.■

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[27] H. Lj. Odhner, *Creation* (Bryn Athyn, Pa.: Academy Publication Committee, 1964), p. 103.

THINKING FROM CORRESPONDENCES

N. J. Berridge

VII. Some Questions About the Eye

Thinking from correspondences does not involve the drawing out or invention of new doctrine from a knowledge of correspondences and science. Sometimes it helps to confirm revealed doctrine. Sometimes it emphasizes relationships and helps to clarify doctrine; but whether it does these or not, it enables the thinker to grasp the doctrine more firmly, to think about it more confidently, and to see new perspectives. It is the only sound way to think of spiritual things (AC 9300: 3). However, as emphasized in part I, it is essential that the natural things in which we see spiritual things should be correct. When the correspondences of the eye were being studied some