Volume 8
Print Reference: Pages 82-94

Article 39

2018

A Solution for the Distant Starlight Problem Using Creation Time Coordinates

Tichomir G. Tenev
Mississippi State University

John Baumgardner
Logos Research Associates

Mark Horstemeyer

Tenev, T.G., J. Baumgardner, and M.F. Horstemeyer. 2018. A solution for the distant starlight problem using creation time coordinates. In *Proceedings of the Eighth International Conference on Creationism*, ed. J.H. Whitmore, pp. 82-94. Pittsburgh, Pennsylvania: Creation Science Fellowship.

A SOLUTION FOR THE DISTANT STARLIGHT PROBLEM USING CREATION TIME COORDINATES

Tichomir Tenev, Mississippi State University, Department of Computational Engineering, Mississippi State University, MS 39762
ticho@tenev.com
John Baumgardner, Logos Research Associates, 24515 Novato Place, Ramona, CA 92065, USA
M.F. Horstemeyer, Center for Advanced Vehicular Systems, Mississippi State University, Mississippi State, MS 39762, USA

ABSTRACT
We present a solution for the distant starlight problem that is consistent with Scripture, Special Relativity, and observations of a young cosmos that is based on a special divine choice of initial conditions and a new synchrony convention. The initial conditions constrain the spacetime coordinates of all stellar creation events (Genesis 1:17) to be just outside the past light cone of Earth's Day Four but within the past light cone of Earth's Day Five while also being causally independent from one another. The synchrony convention interprets God's numbering of the creation days in Genesis 1 as prescribing a time coordinate for each location in the cosmos, a coordinate we call the Creation Time Coordinate (CTC). The CTC at a given star is defined as the elapsed time since that star was created plus three days. Two events are considered simultaneous (synchronous), if and only if, they have the same CTCs. We show that for these initial conditions and synchrony convention, starlight emitted on Day Four (stellar CTC) arrives at Earth also on Day Four (Earth CTC). Our solution is a reformulation of Lisle's solution (Newton 2001, Lisle 2010), but ours spells out the required initial conditions, without which Lisle's solution is ambiguous. It also replaces Lisle's use of the Anisotropic Synchrony Convention, which is an observer-specific subjective definition of simultaneity, with the CTC synchrony convention, which is a divinely-prescribed objective definition of simultaneity. Our solution predicts that stellar objects should appear youthful, because the light we receive from them displays them at only a few thousand years after their creation. We show for our own galaxy the number of observed supernova remnants and observed supernova frequency support this prediction. Finally, we discuss the strong agreement among current creationist cosmologies regarding spacetime coordinates of stellar creation events relative to the creation of the Earth itself.

KEY WORDS
cosmology, cosmological history, distant starlight problem, creation time coordinates, young distant cosmos, missing supernova remnants, synchrony conventions, special relativity

INTRODUCTION
The distant starlight problem often raised against young-age creation cosmology is as follows: "If Creation occurred only a few thousand years ago, how can we see light from stars that are billions of light years away?" Over the past decades several solutions have been proposed including light created already in transit (Morris 1976), a variable speed of light (Setterfield 1989), gravitational time dilation (Humphreys 1994), supernatural time dilation (Hartnett 2003), and the anisotropic synchrony convention (ASC) model (Newton 2001; Lisle 2010). Faulkner (2013) provides a brief overview and criticism of the above solutions and offers his own, which involves the miraculous "shooting" forth (Hebrew: *dasha*) of light from distant stellar objects on Creation Day Four. However, Hartnett (2014) has pointed out that Faulkner's scenario would have left behind several types of tell-tale physical evidence, none of which has been observed.

Recently, leading creationist cosmologists seem to have converged around two kinds of solutions to the Distant Starlight Problem: one consistent with a visible cosmos that has aged many millions of years while the other posits a visible cosmos that has aged only thousands. More than two decades ago Humphreys (1994) introduced a model in which gravitational time dilation allowed clocks on Earth to run very slowly during creation Day Four while billions of years of time elapsed in the distant cosmos. In a major update to that initial model (Humphreys 2008), one that also employs gravitational time dilation, Humphreys offers a scenario that allows many millions of years for galaxy wind-up for galaxies throughout the cosmos, which he subsequently defends in more detail (Humphreys 2017). Consistent with the view that the visible cosmos has aged only thousands of years since its creation is Lisle's ASC model (Lisle 2010), Hartnett's endorsement of it (Hartnett 2011a, 2015a), and Faulkner's *dasha* model (Faulkner 2013). Despite Faulkner's ostensible distaste for Lisle's model, Faulkner does not refute it but concurs with its predictions when he states that "we are probably looking at the entire universe in something close to real time, regardless of how far away individual objects may be."

Hartnett's path to agreement with Lisle's ASC model (Lisle 2010) is noteworthy. For several years Hartnett sought to find time dilation solutions to the distant starlight problem. His approach was to utilize a theory developed by the Israeli physicist Moshe Carmeli (2008), which had extended General Relativity by adding a velocity dimension to the conventional space and time dimensions. Although Carmeli's work assumed the Cosmological Principle and old-age creation, Hartnett (2015a) applied its equations to a recently created cosmos with the Earth near its center, as a straightforward reading of Scripture implies. For plausible choices of parameters, Hartnett was able to find solutions that displayed vast amounts of time dilation in the distant cosmos during Day Four on Earth (Hartnett 2007). After Carmeli's death in 2007, Hartnett helped publish Carmeli's final book entitled *Relativity: Modern Large-Scale Spacetime Structure of the Cosmos* (Carmeli 2008). In the process, Hartnett became more conscious of deficiencies in Carmeli's theory, especially the difficulties of melding both time and velocity dimensions together in a consistent manner. As Harnett (2015c) reflected later,

> Carmeli's theory does not need *the fudge factors of dark energy and dark matter* for it to fit observations, but it does need this new [velocity] dimension... What is a velocity dimension? I do not know… [Carmeli's] Cosmological Special Relativity theory I believe is fundamentally flawed. It has problems which I could not see how to overcome.

In 2011 Hartnett wrote a detailed, generally favorable review (Hartnett 2011a) of Lisle's ASC solution to the distant starlight problem (Lisle 2010). Since early 2015 Hartnett has expressed close to unqualified support for Lisle's ASC model and has even proposed enhancements for it, including a mechanism for redshift. He now refers to this model in a title of a paper as "A Biblical creationist cosmogony" (Hartnett 2015a). In a synopsis of that paper he writes, "I now place this model at the top of my list even ahead of my own time-dilation model" (Hartnett 2015d).

The difference between the solution for the Distant Starlight Problem that we propose here and Lisle's ASC model (Newton 2001; Lisle 2010) is that we spell out the required initial conditions, without which Lisle's solution is ambiguous and incomplete. As such, using different initial conditions is admissible within Lisle's ASC model; hence, distant starlight might not arrive at Earth at all during the time of the Earth's existence. Our solution is presented in the following section titled "Proposed Solution." The new formulation also addresses the common criticisms against the ASC model, some of which are arguably due to misconceptions, but a few are substantive. Our solution is motivated by our conviction that the distant cosmos is young, a conviction based on Biblical as well as observational evidence. Much of the observational evidence for a young cosmos has already been detailed by Lisle (2010). To this evidence, we add here our investigation and further development with corrections of Davies's argument (Davies 1994) based on the paucity of supernovae remnants (SNRs). This investigation is presented in the section titled "Evidence for Young Cosmos."

Despite our disagreement with Humphreys concerning the age of the distant cosmos as we view it from Earth (Humphreys 1996, 2008, 2017), we find a notable agreement with his proposition regarding the position in spacetime of stellar creation events in relation to Earth's Day Four light cone. That proposition also leads to the conclusion that distant galaxies appear of to be equal age, which is identical to our own conclusion on this issue. We also fully endorse Humphreys' (1994) rejection of the Cosmological

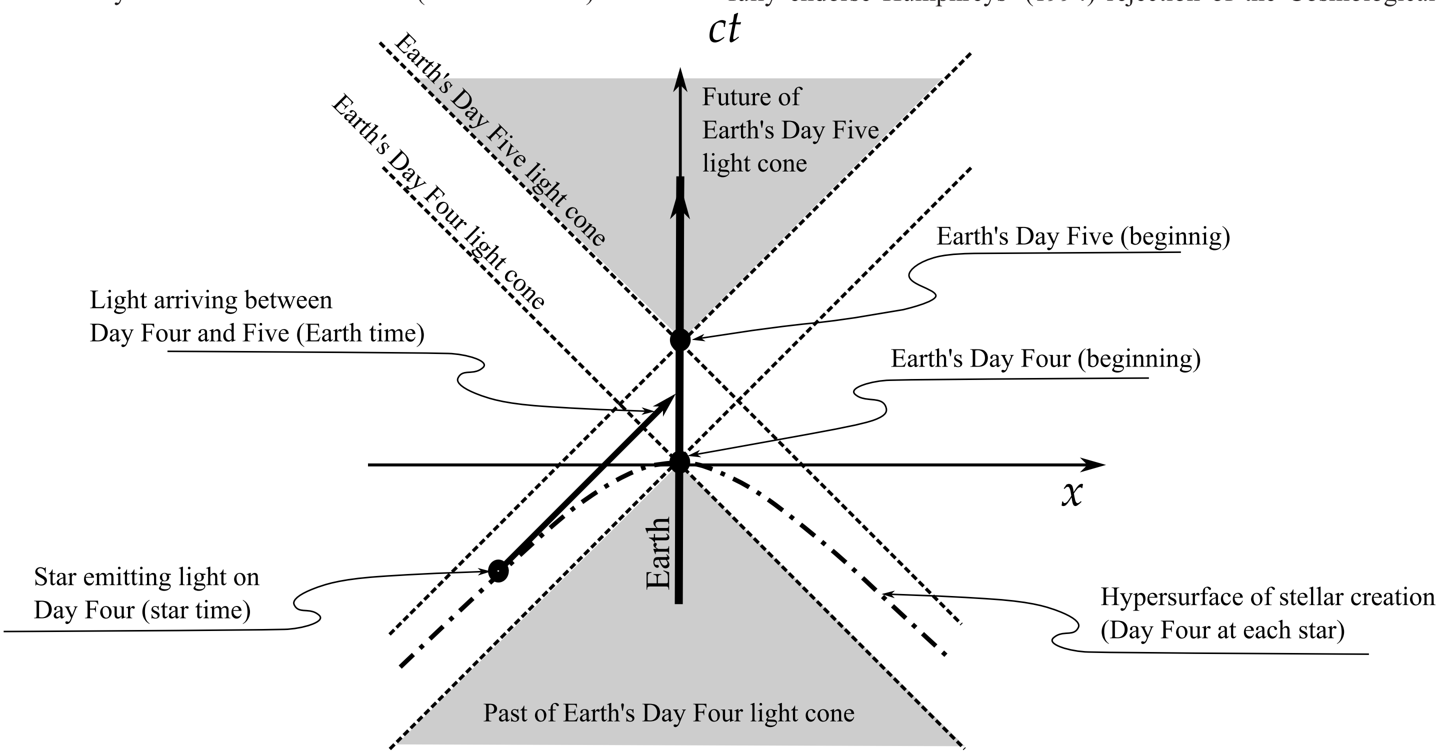


Figure 1. Special initial conditions involving the events of Genesis 1:17 offer a solution for the Distant Starlight Problem. We propose that God arranged the stellar creation events (Genesis 1:17) in spacetime along a hypersurface just outside the past light cone of Earth's Day Four and inside the past light cone of Earth's Day Five. Furthermore, these events are causally independent from one another and from Earth's Day Four. Such arrangement can be accomplished, for example, by choosing a hyperbolic hypersurface of creation whose slope is everywhere shallower than the slope of the light cone. Light emitted by a star on its Day Four arrives at Earth sometime between Earth's Day Four and Five. The *x* coordinate represents distance from the Earth, while the *ct* coordinate represents time scaled by the speed of light *c*.

principle, which is an atheistic assumption rooted in the belief that the cosmos is not designed. The Discussion section details both the differences and similarities of our solution compared to Humphreys' solution. The striking similarities between the two classes of solutions, that is, old-age versus young-age cosmos, are encouraging as we strive toward consensus.

In the following sections, we present our proposed solution to the Distant Starlight Problem and the evidence for a young cosmos; we discuss our findings and respond to potential objections; and to close, we summarize and conclude. The appendix contains a primer on Special Relativity that covers the essential concepts used in this paper.

PROPOSED SOLUTION

We infer a solution for the Distant Starlight problem from a straightforward interpretation of Genesis 1 in the context of Special Relativity (Einstein 1905). It is based on a special choice of initial conditions as well as a new synchrony convention.

The special initial conditions enable starlight from distant stars to arrive at Earth between the beginning and end of Earth's Day Four. We propose that God by his own choice and design constrained the stellar creation events described in Genesis 1:17 to have spacetime coordinates just outside the past light cone of Earth's Day Four but within the past light cone of Earth's Day Five. This arrangement ensured that the first light from any such distant star would have reached Earth between the beginning and end of Earth's Day Four (see Figure 1). The stellar creation events were further constrained such that each was causally independent from all the others. God could have accomplished this, for example, by arranging the creation events along a hyperbolic hypersurface whose slope is everywhere shallower than the slope of a light cone (see the hypersurface of stellar creation in Figure 1). The causal independence of stellar creation events ensures that they can be reckoned as simultaneous as described below.

In addition to selecting the coordinates of all stellar creation events in spacetime in this special manner, God also prescribed the synchrony convention by which causally independent events are to be reckoned as simultaneous relative to one another. According to Special Relativity, simultaneity of causally independent events cannot be decided by physical experiments but instead is a matter of convention; it is a subjective choice (see Appendix A). We propose that God's numbering of the creation days in Genesis 1 defines the synchrony convention for all events in the universe. By declaring that stellar creation events took place on Creation Day Four, God sovereignly prescribed that they should be reckoned as simultaneous with one another and with Earth's Day Four. The synchrony convention can be stated more generally as follows: the Creation Time Coordinate (CTC) of an event is defined to be the elapsed time between that event and Creation Day Four at the event's location, plus three days. An event's CTC is therefore the elapsed time since "The Beginning" of Genesis 1:1. Consequently, two events are considered simultaneous (synchronous), if and only if, they have the same CTCs. The synchrony convention defined in this manner does not conflict with Special Relativity, because stellar creation events are causally independent. It does, however, introduce additional information which cannot be deduced from Special Relativity alone. Our definition of the CTCs parallels the Big Bang's definition of "comoving time coordinates" (Liddle, 2015). Comoving time coordinates are defined as the elapsed time since the Big Bang within the reference frame of observers who perceive the universe as uniformly redshifted in all directions. Just like comoving time coordinates, the CTCs are defined with respect to a well-known inertial reference frame (the rest frame of the firmament) and a well-known initial event (the Creation).

Because of the combination of the special initial conditions and synchrony convention described above, starlight emitted on Creation Day Four according to each star's CTC also arrives at Earth on Creation Day Four according to the Earth's CTC. The Distant Starlight Problem is resolved without violating Scripture or Special Relativity.

A side effect of our solution is the asymmetric relationship between the Earth and stars. While light from distant stars emitted on Day Four also reaches Earth on Day Four, the reverse is not true. In fact, due to the special initial conditions, a star located a billion light years away from Earth will not receive light, or any other signal from Earth, until its CTC clock strikes two billion years. This asymmetry is consistent with Scripture, according to which God appointed the stars "to give light upon the Earth" (Genesis 1:15) but did not grant man dominion over the stars like He did over other parts of Creation (Genesis 1:28). In other words, Scripture indicates that while stars are causally to affect Earth, the reverse is not true.

To understand better the solution proposed here, consider the following example illustrated by Figure 2. In 1987 astronomers observed the explosion of the supernova SN 1987A located about 168,000 light years away from Earth. Based on the distance to the star and the speed of light, astronomers routinely infer that the time of the explosion was about 166,000 BC. At first blush, this conclusion suggests that the star exploded, and therefore existed, before the Biblical date of creation, which is about 4,000 BC.

However, as illustrated in Figure 2, the creation of SN 1987A on Day Four is a causally independent event relative to the morning of Day Four on Earth, and therefore the creation of SN 1987A did not actually happen before the creation of Earth. If SN 1987A did not explode before the creation of Earth, then when did it explode? The date of 166,000 BC is simply a time coordinate that astronomers ascribed to the supernova explosion using the Einstein synchrony convention (see Appendix A) with respect to the Earth's inertial reference frame. An observer in a spaceship moving past the Earth along the Earth – SN 1987A direction would ascribe a later time coordinate to the explosion because within his reference frame the Earth – SN 1987A distance would be Lorentz-contracted and thus less than 168,000 light years. Therefore, neither of these results reflect objective reality. In fact, Special Relativity alone does not provide a way to determine an objective date for the supernova explosion, but the CTC framework does. In terms of CTCs, one would date the star explosion to be about 4,000 + 1,987 = 5,987 years since creation, assuming creation took place about 4,000 years BC, and the star's creation to be Day Four since the beginning of Creation. Moreover, as the light carrying the image of the explosion passes through any given location in the heavens, the CTC clock at that location would read just slightly after 5,987 years since Creation. Finally, when the light reaches Earth, the clock on Earth too would indicate about 5,987 years since creation plus less than a day.

EVIDENCE FOR YOUNG COSMOS

The proposed solution, like Lisle's ASC model, makes the specific testable prediction that stellar objects should appear young. Below, we detail Biblical and observational evidence to support this prediction. Regarding the observational evidence, we consider, respectively, our own galaxy with its neighbors and distant cosmic objects.

1. Biblical evidence

The prediction of youthful cosmos is consistent with Scripture, which states that: "… in six days the Lord made heaven and earth, the sea, and all that is in them, …" (Exodus 20:11). Unless the meaning of "day" in relation to Earth is different from the meaning of "day" in relation to heaven, one must conclude that heaven and all there is in it experienced only six days of time since creation. Furthermore, since God created the stars to be "for signs and for seasons, and for days and years" (Genesis 1:14), it is reasonable to expect that the first light of the newly created stars arrived in time to be visible by the first human couple. This first light would have carried youthful images of the stars only a day or so in age. In the absence of significant time dilation effects, stars would continue to age at about the same rate as the Earth and be only a few thousand years old today.

While significant time dilation effects are not precluded by Scripture, they would have to be orchestrated in few simultaneous bursts to be left unnoticed by ancient astronomers. If at any period of history, a time dilation event took place that caused time lapse to accelerate in a region of the distant cosmos, then starlight from that region would be blue shifted. The stronger the time dilation, the greater the blueshift. To account for the alleged billions of years of stellar history, the blue shift caused by the accelerated time lapse would be so great that it would render the starlight from the affected

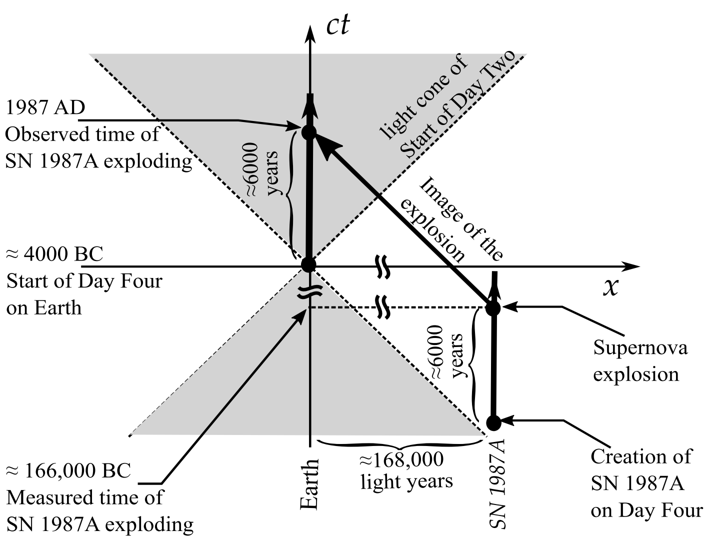


Figure 2. An example illustrating how the light from an exploding star can travel 168,000 light years and yet the star be only about 6,000 years old. The diagram is not to scale.

section of the cosmos invisible.

We are aware that Humphreys (2017) has recently offered an interpretation of certain Scripture verses, which he claims supports time dilation in the cosmos. We respond to these later in the Discussion section.

2. Observations that suggest our galaxy and its neighbors are young: paucity of supernova remnants

One line of evidence that our own Milky Way galaxy and nearby galaxies have existed for only a few thousands of years is the small observed number of supernova remnants that they contain relative to the observed current rate of supernova (SN) explosions, as emphasized by Davies (1994). Two classes of stars are unstable and meet their end in violent SN explosions. The first class, producing what are known as core collapse SN, are stars with masses greater than 8 $M_\odot$, where $M_\odot$ is the mass of our Sun. In this type of supernova, the core of the star undergoes sudden gravitational collapse when its nuclear fuel has been exhausted. The second class of stars, producing what are known as type Ia SN, are white dwarf stars whose mass has grown to exceed 1.4 $M_\odot$. A white dwarf can increase in mass by stripping material from a binary companion or by merging with such a companion. Both core collapse and Ia SN release about 10^{44} J in kinetic energy in the mass expelled by the explosion. The expelled mass equals several $M_\odot$ in the case of a core collapse SN and 1.4 $M_\odot$ for a type Ia SN. For a type Ia SN the surface velocity of the debris cloud is typically on the order of 8,500 km/s, or about 3% of the speed of light.

A supernova remnant (SNR) is the expanding cloud-like structure resulting from a SN explosion. It is composed of stellar material from the explosion itself plus material from the surrounding interstellar medium (ISM) swept up by the advancing supersonic shock front. There are three main phases in SNR history as described by Davies (1994) and spelled out more clearly by Höfner (2010). The first is the free-expansion phase during which the surrounding ISM plays no significant role. The expansion velocity v_{fe} for this phase is given by $\sqrt{2E_{SN}/M_e}$, where E_{SN} is the kinetic energy of the ejecta from the SN explosion, nominally 10^{44} J, and M_e is the expelled mass. For a type Ia SN, M_e is 1.4 $M_\odot$ = 2.77 x 10^{30} kg. In this case v_{fe} = 8,500 km/s, which persists through most of the free-expansion phase. That phase nominally ends when the accumulated mass from the ISM equals the ejected mass of stellar material. The time and the radius of the SNR at that point depends on the ISM density, but for typical values, the elapsed time can be on the order of a few centuries and the SNR diameter can be on the order of 5-10 light years.

The second phase, known as the Sedov-Taylor phase, begins after a reverse shock, toward the end of the first phase, has traveled inward and heated the ejected stellar gas to high temperature and has established a more or less uniform pressure inside the SNR. The temperature inside the SNR is so high that all the atoms are ionized and therefore they do not radiate away energy by recombination of the electrons with the ions. Hence, energy losses by radiation are very small and the subsequent pressure-driven expansion phase may be regarded as adiabatic. The cooling of the gas inside the SNR is then due solely to its expansion. From simple theoretical considerations this adiabatic expansion phase ought to end when the temperature in the outer portions of the SNR drops below 10^6 K. At this critical temperature, the ionized atoms begin to capture free electrons and lose energy by radiation. This radiative energy loss results in rapid cooling of the outer shell of the SNR and a transition to a third phase of its history. For ISM densities of 0.01-0.1 H atom/cm^3, the Sedov phase is estimated last on the order of 100,000 years.

The characteristics and behavior of the third phase, known as the 'snowplow' phase, has been obtained almost entirely from theoretical considerations and numerical modeling (see, for example, Blondin et al., 1998), as opposed to observation. It is known as the snowplow phase because the outer region of the SNR has become a slower moving, high-density cooler shell that expands like a snowplow into the surrounding ISM. It is also known as the radiative phase because the outer high-density shell is no longer ionized and radiates strongly in the visible part of the spectrum. The inner portion of the SNR, on the other hand, is still fully ionized, is expanding adiabatically, and pushes the cold outer shell outward, due to its pressure. Simple calculations on the time required for the inner SNR pressure to drop to that of the surrounding ISM suggest that the snowplow phase can potentially last for as long as a million years. However, several types of instabilities arise and tend to distort and disrupt the expanding SNR shell and reduce its lifetime (Blondin, 1998). Nevertheless, given that theory shows that SNRs in this phase radiate strongly and persist for hundreds of thousands of years, it is a profound puzzle why we do not observe *many thousands* of them in our galaxy, if the age of our galaxy truly exceeds a few hundred thousand years. Indeed, one is hard pressed to find even one good example of a radiative phase SNR reported in the astronomy literature.

After almost additional 25 years of scientific study with much more powerful telescopes and techniques, how defensible today is Davies (1994) conclusion that, given the small number of observed Milky Way SNRs, our galaxy is at most only a few thousands of years old? The answer is that Davies primary findings still hold. First, the 2014 online catalog of SNRs maintained by Cambridge University (Green, 2014) reports a total of 294 observed Milky Way SNRs, while the count in the Davies paper was 205. This difference is obviously due to the improvement in sensitivity/resolution of radio telescopes over that interval. Davies also pointed out that there is a cutoff in SNR diameter at about 60 parsecs (about 200 light years) indicating that all the observed SNRs are at a relatively early stage in their histories. That is still valid. Davies emphasized that there are no observed SNRs in the third, or 'snowplow' stage in their histories. That also is still valid.

However, the case is not as simple as Davies presented it. One reason, unfortunately, is an error in his analysis. Davies failed to include the observability factor of 47% in his estimate for the expected number of observable Sedov stage SNRs under his assumption that the galaxy is 7,000 years old. The figure that Davies used, 268, was obtained by dividing 7,000 years by the average time between SN events, which he took to be 25 years, to obtain 280, from which he subtracted 12, his estimate of the number of first-stage SNRs. Because our view from Earth of much of the rest of the galaxy is obstructed by the dust and stars in the galactic disk, it is essential to include this observability factor in any estimate of the number of observable galactic SNRs. For SNRs in the Sedov phase, that observability factor for the telescopes of 25 years ago was 47%. Davies did include that factor in his estimate of the expected number of observable SNRs were our galaxy much older than the SNR maximum lifetime, but he failed to include it for the case of a 7,000-year age. Including it in that case yields only 126 expected SNRs instead of 268. That number is notably fewer than the 200 actually observed as of 1994. On the face of things, that would suggest that either the galaxy is somewhat older than 7,000 years or else the estimated average time between SN explosions is too large. We suspect that the latter is the more likely explanation.

Despite that oversight on Davies' part, the 200 Sedov-stage SNRs actually observed compared with the 2256 SNRs expected if the age of the galaxy exceeds the Sedov-stage lifetime (Davies used an estimate of 120,000 years) is unaffected and striking. Sedov-stage SNRs are so bright that they remain detectable (apart from obstruction by dust and stars in the galactic disk) at galactic distances throughout their lifetimes. Even more striking is the fact that there are no observed third (snowplow) phase SNRs, given that they are expected to persist as readily detectible entities for hundreds of thousands of years. These conclusions still hold for the current catalog of observed SNRs in our galaxy. This is because the improvement in observability due to improvements in technology ought to scale the expected number of observed SNRs by the same factor as it has increased the actual number observed. That observability factor, instead of 0.47 in 1994, should now be on the order of (294/205) x 0.47 = 0.67.

Davies (1994) also considered the neighboring galaxy known as the Large Magellanic Cloud (LMC) which lies about 160,000 light years from Earth and has a total stellar mass about a tenth that of the Milky Way. He points out that the number of SNRs actually observed in the LMC, a total of 29, is also smaller by large factor relative to the number expected (480) if the actual age of the LMC truly exceeded the Sedov-phase lifetime. With improved spatial resolution and sensitivity in the radio, infrared, optical, and X-ray surveys, the present SNR count in the LMC has increased to 47 (Seok et al., 2013; Badenes et al., 2010). But that number comes nowhere near to closing the gigantic gap between the number of SNRs observed and the number expected if the galaxy is old (Maoz and Badenes, 2010). The same is also the case for the nearby Small Magellanic Cloud, which has a total stellar mass about 7% that of our Milky Way and a total of 23 SNRs (Badenes et al., 2010). It is also the case for the galaxy known as M33 which is about 2.7 million light years away, has a mass about 10% that of the Milky Way, and contains about 100 SNRs (Long et al., 2010). In all three of these galaxies, there ought to be an abundance of observed radiative-phase SNRs if the galaxies were truly more than a few hundreds of thousands of years in age. But they are not observed.

Therefore, the small number of SNRs in our own galaxy as well as in those close enough for radio, infrared, optical, and X-ray telescopes to image and count the individual SNRs is a significant indicator that the elapsed history of our own Milky Way galaxy and of those nearby is short, merely a few thousand years instead of the billions of years that the secularists assume. These SNR observations argue further that our CTC solution to the distant starlight problem also holds for the stars within our own galaxy. In other words, the observations lend support to the inference that God created the stars in our own galaxy very close to Earth's Day Four light cone, just as He did for the rest of the cosmos. In that case, the light we are receiving from stars throughout our own galaxy is reporting a history of close to 6,000 years since the stars were created, despite the fact that many of these stars are as far as 75,000 light years away.

In a recent work Faulkner (2017) cautioned creationist astronomers against using SNR evidence to support young cosmos. Although Faulkner does seem to agree that the cosmos is young (Faulkner, 2013), he recommended avoiding the SNR argument because some SNRs appear to have been expanding for more than 6,000-7,000 years according to clocks in their vicinity. While we do note that some SNRs appear to be older than 6,000 years, such observations may be explainable by yet unknown processes that have caused the SNRs to expand faster than our current models predict. This is why our argument for young cosmos is based not on the "reading out" of the apparent age of the SNRs, but on the *paucity* of SNRs. In other words, it seems more reasonable for a Young Cosmos model to explain appearance of age, than for an Old Cosmos model to explain what would appear as a dramatic acceleration of SNR production rates in recent times.

3. Observations that suggest the distant cosmos is young

What about the more distant stars and galaxies? Lisle (2010) has outlined several notable lines of evidence for the youthfulness of the cosmos at all distances. One is the presence of blue type-O main sequence stars in galaxies as far away as such stars can be resolved with present telescopes. These stars are hot and luminous and appear bluish-white in the visible spectrum. With surface temperatures ranging from 30,000 to 50,000 K and masses between 20 and 100 $M_{\odot}$, their luminosities can exceed 1,000,000 times that of the Sun (Darling 2016). These stars represent the largest mass type of the main sequence stars. Their high mass results in extremely high *core* temperatures, with an extreme rate of burning of the star's nuclear fuel, leading to short lifespans--on the order of a few million years at most according to secular models. Particularly because of their size, there is no credible naturalistic explanation for their origin. Hence, the roughly 20,000 such stars in our own galaxy is another argument for its youthfulness. The existence of such stars in all the galaxies for which we have technology to detect testifies to their youthfulness as well. Moreover, as Lisle (2010) also points out, the finding that the galaxies in the Hubble ultra-deep field images display similar structure and maturity as nearby galaxies appears to constrain the distant cosmos, as we observe it today, likewise to be young.

DISCUSSION

We now consider how the CTC solution for the Distant Starlight Problem relates to secular cosmologies and creationist solutions. As stated earlier, current creationist solutions fall into two categories: one consistent with an old cosmos, represented by Humphreys' solution (Humphreys 2008), and another consistent with young cosmos and represented by Lisle's ASC model (Lisle 2010). Below we compare the CTC solution with each one of these: old-age secular models, Humphreys' cosmology, and Lisle's model. Finally, we address potential objections to the proposed CTC solution.

1. CTC solution versus conventional old-age cosmologies

Our solution is consistent with well-established scientific theories, such as the theory of Special Relativity. It invokes neither new physics nor miracles, except the miracle of Creation itself. There is no need to assume, as Setterfield (1989) proposed, that the speed of light varied in time, although if a slight change of light speed over time were discovered, it would not invalidate our solution. Rather, the ability to see distant stars in real time is a natural consequence of applying the principles of Special Relativity and God's own choice of initial conditions. Moreover, our proposed solution neither requires nor contradicts the modern theory of the expansion of space, which is based on the observation that distant starlight is red-shifted. Neither does our solution depend upon time dilation effects as described in General Relativity, but neither do such effects conflict with the solution we are proposing.

However, there are two important ways in which our proposed solution is in sharp conflict with most conventional old-age cosmologies. First, according to our CTC solution, stars at all distances, as we observe them from Earth today, truly have accumulated only a few thousand years of history since they came into existence. This applies to the stars in our own galaxy as well as to the stars in the most distant galaxies our telescopes can detect. By contrast, conventional old-age cosmologies require that the galaxies, especially our own and those nearby, have undergone billions of years of history. Our solution is consistent with the account in Genesis 1, according to which stars were made supernaturally by God on Day Four and therefore do not require vast spans of time to form by natural processes.

Second, our proposed solution excludes the Cosmological Principle, which is assumed by almost all conventional cosmological theories. According to this principle, there can be no special place in the cosmos. By contrast, our solution requires that the position of the Earth's world line in spacetime be arranged in a special way relative to the stellar creation events (see Figure 1). The idea that young-age cosmologies ought to discard the Cosmological Principle was stressed more than 20 years ago by Humphreys (1994). This principle is acknowledged by most cosmologists, even if grudgingly, as an unproven assumption. Fundamentally, it is rooted in the presupposition that the universe is not designed and therefore ought not have any privileged location such as a center. By contrast, the Bible clearly teaches that God designed the universe and that the Earth itself indeed is a special place.

2. CTC solution versus Humphreys' Cosmology

How do other proposed creationist solutions for the Distant Starlight problem compare with our own which posits that God created the stars, near and distant, in an extremely special configuration in spacetime, namely, to lie near Earth's Creation Day Four light cone? This initial distribution for the stars at Creation, by definition, results in their first light arriving on Earth during Creation Day Four. It is noteworthy that the latest solution published by D. Russell Humphreys (2008; 2017) displays striking similarities. However, in contrast to the solutions of the present authors and of Lisle, the general relativity phenomenon of *gravitation time dilation* plays an essential role in his model. This is because Humphreys posits a massive but thin spherical shell of water, likely in the form of ice crystals, surrounding the visible cosmos. He requires the mass in this thin spherical shell of water to be more than 20 times greater than the total mass of galaxies in the visible cosmos. He equates this water to the 'waters above the firmament' of Genesis 1:7 and to the 'waters that are above the heavens' mentioned in Psalm 148:4. In this model the mass of this thin shell of water is sufficient to produce a large, negative gravitational potential throughout the cosmos, with values not far from $-c^2/2$, the value at which, according to Humphreys, all physical processes stop.

Humphreys proposes that on Creation Day Four on Earth God caused a front of star formation to sweep outward from the Earth in all directions toward the bounding layer of the 'waters above.' He suggests that the gravitational potential already was sufficiently close to the value $-c^2/2$ that the additional mass from the newly created stars caused the gravitational potential to fall below $-c^2/2$ just behind this front of star creation. The consequence was that a region of timelessness engulfed everything behind this creation front. Within this region all physical processes, including that of clocks, came to a halt. With the earth at its center, this timeless region, at a moment on Day Four, first enveloped the Earth and then expanded rapidly to include the entire star-containing cosmos.

After all the galaxies had been created and engulfed in the timeless zone, Humphreys proposes that God began steadily to increase the tension in the fabric of space, first causing the gravitational potential to rise above the value $-c^2/2$ at the outer edge of the cosmos and then causing the boundary of the timeless zone to race inward toward the earth at near the speed of light. Stars just behind this inward racing boundary suddenly began to shine again. Eventually, the gravitational potential in Earth's neighborhood rose above $-c^2/2$ and physical processes on Earth resumed. Clocks on Earth, being stopped, recorded no elapsed time between the instant during Day Four when everything had stopped and when everything resumed. In contrast to a sky devoid of stars when everything on Earth stopped, now the sky was ablaze with light from the Sun, Moon, and stars. That means that the starlight received on Earth on Day Four from stars throughout the cosmos is light the stars emitted almost immediately after they emerged from the timeless zone.

By controlling the tension in the fabric of space, God was able to control how long the newly created stars were in the region where the gravitational potential was greater than $-c^2/2$ before the potential fell below that value and the stars entered the timeless zone. Hence in his model, Humphreys can dial in time for galaxies, after they are first created, to wind into spiral form, for example. However, Humphreys can just as well choose that time interval to be vanishingly small. With this latter choice, the result is close both to our CTC solution and to Lisle's ASC model, with first light from all the stars and galaxies arriving at Earth on Creation Day Four and subsequent stellar history unfolding as if in real time. With this latter choice in Humphreys model, subsequent to Day Four, all the stars and galaxies, nearby and far away, track together as if they were created nearly instantaneously along Earth's Day Four light cone.

3. CTC solution versus Lisle's ASC model

Jason Lisle's solution (Newton 2001; Lisle 2010) is based on a synchrony convention, according to which light arrives instantaneously when traveling toward an observer but propagates with velocity $c/2$ in directions away from the observer. He refers to this convention as the anisotropic synchrony convention (ASC). Lisle (2010, p. 201) elaborates,

> Since we cannot (even in principle) ever measure the one-way speed of light, Einstein concludes that the one-way speed of light is not actually a property of nature, but a choice of man. Before Einstein, we might have assumed that the one-way speed of light (and thus, the corresponding synchrony convention) is a property of the universe—one that we are not clever enough to measure. But according to Einstein, the fact that we can never test a synchrony convention shows us something fundamental about the universe. Namely, it tells us that synchrony conventions are not a property of the universe but are instead a system of measurement invented by man. According to the conventionality thesis, no experiment will ever be able to establish one synchrony convention over another, because synchronization systems are a human invention by which we measure other things—much like the metric system.

Lisle (2010) grounds his ASC model upon a face-value understanding of Genesis 1, namely, that God created all the stars on Day Four of Creation Week and that they immediately became visible on Earth. He assumes the anisotropic synchrony convention (ASC) to account for this immediate visibility. Furthermore, he assumes that conventional estimates of present galactic distances, redshifts, and cosmic expansion are basically correct and that gravitational time dilation effects are negligible based on the estimated mass of the visible universe together with the estimated galactic distances.

In its essence, our solution is a reformulation of Lisle's solution (Newton 2001; Lisle 2010), but ours spells out clearly the required initial conditions, without which Lisle's solution is at best ambiguous if not incomplete. While Lisle does make a distinction between the ASC *convention* and his ASC *model*, thus recognizing that the convention alone as insufficient, at the same time he does not adequately delineate the initial conditions associated with his model. Discussion of the initial conditions should have stressed the unique role of the Earth in relation to the stars. Lisle neglects to address this crucial issue.

In addition to spelling out the initial conditions, our solution also replaces Lisle's use of the Anisotropic Synchrony Convention (ASC) with the CTC-based synchrony convention. The ASC is an observer-specific and hence subjective definition of simultaneity, while the CTC-based synchrony convention is a divinely-prescribed and hence objective definition of simultaneity. The straightforward interpretation of the ASC solution fails to capture the fundamental star-Earth asymmetry described above, but ostensibly suggests that one can simply define light to travel arbitrarily fast between any two points via an appropriate choice of observer. This inherent subjectivity of the ASC has been a source of criticisms and an obstacle to the acceptance of Lisle's solution. By contrast, our

CTC-based solution is independent of the choice of observer and clarifies the respective roles of the initial conditions and synchrony convention.

Figure 3 compares the ASC and CTC conventions to each other and to the commonly used Einstein Synchrony Convention (ESC), according to which the one-way speed of light is c in all directions (see Appendix A). From the figure one can readily conclude that the three conventions are just that; the choice of one over another does not affect the underlying physical reality. In the diagram, the events A and B correspond to objectively real phenomena, while the coordinate axes merely serve to assign coordinates. Switching conventions alters the coordinate axes, changes how coordinates are assigned to events, and consequently the events' perceived ordering, but does not change the relationship among the events in spacetime. For this reason, for example, switching from one convention to another does not affect how light propagates in spacetime and does not change the properties of spacetime.

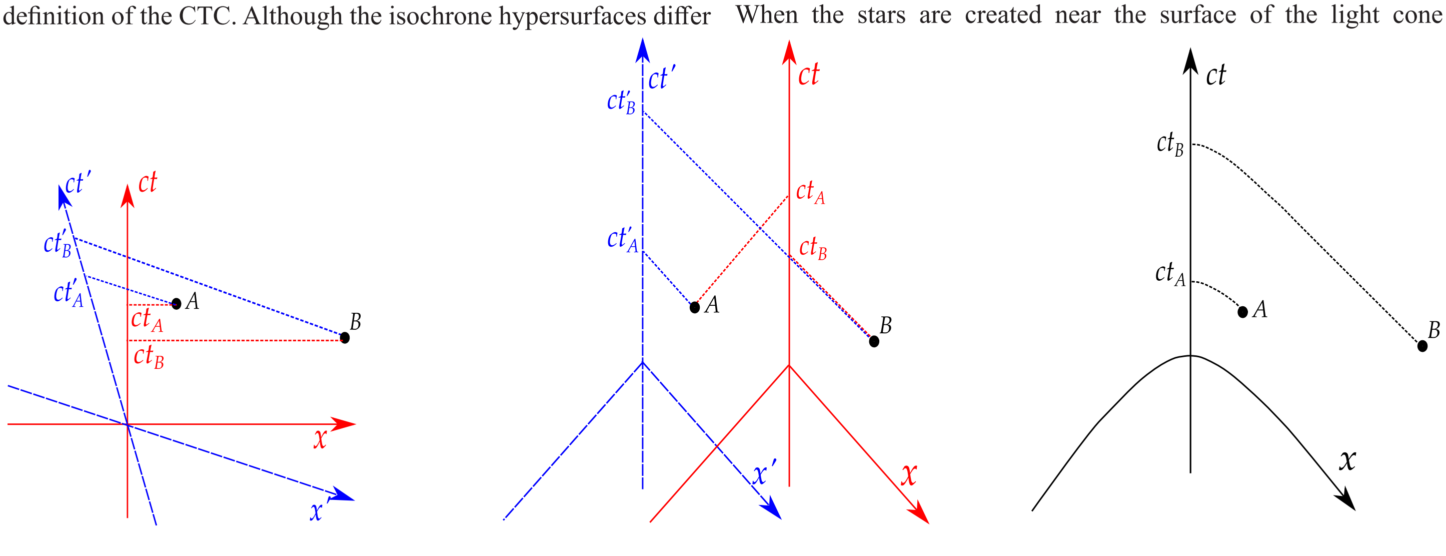
Another conclusion from the diagram in Figure 3 is that the CTC synchrony convention prescribes an objective time and space reference frame. By contrast, both the ASC and ESC are subjective conventions, because they both depend on the choice of observer. For any given situation one could choose among arbitrarily many ASC or ESC conventions according to the number of observers involved, but there can be exactly one CTC-based synchrony convention. Therefore, compared to the ASC convention, the CTC convention is ostensibly more consistent with Scripture, because Scripture always speaks of time in absolute terms. In reality, however, Lisle (2010) does not use the ASC convention in its general form but applies it only to observers on Earth. This narrower definition of the ASC is essentially equivalent to our definition of the CTC. Although the isochrone hypersurfaces differ slightly, hyper-cones in one case versus hyper-hyperboloids in the other, they converge asymptotically with each other at large distances.

Perhaps the most significant difference between our CTC convention and Lisle's narrowly defined ASC convention, is how they are motivated. Lisle's explanation for why the Bible uses the ASC is based on the presumption that ancient cultures were unsophisticated, which is a rather weak justification. By contrast, we infer that the CTC convention is the divinely-prescribed synchrony convention of Scripture. A common question raised in regard to Lisle's model is about the convention that God Himself uses: is it the ASC or the ESC? Our definition of the CTC convention provides a clear answer; using Scripture as our guide, it appears that God uses the CTC convention. As we have shown above, this happens to be essentially equivalent to Lisle's narrow application of the ASC.

Next, we consider how the initial conditions implied by Lisle (2010) compare to the initial conditions of the CTC solution. Although Lisle is vague about the fact that special initial conditions are needed, the following quote (Lisle, 2010, p. 204) suggests he understands that the ASC convention alone is insufficient to resolve the Distant Starlight problem and that some sort of special initial conditions are required:

> To be clear, the ASC convention does not make testable predictions and cannot be falsified. However, the ASC model goes beyond the mere convention and does make testable claims and is therefore falsifiable. The essential claim of the ASC model is that the Bible uses the ASC convention.

When the stars are created near the surface of the light cone



ESC ASC CTC

Figure 3. Simultaneity of two causally independent events A and B decided by two different observers: unprimed observer (red) and primed observer (blue) while using, alternatively, three separate synchrony conventions ESC, ASC, and CTC. The spatial axes, of which only x is represented on the diagram, determine the isochrone hypersurfaces (hypersurfaces of simultaneity). For the ESC, ASC, and CTC cases, these hypersurfaces are shaped, respectively, as hyperplanes, hyper cones, and hyper-hyperboloids. (The prefix "hyper" refers to the fact that these are three-dimensional surfaces within four-dimensional spacetime instead of ordinary two-dimensional surfaces within three-dimensional space.) In the ESC case, the primed observer is moving with speed close to c in the negative x direction relative to the unprimed observer and determines that the time coordinates of A and B are ordered differently from what the unprimed observer determines; that is, $t'_A < t'_B$ while $t_A > t_B$. In the ASC case, the two observers are spatially separated and similarly disagree on the order of A and B. In the CTC case, the axes do not depend on the observer, and the order of events is absolute.

associated with Creation Day Four on Earth, their light arrives during Creation Day Four on Earth regardless of the assumed convention. Therefore, for the above statement to be valid, Lisle must have envisioned, similarly to what we have proposed here, that stellar creation events are just outside the past light cone of Earth's Day Four. These are precisely the initial conditions required for the ASC model to make the testable predictions that Lisle is describing.

It is useful to note that both Humphreys' (2008) and Lisle's (2010) solutions posit that God created all the stars and galaxies in a near-instantaneous and supernatural manner at extremely specific locations in spacetime.

If the above interpretation of Lisle's model is correct, then his idea is essentially equivalent to what we are proposing. The main differences are in the way the two solutions are motivated and presented. We believe that our formulation obviates most of the common objections often raised against Lisle's by clarifying the key issues of synchrony convention and the initial conditions.

4. Addressing potential objections to the CTC solution

We anticipate that some of the objections against Lisle's (2010) ASC model may be also directed at the CTC solution. Some of these might have been the result of Lisle's unclear distinction between the synchrony convention and initial conditions. We clarify this point below before proceeding to discuss potential objections.

The initial conditions, which are independent of the choice of synchrony convention, are fundamentally what enable distant starlight to arrive at Earth on Day Four. All that is needed is for stellar creation events to be positioned just above the Earth's Day Four past light cone. The purpose of the synchrony convention is to prescribe an absolute ordering of these events, so that, for example, all stellar creation events can be reckoned as taking place on Day Four, as God had declared in Genesis 1:19.

With the above clarification in mind, let us now consider some potential objections to the CTC solution. Some of these are shared in common with the ASC solution and have already been addressed in part by Lisle (2010, p. 203). We include them here because the responses to these objections become clearer in the context of the CTC formulation.

A. Does the ASC model (and by extension the CTC solution) simply define the problem away?

Lisle (2010, p. 206) writes: "Moreover, we have seen that there are good reasons to suppose that the Bible does indeed use ASC… Indeed, the problem disappears when we use ASC." Taken at its face value, the quoted paragraph suggests that the Distant Starlight problem is resolved by simply switching the synchrony convention. As pointed out earlier, however, it is the initial conditions that make the solution possible and not the convention. These two concepts: initial conditions and synchrony convention are often conflated within Lisle's use of the term "ASC," which has been a source of confusion, but the CTC solution elucidates the distinction.

B. The ASC (and by extension the CTC) is an awkward convention

Many have criticized the ASC as an awkward convention to use and may apply the same criticism to the CTC. For example, Faulkner (2013) writes: "Thus, astronomers have two time conventions as to when something happened, when it actually happened, and when it is observable on earth." Lisle (2010, p. 203) expresses the same objection as this: "ASC is more mathematically complex than the Einstein synchrony convention. Therefore, by Occam's razor, Einstein synchrony is more likely to be correct." Both objections are logical fallacies. First, the awkwardness or complexity of a convention does not necessarily invalidate it. Second, the convention may be awkward and complex for one purpose but simple for another. A synchrony convention is like the choice of a time zone when reporting times on travel itineraries. For example, an airplane's takeoff and landing times are typically reported with respect to local time zones. While this may be an awkward convention for computing travel time, it is exactly the convention needed to make hotel and car reservations at the travel destination.

C. Does the asymmetric light speed imply that space is anisotropic?

It is important to recognize that the ASC is but one of an infinite number of equally valid conventions concerning the one-way speed of light. None of these conventions affects the underlying nature of physical reality. And none of them implies that space is anisotropic. Choosing the ASC means choosing the one-way light speed toward an observer to be infinite and the one-way light speed away from the observer to be $c/2$. The CTC convention has a similar implication except "observer" is replaced with "Earth." Does this asymmetry imply anisotropic properties of space? It is easier to see that the answer is "no" when one realizes that the one-way speed of light is a direct consequence of the synchrony convention and is not therefore an objective physical quantity.

D. How can light travel faster than c?

This question is related to the one above and has the same answer: the one-way speed of light is not a physical quantity. On the other hand, the round-trip speed of light is a physical quantity and is always c regardless of the synchrony convention one chooses.

E. Are the CTCs physically realizable coordinates?

CTCs are well-defined time coordinates representing the elapsed time since Creation (Genesis 1:1) at each point of the firmament within the rest reference frame of the firmament. The definition parallels the Big Bang model's definition of the comoving time coordinates, also known as "cosmological time," which represents the elapsed time since the Big Bang (our reference of the comoving coordinates from the Big Bang model is NOT an endorsement of that model) in the rest frame an observer who perceives distant stars as uniformly shifted in all directions (Liddle, 2015). In both cases, the time coordinate is defined as the elapsed time at a given location with respect to a well-known reference frame and a well-known initial event. Therefore, any criticisms directed at the construction of the CTCs would also have to apply to the construction of the comoving time coordinates, but the latter have been well vetted by cosmologists.

Nevertheless, we present here a procedure according to which a clock in any location in the universe can, at least in principle, be synchronized to reflect the CTC at its location. To keep the description simple, we will assume that the rest reference frame of the cosmic microwave background (CMB) is a good approximation of the rest reference frame of the firmament, and we will ignore the relative motion of the Earth with respect to the CMB. We will also assume that time dilation effects, such as described by General Relativity, are negligible. The procedure can be further refined to account for these factors, but at the expense of additional complications, that we wish to avoid here.

To accomplish this synchronization, we first establish a clock *E* local to Earth to reflect the current time since Creation. Using the information provided in Scripture, we can do this with a precision to within just a few decades. (A few decades may seem like a course precision at first but is actually extremely fine compared to cosmological light travel times.) Let t_E be the time displayed by clock *E* once it has been established in this way. Next, consider an observer with a clock *X* in cosmic space, which ticks at the same rate as clock *E*. Prior to clock synchronization, the observer must adjust his motion to be at rest with respect to the CMB by, for example, temporarily accelerating along the direction of the perceived CMB redshift anisotropy dipole until the CMB appears equally redshifted in all directions. After coming to rest with the CMB, the observer must send a light signal to Earth, which is immediately returned carrying along the value t_E that was displayed by clock *E* at the time the signal was received. Let τ_1 and τ_2 be, respectively, the emission and reception times of the light signal from and back to clock *X* as measured by *X* prior to its synchronization. Upon receiving the returned light signal, clock *X* should be adjusted to display time equal to $t_X = t_E + (\tau_2 - \tau_1)$. Once we have a way to synchronize a clock *X* in space with a clock *E* at earth, we can synchronize two arbitrary clocks *X* and *Y* with each other by synchronizing each individually with *E*.

F. Does the existence of a special reference frame, as suggested by the CTC convention, conflict with Special Relativity?

Special relativity postulates that all physical laws are the same in all inertial reference frames. This fact is not changed by giving a special designation to one reference frame by a choice of convention. In the same way, for example, there is nothing physically distinguishable about the Greenwich meridian, but it has been given a special designation amongst all meridians. This is, however, only part of the answer, because we also claim that our specially designated reference frame can be distinguished by physical observations. Before we respond to this second part of the question, notice that our ability physically to distinguish the special rest reference frame has nothing to do with the adopted convention and so it is not our choice of convention that appears to be the issue here. In fact, the same issue exists when specifying the Big Bang's cosmological time (Liddle, 2015).

The issue is that the Relativity Principle applies to physical laws, which are local. The Principle of Relativity postulates that, based solely on local observations, all reference frames look the same. For example, while traveling in a very smooth train Special Relativity tells us that one will not be able to run any experiments within the train to measure its speed. However, one can do so very simply by looking out of the window, which is a non-local observation. In our synchronization procedure detailed above, we used observations of the CMB redshift to determine the special rest reference frame, which are non-local observations. Nevertheless, our procedure in no way changed the fact that physical laws are local and are the same in all inertial reference frames.

G. Humphreys' (2017) argument that Scripture points to old cosmos

In a recent article, Humphreys (2017) points to several Scripture verses, which he claims to require that the distant stars be much older than the Earth. Some of these verses, Humphreys interprets as describing the slow winding down of the cosmos, but a more straightforward interpretation is that of a quick and sudden change caused by God's judgment. Other verses that Humphreys cites as referring to long ages refer not to the past but to the future end-times reign of Christ. Humphreys explanation of the "falling stars" references in Matthew 24:29 and Revelation 6:13-14 is also problematic. It requires for light to be capable of propagating outside the fabric of space and also for the nearly infinite blueshift resulting from the increased light speed to be almost perfectly compensated by the redshift due to the stars' recession from the Earth. For these reasons, we find both the Scriptural justification and the cosmological implications that Humphreys offers in support of old distant cosmos to be unconvincing.

SUMMARY AND CONCLUSION

In this paper, we have described a solution for the Distant Starlight Problem that is based on the synchrony convention implied by God's numbering of the days in Genesis 1 plus a proposed set of initial conditions that constrain how we infer God arranged stellar creation events in spacetime. In its essence, our solution, based on the notion of Creation Time Coordinates (CTC) is similar to Lisle's Anisotropic Synchrony Convention (ASC) model (Newton, 2001; Lisle, 2010). Our CTC-based solution's explicit initial conditions adds clarity and points to the same falsifiable predictions, namely that the cosmos should appear young and that the first light from all stars, near and far, appeared on Earth on Day Four. We showed that these predictions are supported both by Scripture and by observations.

We also compared our solution to other current ones and noted a strong convergence of thought among creationist researchers pertaining to the arrangement of the stellar creation events in spacetime. That arrangement is the one in which the creation events of all the stars and galaxies, including the stars within our own galaxy, lay very close to Earth's Day Four light cone when they were created by God. Simply from those initial conditions, first light from all these objects arrived on Earth during Creation Day Four, and the light that has arrived ever since carries the subsequent histories of these objects synchronized in time as measured by clocks on Earth.

The proposed solution does not constitute a complete cosmology and relies on a sparse set of assumptions, which makes it suitable for incorporation into a more comprehensive cosmological theory. Furthermore, the solution does not attempt to explain how creation itself might have happened. We are persuaded from the Biblical text that the creation of the cosmos was supernatural, a result of God's spoken word (Psalm 33:6,9). Nevertheless, the fact that we can see distant stars today is clearly within the realm of the natural. The solution we present attempts to explain how our ability to see distant stars can be consistent with a young creation based on the laws of nature as we understand them today.

REFERENCES

Badenes, C., D. Maoz, and B. Draine. 2010. On the size distribution of supernova remnants in the Magellanic Clouds. *Monthly Notices of the Royal Astronomical Society* 407, no. 2:1301-1313.

Blondin, J.M., E.B. Wright, K.J. Borkowski, and S.P. Reynolds. 1998. Transition to the radiative phase in supernova remnants. *The Astrophysical Journal* 500:342-354.

Carmeli, M. 2008. *Relativity: Modern Large-Scale Spacetime Structure of the Cosmos*. Singapore: World Scientific.

Darling, D. 2016. *Encyclopedias*. http://www.daviddarling.info/encyclopedia/O/Ostar.html. Accessed in 2017.

Davies, K. 1994. Distribution of supernova remnants in the galaxy. *Proceedings of the Third International Conference on Creationism, Technical Symposium Sessions*, ed. R.E. Walsh, pp. 175-184. Pittsburgh, Pennsylvania: Creation Science Fellowship.

Einstein. A. 1905. Zur Elektrodynamik bewegter Körper. *Annalen der Physik* 322, no. 10:891–921.

Faulkner, D. R. 2013. A proposal for a new solution to the light travel time problem. *Answers Research Journal*, 6, no. 1:279–284.

Faulkner, D.R. 2017. Are old supernova remnants really missing? Re-evaluating a well-known young-universe argument. *Answers Research Journal,* 10:245-258.

Green, D.A. 2014. A catalogue of galactic supernova remnants. *Bulletin of the Astronomical Society of India* 42:47-58. http://www.mrao.cam.ac.uk/surveys/snrs/

Hartnett, J.G. 2003. A new cosmology: solution to the starlight travel time problem. *Journal of Creation*, 17, no. 2:98–102.

Hartnett, J.G. 2007. *Starlight, Time and the New Physics: How we can see starlight in our young universe*. Eight Mile Plains, Queensland, Australia: Creation Book Publishers.

Hartnett, J. 2011. The anisotropic synchrony convention model as a solution to the creationist starlight-travel-time problem. *Journal of Creation* 25, no. 3:56-62.

Hartnett, J.G. 2014. Critique: Faulkner's miraculous translation of light model would leave evidence. *Answers Research Journal* 9:459-460.

Hartnett, J.G. 2015a. A biblical creationist cosmogony. *Answers Research Journal*, 8, no. 1:13-20.

Hartnett, J.G. 2015b. Supernova remnants and the age of the universe. Bible Science Forum, on-line article dated 01/26/2015. https://biblescienceforum.com/2015/01/26/supernova-remnants-and-the-age-of-the-universe/

Hartnett, J.G. 2015c. An update: correspondence on cosmology. Bible Science Forum, on-line article dated 02/07/2015. https://biblescienceforum.com/2015/02/07/an-update-correspondence-on-cosmology/

Hartnett, J.G. 2015d. Synopsis: A biblical creationist cosmogony. Bible Science Forum, on-line article dated 03/09/2015. https://biblescienceforum.com/2015/03/09/synopsis-a-biblical-creationist-cosmogony/

Höfner, S. 2010. Dynamical evolution of supernova remnants. Lecture Notes, Department of Physics and Astronomy Uppsala University, posted online at http://www.astro.uu.se/~hoefner/astro/teach/apd_files/apd_SNR_dyn.pdf

Humphreys, D.R. 1994, *Starlight and Time: Solving the Puzzle of Distant Starlight in a Young Universe*. Green Forest, Arkansas: Master Books.

Humphreys, R. 2008. New time dilation helps creation cosmology. *Journal of Creation* **22**, no. 3:84–92.

Humphreys, R. 2017. Biblical evidence for time dilation in the cosmos. *Creation Research Society Quarterly*, no. 53:297-305

Liddle, A. 2015. *An Introduction to Modern Cosmology*. West Sussex, PO19 8SQ, United Kingdom: John Wiley & Sons, Ltd.

Lisle, J.P. 2010. Anisotropic synchrony convention: a solution to the distant starlight problem. *Answers Research Journal*, 3, no. 1:191–207.

Long, K.S, W.P. Blair, P.F. Winkler, R.H. Becker, T.J. Gaetz, P. Ghavamian, D.J. Helfand, J.P. Hughes, R.P. Kirshner, K.D. Kuntz, E.K. McNeil, T. G. Pannuti, P.P. Plucinsky, D. Saul, R. Tullmann, and B. Williams. 2010. The Chandra ACIS survey of M33: X-ray, optical, and radio properties of the supernova remnants. *The Astrophysical Journal Supplement Series*, 187:495–559.

Maoz, D. and C. Badenes. 2010. The supernova rate and delay time distribution in the Magellanic Clouds. *Monthly Notices of the Royal Astronomical Society* 407, Is. 2:1314-1327.

Morris, H. . 1976. *The Genesis Record*. Grand Rapids, Michigan: Baker Book House, pp. 65-66.

Newton, R. 2001. Distant starlight and Genesis: conventions of time measurement. *Journal of Creation,* 15, no. 1: 80–85, 2001.

Seok, J.Y., B.-C. Koo, and T. Onaka. 2013. A survey of infrared supernova remnants in the Large Magellanic Cloud. *The Astrophysics Journal* 770:134-161.

Setterfield, B. 1989. The atomic constants in light of criticism. *Creation Research Society Quarterly*, 25:190–197.

THE AUTHORS

Tichomir Tenev has an M.Eng. degree in computer science and electrical engineering from MIT as well as BS degrees in mathematics and computer science also from MIT. He is currently pursuing a Ph.D. degree in computational engineering at Mississippi State University researching an elastic constitutive model of spacetime and its applications to General Relativity and Cosmology. Since 1996, Tichomir has held top software engineering positions at several Silicon Valley companies such as VMware, and most recently Instart Logic.

John Baumgardner has a Ph.D. in geophysics and space physics from UCLA and worked at Los Alamos National Laboratory in computational physics research during most of his scientific career. Since the early 1980's he has undertaken most of the primary research undergirding the concept of catastrophic plate tectonics in connection with Noah's Flood. Beginning in 1997 he served on the Radioisotopes and the Age of the Earth (RATE) team that documented multiple independent lines of radioisotope evidence that the earth is thousands, not billions, of years old. Since 2005 he has been part of a small team that has developed Mendel's Accountant, a computer model for exploring key topics population genetics relating to the origin and history of life. John currently is a senior research associate with Logos Research Associates based in Santa Ana, California, and teaches science apologetics courses at Southern California Seminary in the San Diego area.

Mark Horstemeyer earned a Ph.D. degree from Georgia Institute of Technology in Mechanical Engineering and Math and Materials (minors) in 1995. As a fellow of four societies (ASME, ASM, SAE, and AAAS) Dr. Horstemeyer has garnered national and international acclaim having published over 400 journal articles, conference papers, books, and technical reports. He is currently a Giles Distinguished Professor at Mississippi State University (MSU) and professor in the Mechanical Engineering Department at MSU (2002-present) holding a Chair position for the Center for Advanced Vehicular Systems (CAVS) in Computational

Solid Mechanics and is the Chief Technical Officer for CAVS.

APPENDIX: Special Relativity Primer

This appendix introduces fundamental concepts of Special Relativity that are used throughout the paper, such as: synchrony conventions, Minkowski diagrams, relativity of simultaneity, and light cones.

1. Synchrony conventions

The concepts presented in this appendix are based the Einstein Synchrony Convention (ESC), which prescribes that the one-way speed of light is *c*. Only the round-trip speed of light is a physical quantity, and not the one-way speed, which is why it is chosen by convention. While the ESC is the most commonly used convention because of its convenient mathematical properties, other conventions are also valid and useful for special types of application. For example, Lisle, writing under the pen name Newton (2001) introduced a synchrony convention he called 'anisotropic synchrony convention' (ASC), according to which light is reckoned to arrive instantaneously when traveling toward an observer, but whose one-way speed is $c/2$ when traveling away from the observer.

It is important to realize that the choice of synchrony convention does not change the outcome of physical experiments and has no physical significance at all.

2. Minkowski diagrams

Special relativity postulates that the speed of light relative to any observer does not depend on the velocity of the observer relative to the light source (Einstein, 1905). This postulate is known as the *invariance of the speed of light*. The invariance of the speed of light implies, however, that elapsed time and distance measurements are not absolute but depend on the motion of the observer performing the measurement. We will use Minkowski diagrams to illustrate geometrically the application of this postulate and to present our proposed solution to the distant starlight problem.

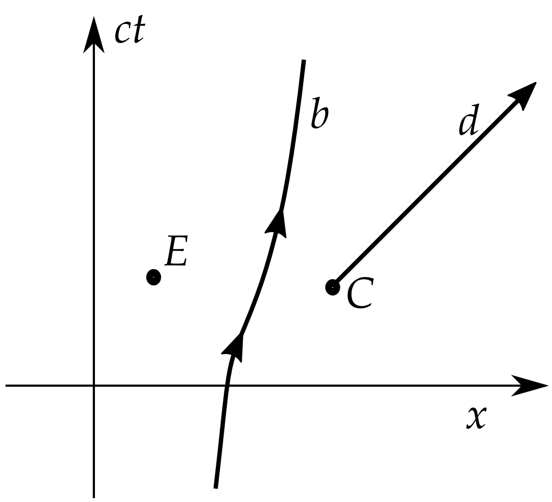


Figure 4. Minkowski diagram showing an example event *E*, a world line *b* of some particle, and a beam of light *d* emitted at event *C*. The vertical axis *ct* represents the time dimension, while the horizontal axis *x* represents one of the spatial dimensions. The other two spatial dimensions are implied but omitted from the diagram for clarity. Note that the time dimension is measured in units of time *t* multiplied by the speed of light *c*.

A Minkowski diagram (see Figure 4) is a schematic of spacetime in which one axis represents time, such as the *ct*-axis in the figure, and the remaining axes represent one or more spatial dimensions. Although often only one spatial dimension is visualized, such as the *x*-dimension in the figure, the remaining two spatial dimensions are always implied. Furthermore, time measurements are normally scaled by the speed of light *c,* so that one unit along the time axis represents the distance that light travels during one unit of time. Consequently, the path that a light beam traces on a Minkowski diagram subtends equal angles with the time and space axes (see object *d* on Figure 4). On the other hand, the tangents to the path that a material particle traces through spacetime, also known as that particle's *world line*, must always subtend smaller angles with the time axis than the spatial axes for the particle's speed to remain less than the speed of light (see object *b* on Figure 4).

A point on a Minkowski diagram corresponds to an *event* at a particular place and time. For example, object *C* in Figure 4 corresponds to the event when the light beam *d* was emitted in the positive x-direction. Similarly, the world line of a particle is made up of many events each representing the particle being in a particular location at a specific instant in time. While events themselves are objective, in the sense of being independent from the observer who measures them, the time and space measurements of these events are subjective and depend on the motion of the observer. The time and space measurements of an event are in fact the event's coordinates on a Minkowski diagram. Hence each observer corresponds to a set of coordinate axes on a Minkowski diagram. We use the term inertial reference frame for the set of axes associated with each observer.

It is not necessary for the coordinate axis on a Minkowski diagram to be perpendicular to each other. In fact, different inertial reference frames are indicated on a Minkowski diagram by varying the tilt of the coordinate axes. The following subsection uses this diagraming technique to compare two inertial reference frames.

3. Relativity of simultaneity

Figure 5 shows two reference frames, primed and unprimed, corresponding to two observers moving with velocity *v* relative to each other. Specifically, the primed observer is moving in the negative *x*-direction of the unprimed reference frame. A particle comoving with (that is, stationary in relation to) the primed observer, moves with velocity *v* in the negative *x*-direction relative to the unprimed observer. Consequently, the primed time axis ct', which may be viewed as the world line of a particle comoving with the primed observer, has a slope of magnitude c/v with respect to the unprimed reference frame. As discussed earlier, due to the invariance of the speed of light, the path of a light beam must subtend equal angles with the time and space axes within each of the two reference frames. Therefore, the primed spatial axis x' must have a slope of magnitude c/v with respect to the unprimed reference frame. Let t_A and t_B be the coordinates of events *A* and *B*, respectively, in relation to the unprimed reference frame, and let t'_A and t'_B be their coordinates in relation to the primed reference frame. As illustrated on Figure 5, we find that $t_A > t_B$ while $t'_A < t'_B$. The implication is that the objective ordering between Events *A* and *B* is indeterminate.

In the example in Figure 5, Events *A* and *B* are causally independent, which is why their relative order in time is objectively indeterminate. Events *A* and *B* are causally independent because a signal emitted at *B* and traveling at the speed of light, does not have enough time to reach the location of *A* before *A* takes place, and vice versa. Therefore, neither event could have influenced the other. Stated in geometrical terms, two events *A* and *B* are causally independent if and only if the slope of the segment *AB* is shallower than the slope of a light beam.

4. Light cones

Unlike causally independent events, the order of causally dependent events is objectively fixed and does not depend on the choice of reference frame. The concept of an event's light cone helps to illustrate the causal relationship between events (see Figure 6). In the figure, events such as *D* and *C* are within the light cone of Event *E* and therefore are causally related with *E*. Furthermore, one can see that for any possible choice of the primed reference frame, Event *D* remains in the future of *E* , while Event *C* remains in *E*'s past. Therefore, one can objectively state that *C* happened before *E*, which happened before *D*. At the same time, for any choice of reference frame, events *A* and *B* remain outside *E*'s light cone and are therefore causally independent from *E*. Moreover, in some reference frames, such as the unprimed reference frame in the figure, *A* appears to have happened before *E*, while in other reference frames, such as the primed reference frame, *A* appears to have happened after *E*. Thus, according to special relativity, our everyday notions of 'before', 'after', and 'at the same time', are superseded by the more objective notions of 'past', 'future', and 'causally independent' events.

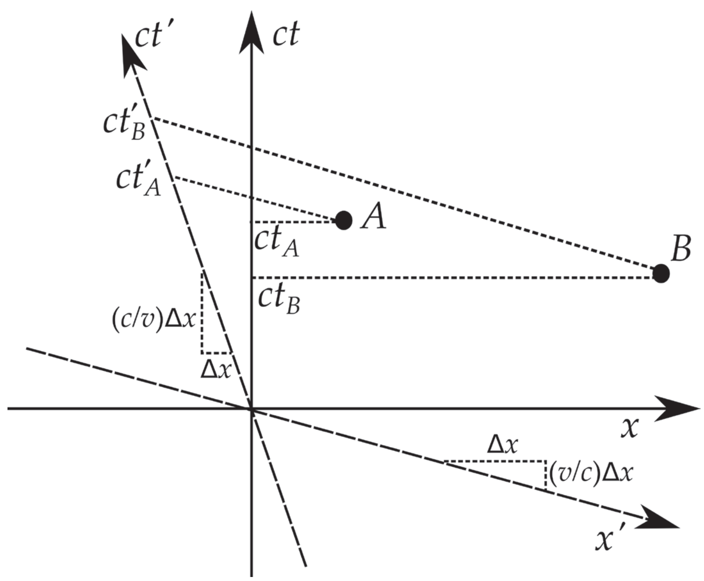


Figure 5. Minkowski diagram showing events *A* and *B* measured by two observers who are moving with velocity v away from each other. The unprimed observer determines *A* and *B* to have occurred at times $t_A > t_B$, while according to the primed observer $t'_A < t'_B$. Consequently, the unprimed and primed observers arrive at different conclusions about the order of events.

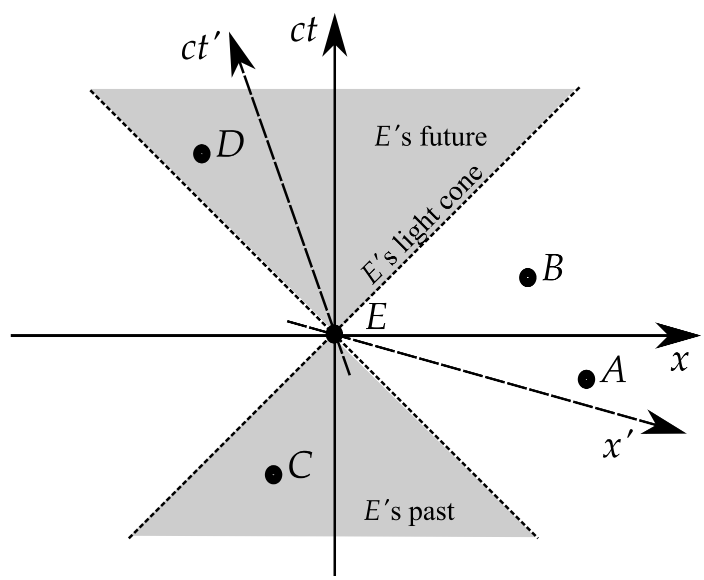


Figure 6. The light cone of an event *E*. The lines forming the boundary of the light cone correspond to all possible paths that light emitted at *E* can take. The top portion of the light cone, called *E*'s future, consists of all events that causally depend on *E*. The bottom portion, *E*'s past, consists of all events that are causal dependencies of *E*. Events outside of the light cone, are causally independent from *E*.