A Refutation of Phillip Dennis's Claims Regarding Alleged Inconsistencies in ASC

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Abstract

Did Phillip Dennis actually disprove the conventionality thesis (Dennis 2024)? Did he really prove at long last what physicists over the last century have been unable to do – to establish that the one-way speed of light in any given direction must be the same as the round-trip speed of light? Did he find any genuine inconsistency with the Anisotropic Synchrony Convention (ASC) and the young universe model upon which it is based? Well, no to all of the above. Rather, Dennis arbitrarily *assumed* the alternative Einstein Synchrony Convention (ESC) at the first step of his proof, and then showed that this results in ESC, which is hardly surprising. Dennis has committed the *a petitio* fallacy – he has begged the question by arbitrarily assuming in his first equation the very thing he has attempted to prove. Furthermore, he did not bother to run through the same steps using the ASC system, or he would have found that it too is self-consistent and allows for an anisotropic one-way speed of light. This is an example of confirmation bias. We show below that when the full synchrony-independent equations are used, they do not support Dennis's conclusion but rather the opposite. Furthermore, we will demonstrate several critical errors in Dennis's analysis and show that several of his claims are incompatible with the physics of relativity.

Introduction

It is possible to measure the average speed of light on a round trip in any number of ways. A conceptually simple method is as follows: Light is emitted at point *A* toward point *B* which is some distance away. Point *B* has a mirror which reflects the light back to point *A*. A clock at point *A* measures the time of departure of the light, and also the arrival of the reflected light, and the difference (Δt) is computed. Twice the distance between *A* and *B* is divided by Δt to arrive at the round-trip, time-averaged speed of light (c). When this type of experiment is performed in a vacuum, the result is always c = 299,792,458 m/s.

Naively, we might assume that the light took the same time to traverse the path *A* to *B* as *B* to *A*. That is, we might suppose that the speed of light in any given direction (its one-way speed) is the same as its round-trip time-averaged speed. We are tempted to test this hypothesis by placing a second clock at *B*. If the arrival of light at *B* coincides with exactly ½Δt past the time of emission at *A*, then we would conclude that light indeed travels the same speed from *A* to *B* as from *B* to *A*. But this would only work if the clocks at *A* and *B* are exactly synchronized – that they display the same time at the same time (simultaneously). But how do we know that they are exactly synchronized? How do we operationally define "simultaneous?"

If we knew in advance that light travels the same speed from *A* to *B* as from *B* to *A*, then we could use light beams to test whether clocks are synchronized by the following method. Clocks *A* and *B* are separated by some distance. An observer is placed exactly between them at point *M*. When each clock strikes noon, it emits a light pulse toward *M*. If the observer at *M* (equipped with two mirrors at a 90° angle so that he can see both *A* and *B*) sees both pulses at exactly the same instant, then the clocks are said to be synchronized since each pulse traversed exactly the same distance at presumably equal speeds. We could even define the "simultaneous" events by such a procedure.

But as Einstein pointed out, "Your definition would certainly be right, if only I knew that the light by means of which the observer at *M* perceives the [light] flashes travels along the path *A* to *M* with the same velocity as along the path *B* to *M*. But an examination of this supposition would only be possible if we already had at our disposal the means of measuring time. It would thus appear as though we were moving here in a logical circle" (Einstein 1916). That is, we would have to know in advance the one-way speed of light to synchronize two clocks separated by a distance, and we would have to already have two synchronized clocks separated by a distance in order to ever measure the one-way speed of light. In order to discover one truth, we would need to know the other one first. Thus, neither can ever be discovered.

Some people have suggested some other method of synchronizing the two clocks, such as setting them to the same time when they are both at the same location and then moving them to *A* and *B* respectively. But Einstein showed that motion affects the rate at which clocks tick: a phenomenon called time dilation. Time dilation can be calculated, but the (full, synchrony-independent) formula involves the one-way speed of light (Winnie 1970). Thus, again, the one-way speed of light would have to be known in advance to know that two clocks are still synchronized upon slow transport.

Einstein's conclusion was to recognize that the one-way speed of light is not measurable because it is not a property of nature at all, but a humanly stipulated convention which then defines what "simultaneous" means for a given observer (and not necessarily other observers). As he put it, "That light requires the same time to traverse the path *A* to *M* as for the path *B* to *M* is in reality neither a *supposition nor a hypothesis* about the physical nature of light but a *stipulation* which I can make of my own freewill in order to arrive at a definition of simultaneity" (Einstein 1916, emphasis in the original). That is, we choose/stipulate the speed of light in any one direction (the speed in the opposite direction is then determined by the requirement that the time average has to be *c*), and this tells us what constitutes synchronized clocks for a given observer. When we then measure the one-way speed of light with our synchronized clocks, assuming we make no errors in measurement or arithmetic, we will find the one-way speed of light to be whatever we initially chose.

Physicists typically prefer to stipulate that the one-way speed of light is the same in all directions because this imposes an isotropy that makes the math easier in most situations. But the natural question is: "the same in all directions *relative to whom*?" If Sarah perceives light moving in the positive *x* direction as having the same speed as light moving in the negative *x* direction relative to herself, what about Michael? Suppose he is moving in the positive *x* direction at half the round-trip speed of light relative to Sarah. Then the light moving in the positive *x* direction will be only 0.5*c* faster than Michael, but light moving in the negative *x* direction will have a speed of 1.5*c* relative to Michael (by Sarah's estimation). So, if the one-way speed of light is the same in all directions relative to Sarah, it certainly won't be for Michael as shown in Figure 1.

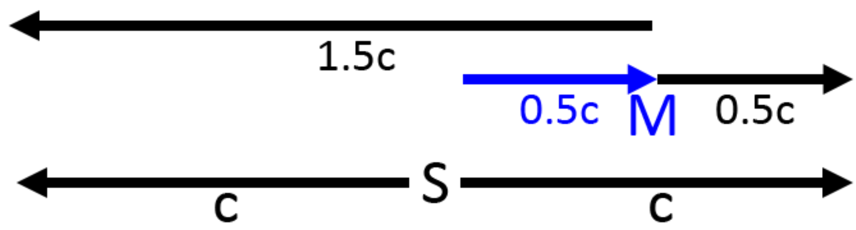

Figure 1

Or so one would think, except Michael is also allowed to stipulate that the one-way speed of light is the same in all directions relative to himself – and therefore not to Sarah. Who is right? Since the one-way speed of light is stipulated rather than discovered, both observers are equally right. They are using different coordinate systems and therefore *different definitions of simultaneity*. Consequently, Sarah and Michael will disagree on whether or not two clocks are synchronized. This is because Michael stipulates that the one-way speed of light is isotropic relative to Michael and therefore not to Sarah, but Sarah stipulates that the one-way speed of light is isotropic relative to her and therefore not to Michael. Both points of view are equally legitimate. This is called the *relativity of simultaneity*, and it flows logically and inescapably from the principle that the one-way speed of light is stipulated and can be different for different observers. The Lorentz transformations allow us to convert between Sarah's coordinate system (and thus her definition of simultaneous) and Michael's coordinate system (and thus his different definition of simultaneous).

Synchrony Conventions

A synchrony convention is a conceptual method of defining what constitutes synchronized clocks when those clocks are separated by some distance for a given class of observers. Changing synchrony conventions therefore does not change any underlying reality; it merely changes how we describe that reality. In particular, it affects the time coordinate (t) we use to describe an event in spacetime.

The practice of stipulating that the one-way speed of light is the same in all directions (isotropic) for a given observer is called the Einstein synchrony convention (ESC). I use the term *anisotropic synchrony convention* (ASC) to stipulate the one-way speed of light to be infinite when traveling directly toward the observer and ½*c* when traveling directly away. The speed for intermediate angles is given by equation 7 below. Technically, all synchrony conventions except ESC are anisotropic, but ASC has some unique properties and was implicitly used by all ancient cultures because it stipulates that we see the universe in real time.

Hans Reichenbach developed the epsilon (ε) notation now used to express different synchrony conventions. To understand this notation, we return to the experiment mentioned in the introduction. We define t_1 as the time the light is emitted at *A*, t_2 as the time the light reflects at *B*, and t_3 as the time the light returns to *A*. Then, since effects never precede their cause, the following must be true:

$$t_2 = t_1 + \varepsilon(t_3 - t_1), \quad (0 \leq \varepsilon \leq 1)$$

For ESC, $\varepsilon = ½$. That is, if we set $\varepsilon = ½$ we are stipulating that the one-way speed of light is the same in all directions and exactly equal to its round-trip speed (c). For ASC, it depends on the way the coordinate system is set up. Let's suppose the experiment in question takes place on the *x*-axis, far to the right of the observer. Then ε = 1. This choice stipulates that the one-way speed of light is ½*c* when traveling in the positive *x* direction, and infinite when traveling in the negative *x* direction. So, choosing the value of ε is the same as stipulating the one-way speed of light in a given direction.

In 1970, John Winnie showed that special relativity works perfectly well for any value of epsilon – for any synchrony convention. He pointed out that many relativistic equations take their simplest form (certain terms reduce to zero or to unity, for example) when we set ε = ½. This is indeed why physicists use primarily the ESC system. For example, in my book *The Physics of Einstein*, the first sixteen chapters work entirely within the ESC coordinate system. Only in chapters seventeen through twenty do we discuss alternative synchrony systems and how the equations of relativity are expressed in their full, synchrony-independent form.

It is very easy, particularly for physicists who are not well versed in synchrony conventions, to use an equation that assumes ESC, and mistakenly think that it is synchrony independent. This was Dennis's mistake, and it occurs at his first step. That is, he assumed that ε = ½ in his attempt to prove that ε = ½. This is the logical fallacy of *a petitio* (begging the question). When we use the correct, synchrony-independent equation, we will see that the result is perfectly consistent with ASC. For the derivation below, we define the *x*-axis as the line of sight of the observer who is at great distance in the negative *x* direction; this will allow us to use Winnie's notation in rectangular coordinates to better compare with Dennis's article, rather than the spherical coordinates that ASC properly uses and which are explored in Appendix B.

The Correct Derivation

The location of any event that takes place in space and time can be described by four coordinates (*x*, *y*, *z*, *t*). A second event in space and time will naturally have different coordinates. By subtracting the time of the first event from the second event, we can derive the time interval between them (Δt). Intuitively, we might think that everyone in the universe would compute the same time interval, but Einstein demonstrated that this is wrong. Likewise, different observers in different states of motion will disagree on the (spatial) distance between the two events. The distance between the two events and the time interval between them are not objective, observer-independent quantities. But there is a combination of spatial distance and time interval that is objective. It is called the spacetime interval.

So, the spacetime interval is a combination of measurements in space and in time that is *invariant* – meaning all observers measure the same spacetime interval regardless of their position or motion. This is remarkable because individual distances or time intervals are not invariant. That is, the distance between two events depends on the reference frame of the observer, and so does the time between two events. But the spacetime interval does not. Without assuming any synchrony convention regarding the speed of light in the *x* direction, the spacetime interval in "flat" (Minkowski) space[1] is given as follows:

$$S^2 = \Delta x^2 + \Delta y^2 + \Delta z^2 - c^2 \Delta t^2 - (2\varepsilon - 1)^2 \Delta x^2 + 2c(2\varepsilon - 1)\Delta x \Delta t \qquad (1)$$

This equation is given (in differential form) in chapter 19 of *The Physics of Einstein* (Lisle 2018). For ASC,

[11] This is a non-rotating, non-accelerating coordinate system far from any gravitational effects.

ε = 1. Notice what happens when we select the ESC system by setting ε = ½. Then the two terms on the right that are multiplied by (2ε -1) reduce to zero and the equation becomes:

$$S^2 = \Delta x^2 + \Delta y^2 + \Delta z^2 - c^2 \Delta t^2 \qquad \text{(ESC)} \qquad (2)$$

This of course is Dennis's equation 1 and shows that he tacitly assumed ESC (ε = ½) at the first step. That is, he inadvertently assumed that the one-way speed of light is the same in all directions in his attempt to prove that the one-way speed of light is the same in all directions. To stipulate ε = ½ is an acceptable convention, but it cannot be the first step in an attempt to prove that it is the only convention. This begs the question.

To be fair, almost all special relativity textbooks introduce the spacetime interval using ESC in which it takes the simplified form. And there is nothing wrong with ESC. My own book on relatively (*The Physics of Einstein*) uses ESC exclusively until chapter seventeen (Lisle 2018). But if Dennis wants to prove that ESC is the only option, he cannot start his proof by simply assuming ESC. If we stipulate light to be instantaneous in the negative *x*-direction as in ASC, then ε = 1 and the equation for the spacetime interval reduces to:

$$S^2 = \Delta y^2 + \Delta z^2 - c^2 \Delta t^2 + 2c\Delta x \Delta t \qquad \text{(ASC)} \qquad (3)$$

Next, Dennis considers two vectors, representing a light ray going from (x_0, 0, 0, t_0) to (x_1, 0, 0, t_1) and reflecting back to the source: (x_1, 0, 0, t_1) to (x_0, 0, 0, t_2). He rightly points out that for light, the spacetime interval (*S*) is always zero. But since his spacetime interval equation assumes ESC, his equation 2 also assumes ESC. That is, he writes:

$$S^2 = \Delta x^2 + \Delta y^2 + \Delta z^2 - c^2 \Delta t^2 = 0$$

The above equation is the null interval *according to ESC*. However, without assuming any synchrony convention, the correct formula for describing the interval between photon departure and arrival is derived by setting equation 1 equal to zero:

$$S^2 = \Delta x^2 + \Delta y^2 + \Delta z^2 - c^2 \Delta t^2 - (2\varepsilon - 1)^2 \Delta x^2 + 2c(2\varepsilon - 1)\Delta x \Delta t = 0 \qquad (4)$$

Since speed is distance divided by time, the one-way speed of light is:

$$v = \frac{\sqrt{\Delta x^2 + \Delta y^2 + \Delta z^2}}{\Delta t} \qquad (5)$$

However, when Dennis writes this equation, he uses "*c*" (the symbol for the round-trip speed of light) instead of "*v*," thereby arbitrarily assuming that the one-way speed of light is the same as the round-trip speed (*c*) – the very thing he is supposed to be proving. This again begs the question. Without that assumption the correct equation reduces to:

$$\Delta x^2 + \Delta y^2 + \Delta z^2 - v^2 \Delta t^2 = 0 \qquad (6)$$

Again, in Dennis's version, he uses *c* instead of *v*, thereby tacitly assuming that the one-way speed of light is the same as the round-trip speed *c*. He then shows that this matches his equation 2 which also assumes that the one-way speed is the same as the round-trip speed. This shows consistency, but nothing else. It's an example of confirmation bias because showing that one convention (ESC) is internally consistent doesn't prove that a different convention (ASC) isn't.

So, let's do what Dennis failed to do and see if other synchrony conventions also satisfy the condition that $S = 0$ for light. In particular, if we set $\varepsilon = 1$, can we recover equation 3 from equation 6? Under ASC, the speed of light in one direction is

$$v = \frac{c}{1 - \cos\theta} \tag{7}$$

where θ is the angle between the light velocity vector and the negative direction along the x axis (Lisle 2010). To be precise, this equation should be written as a limit so that $v = \infty$ when $\theta = 0$ as follows:

$$v = \lim_{\varphi \to \theta} \frac{c}{1 - \cos\varphi}$$

For simplicity, I will suppress the limit notation going forward. The distance R is defined as follows:

$$R = \sqrt{\Delta x^2 + \Delta y^2 + \Delta z^2} \tag{8}$$

From geometry and the definition of cosine, we have:

$$\cos\theta = \frac{-\Delta x}{R} \tag{9}$$

And by substitution of equation 9 into equation 7, and substitution of equation 8 into equation 6, respectively, we find:

$$v = \frac{c}{1 + \frac{\Delta x}{R}} \tag{10}$$

$$v = \frac{R}{\Delta t} \tag{11}$$

Since equations 10 and 11 are both expressions of v, it follows that:

$$\frac{R}{\Delta t} = \frac{c}{1 + \frac{\Delta x}{R}}$$

Solving for R we find:

$$R = c\Delta t - \Delta x$$

Squaring this result along with squaring equation 8, respectively, yields:

$$R^2 = c^2 \Delta t^2 + \Delta x^2 - 2c\Delta x \Delta t \tag{12}$$

$$R^2 = \Delta x^2 + \Delta y^2 + \Delta z^2 \tag{13}$$

Combining equations 12 and 13 and simplifying yields:

$$\Delta y^2 + \Delta z^2 - c^2\Delta t^2 + 2c\Delta x\Delta t = 0$$

This is, of course, equation 3 – the spacetime interval in ASC coordinates. Therefore, the non-isotropic one-way speed of light as given by equation 7 satisfies the null interval property of light when the correct equation is used. Thus, ASC and ESC are equally legitimate conventions in which the spacetime interval for light-like events is zero.

Derivation of the One-Way Speed of Light

Dennis states, "We now show that the invariance of the spacetime interval yields (as it must) isotropic speed-of-light, contrary to the assertion of ASC." Presumably, he refers to the *one-way* speed of light, since ASC affirms that the round-trip speed in vacuum is always *c* regardless of coordinate systems. But his "proof" assumes an isotropic one-way speed of light at the first step by setting ε = ½ and thus using the spacetime interval in ESC coordinates; i.e., equation 2 (Dennis's equation 1). Thus, he again begs the question and proves nothing beyond his assumptions. If we don't assume any particular synchrony convention, thereby leaving ε as a free parameter, then we will find (contrary to Dennis's assertion) that the one-way speed of light can indeed have directional dependence as shown below. In fact, it *must* for any choice of ε other than exactly ½.

Using Dennis's notation, we consider two vectors representing outgoing light moving along the *x*-axis ($\boldsymbol{N_{out}}$) and incoming light also along the same *x*-axis ($\boldsymbol{N_{in}}$) representing the reflected beam. Then:

$$\boldsymbol{N_{out}} = (x_1 - x_0, 0, 0, t_1 - t_0) \tag{14}$$

$$\boldsymbol{N_{in}} = (x_0 - x_1, 0, 0, t_2 - t_1) \tag{15}$$

Here $x_1 > x_0$ and $t_2 > t_0$. By definition, $\Delta x = x_1 - x_0$ and $\Delta t = t_1 - t_0$ for $\boldsymbol{N_{out}}$. Since this is a light beam, $S = 0$. So, we substitute this vector into the equation for the spacetime interval and set it equal to zero. This is where Dennis again begs the question by assuming the ESC version of the spacetime interval – equation 2 – and concludes:

$$x_1 - x_0 = c(t_1 - t_0)$$

Dennis then states, "This demonstrates that the outgoing speed of light is *c*," and draws the same conclusion for the incoming speed. But he already assumed that conclusion by using equation 2 (ESC) rather than the synchrony-independent equation 1. So, all Dennis really proved here is that ***if we assume the one-way speed of light is the same in all directions, then the one-way speed of light is the same in all directions.***

The correct (non-question-begging) procedure is to use equation 1 which doesn't assume anything about the one-way speed of light in the *x* direction. Setting $S = 0$ and substituting the vector in equation 14 into equation 1 we find:

$$S^2 = (x_1 - x_0)^2 - c^2(t_1 - t_0)^2 - (2\varepsilon - 1)^2(x_1 - x_0)^2 + 2c(2\varepsilon - 1)(x_1 - x_0)(t_1 - t_0) = 0 \tag{16}$$

Solving for velocity, we find two solutions: a positive and negative one, corresponding to outgoing and incoming light, respectively. Since we defined the first light beam as outgoing, we select the positive solution for it, and the negative solution for the incoming beam:

$$\frac{(x_1 - x_0)}{(t_1 - t_0)} = \frac{c}{2\varepsilon} \tag{17}$$

$$\frac{(x_0 - x_1)}{(t_2 - t_1)} = \frac{c}{2\varepsilon - 2} \tag{18}$$

Using ESC coordinates in which ε = ½, these equations reduce to $\pm c$, thus establishing that the one-way speed of light is the same in both directions *when using ESC coordinates*. But this was never in doubt since the ESC system is predicated upon that stipulation. Under ASC, ε = 1. By substitution into equation 17, we see that (under ASC) outgoing light has a velocity of ½*c*. And by substitution into equation 18, we see that incoming light has infinite speed.[2] This is exactly as ASC requires of the one-way speed of light according to equation 7, for θ = 180° and θ = 0°, respectively. We see that the incoming and outgoing speeds of light are quite different, even though the roundtrip speed is invariant.

Furthermore, equations 17 and 18 show that the incoming and outgoing one-way speed of light *must* have different speeds for all values of epsilon except ½. Thus, when the full equations are used without synchrony assumptions, they prove the opposite of Dennis's claim. The one-way speed of light cannot be computed without first assuming/stipulating it, either directly or indirectly.

Corrections of Misrepresentations

Dennis writes, "Lisle's ASC thesis is that the speed-of-light is a convention and can be made infinitely fast in one arbitrary direction and slower in the opposite arbitrary direction. But is that so?" Of course, we just demonstrated in the above proof that it is. I should point out that the idea that the one-way speed of light "is in reality neither a *supposition nor a hypothesis* about the physical nature of light but a *stipulation* which I can make of my own freewill in order to arrive at a definition of simultaneity" is not "Lisle's thesis," but Albert Einstein's (Einstein 1916). It's built into relativity. To be clear, only the one-way speed of light is conventional. As John Winnie demonstrated (Winnie 1970), the value of the Reichenbach epsilon (and hence the one-way speed of light) has no effect on predictions of any observable phenomenon; it only affects the numbers we assign to times and speeds. And no synchrony convention is any more objectively "true" than any other.

Dennis then writes, "There is another telling remark of Lisle. In Lisle, 2018, p.91, he correctly states: 'Relativity does have absolutes, such as the speed of light in vacuum and the spacetime interval. These are invariant absolute quantities.'" Dennis seems to imply that I am here referring to the one-way speed of light. But clearly, I am referring to the round-trip speed (*c*). In fact, I do not even begin a discussion of the possible anisotropy of the one-way speed of light until chapter 17, page 208![3] The quote that Dennis pulls out of context is from a chapter which introduces the spacetime interval using the ESC system which I affirm is an equally legitimate convention to ASC. My claim is, and always has been, simply that ASC and ESC are equally legitimate and that the Bible uses ASC when timestamping celestial events.

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[2] I am again suppressing the limit notation. We should understand equation 18 as the limit as $\varepsilon \rightarrow 1^-$.

[3] Of the first edition.

Dennis states, "This raises the question that if the speed of light is invariant and absolute (and it is), then how can ASC claim otherwise? Simply put, it can't." This is a classic equivocation fallacy since the term "speed of light" can refer either to its one-way speed or its round-trip speed (*c*) depending on context. There is no logical reason why one must be invariant if the other is. Dennis's error is just like that of some evolutionists who claim that evolution is proved since some bacteria have *evolved* resistance to antibiotics. One kind of "evolution" does not prove the other, nor does the invariance of the round-trip speed of light prove the invariance of the one-way speed. The round-trip speed of light is measured, but, as Einstein pointed out, the one-way speed is stipulated.

In our proof above, we showed that the one-way speed of light can indeed have directional dependence depending on the choice of epsilon, and *must* have directional dependence for any value of epsilon except ½. And that proof assumed the invariance of the round-trip speed of light (*c*). In fact, as will be demonstrated below, if the round-trip speed of light is truly invariant in all inertial reference frames, then the one-way speed of light is necessarily conventional. We show below that the relativity of simultaneity necessarily implies the conventionality of simultaneity.

We also see a misrepresentation of ASC in the form of a false analogy in Dennis's footnote 7. There he states the following:

> Here is a more "down to earth" example to elucidate the method of equation [29]. I am taking a flight from New York City to Los Angeles at noon *LA time*. The flight duration is 6:20 hours. I "synchronize" the local NY clock by setting it forward by 6:20 hours from noon LA time to 6:20 pm ("synchronizing" it with LA time). I land at Los Angeles and check the times. I departed at 6:20 pm (according to the ASC "synchrony") and land at LA at 6:20 pm, so I compute my speed as infinite! Of course, artificially setting the departure time forward by 6:20 hours cannot alter aircraft speeds, and neither can the ASC transform in equation [29] alter light speeds.

A false analogy occurs when people draw an inference from an analogy *in an area that is not similar*. All analogies have similarities and differences to what they represent. But correct reasoning draws conclusions from the areas in which they are similar – not areas in which they differ, as Dennis has done here. To be clear, the error is not in comparing time zones to synchrony conventions – that has some value. The error is when Dennis argues that computing an infinite speed for an airplane that lands at the same local time that it departs is the same as the one-way speed of light being infinite under ASC coordinates. It isn't. These are fundamentally different for three reasons. And if Dennis had bothered to think through *why* it is absurd to conclude an infinite speed for an airplane, he would have quickly discovered his mistake.

To start, the times and time zones Dennis uses are not sensible. Los Angeles is on Pacific time which is three hours behind New York's Eastern time – not six hours and twenty minutes. Second, Dennis should have set his watch *back* by three hours, not forward. Third, he would not have arrived at the same local time he left, but three hours and twenty minutes later. So, this isn't remotely like ASC. But let's correct the math to make it more fitting and suppose he leaves New York at local noon on a supersonic aircraft that can make the trip in only three hours. Then he arrives at Los Angeles at local noon and concludes the aircraft moved infinitely fast. This fixes the math but is still a false analogy for the following reasons:

First, a passenger on the plane would not perceive the trip as instantaneous. His internal mental clock would register three hours and would therefore not conclude that the plane moved with infinite speed.

But the same cannot be said for light. For a photon, every trip is instantaneous. Time dilation approaches infinity as speed approaches the speed of light. Thus, Dennis commits the fallacy of false analogy.

Second, if the plane traveled just a bit faster, it would have arrived at its destination at an earlier local time than its departure. Thus, using local time zones on Earth does not respect causality. But ASC does! Photons never arrive before they depart under ASC. Thus, Dennis commits the fallacy of false analogy.

Third, a plane traveling faster than the one in the example could depart at the same time as the slower plane but land at the same destination earlier. The pilot of the faster plane would note by his own internal clocks that the slower plane took time to reach the destination and thus did not travel instantaneously. But this is not analogous to ASC because there is no information-carrying substance that can travel faster than light. Thus, no external witness can verify that light on a one-way journey is not instantaneous. And thus, Dennis commits the fallacy of false analogy.

Dennis also misrepresents ASC as attempting to "alter light speeds." It doesn't actually "alter" anything. Rather, it merely illustrates the fact – noted by Einstein – that the one-way speed of light is not a property of nature at all but a humanly-stipulated convention by which to define "simultaneous" for some group of observers. Speeds will differ between the two conventions, but each speed is legitimate.

In his third footnote, Dennis states, "In Appendix B it is shown that the spatial geometry of ASC is non-Euclidean." He makes this claim numerous times in his paper. We show in our Appendices A and B that Dennis's claim here is false; the spatial geometry of ASC is perfectly Euclidean. Nonetheless, what would it mean if it were true? Euclidean geometry is merely one of many self-consistent geometries that are useful in various situations. It is not as though Euclidian geometry is somehow truer than any other. Moreover, the geometry of general relativity is not Euclidian, but pseudo-Riemannian. Would Dennis argue that this makes general relativity false?

Furthermore, we show in the appendices that spatial components are unchanged upon synchrony conversion for a given observer. Thus, the spatial geometry of ASC is identical with ESC. Both are Euclidian with regard to their spatial components. However, neither ASC nor ESC are Euclidian once the time component is included. Hence, there is a negative sign before the time component in equation 2. We might call this "Lorentzian geometry" – a special case of pseudo-Riemannian geometry. Would Dennis argue that this makes relativity wrong? So, if Dennis's argument is that ASC is not correct because it is non-Euclidian, then ESC is also not correct because it too is non-Euclidian. Yet, Dennis apparently embraces ESC while rejecting ASC. This is quite inconsistent.

Presentism

Many of Dennis's misrepresentations of my position, and perhaps of relativity in general, may stem from his philosophy of "presentism." I reject such a philosophy as mere rhetoric at best and inconsistent with physics and the Bible at worst. But I wish to be fair to Dennis, and so I will not offer a full refutation of presentism here since this was not his main focus. Rather, in this section I will simply point out some misrepresentations that may stem from that belief, and I will also show that his position is not consistent with the physics of Einstein.

In his first footnote, Dennis states, "When I use the term 'spacetime,' I am referring to the *abstract* mathematical structure developed by Minkowski. 'Spacetime' does not exist." Actually, if spacetime did not exist then neither could Dennis exist, and thus he could not have written those comments. As physical beings (with an immaterial spirit), we humans require the three dimensions of space and the one of time in order to exist. We require a real volume in which to exist and real time in which to have duration; these constitute spacetime. The way we think about spacetime may be an abstraction, but spacetime does exist or else we couldn't.

Dennis continues, "Unfortunately, ASC presumes that spacetime exists as an actual non-abstract and eternal indivisible four-dimensional reality ('eternalism') in which time and space cannot be objectively resolved." One *possible* misrepresentation here is that I allegedly believe that spacetime is eternal. I contend that spacetime has a beginning, so it is not eternal in the same way God is. Nor will this spacetime continue indefinitely into the future, at least as it is. Judgment Day is coming, and the universe will be destroyed and remade. I do believe that the New Heavens and New Earth will exist forever in the future direction and that all believers will enjoy eternal life: *biblical* eternalism.

Furthermore, I hold that space and time can be divided (they are not "indivisible" as Dennis claims I believe), but that such division will be observer-dependent (not invariant). That is, an interval that one observer sees only as time, another will see as a combination of time and space. I do hold that spacetime is non-abstract – no misrepresentation there. And I agree that space and time cannot be objectively resolved in a way that all reference frames would agree on the components of space and time. In other words, only the spacetime interval is invariant, not the individual components of space and time. Dennis calls this "eternalism." However, really it is just "relativity" – the physics of Einstein.

Apparently, eternalism exists in contradistinction with Dennis's view in which reality is "a three-dimensional spatial universe that persists through time ('presentism')." At best, this is a distinction without a difference. What is a "three-dimensional spatial universe that persists through time" if not a four-dimensional spacetime? It would be like a person arguing, "there are only two real dimensions of space: length and width, but these lengths and widths persist over height."

In his sixth footnote, Dennis states, "If the ASC advocate embraces eternalism then he can claim there is no such thing as 'simultaneity.'" This is simply not accurate. If by "eternalism" Dennis means "relativity" as in the physics Einstein discovered, then simultaneity is real. It is simply *not invariant*. An essential feature of the physics of Einstein is that two events that are judged to be simultaneous according to one observer will not, in general, be judged as simultaneous relative to another observer. The space of simultaneity is dependent on the reference frame (and synchrony convention). This principle of physics is called the *relativity of simultaneity* and is an essential feature of the physics of Einstein. Even if Dennis endorses ESC, it too maintains that the space of simultaneity is not invariant, but observer-dependent, which apparently is contrary to his philosophy of presentism.

Dennis continues, "That answer provides no solace to ASC, since the ability to select any time of reflection and maintaining the claim that the distance R is the 'real' distance means there is no unique reflection event." This too is false. In relativity, the reflection of light off of a mirror is a real and objective event. What is observer-dependent is the time and space coordinates assigned to that event. But all observers would agree on whether the reflection took place, and they could easily convert from the coordinate system of any one observer to any other. Furthermore, we show in Appendix A (contrary to Dennis's claim) that $R = R'$. Namely, distances to a given event are unaffected by a change of synchrony convention for a given observer. Distances/lengths are relative to an observer's *motion*, but that is not the topic under discussion.

In the same footnote, Dennis continues, "On the other hand, abandoning the uniqueness of *R* means that there is no objective spatial distance to the reflection. This last conclusion is a basic feature of eternalism." In fact, that distances are not unique (not invariant) but dependent on the reference frame is a basic feature of relativity – the physics of Einstein. If the spacetime interval is invariant, then distances are not (and vice versa). Yet, Dennis claims to embrace the invariance of the spacetime interval in his paper (Dennis 2024). Does he really believe that distances are also invariant? What about length contraction?

He continues his claim about eternalism saying, "Objects have no actual 3D properties, only eternal 4D spacetime properties." This is false as written. We all agree that objects have actual length, width, height, and duration. But perhaps by "actual" Dennis means "invariant" or "objective." Einstein showed that lengths and durations depend on the reference frame. This is responsible for effects like length contraction and time dilation. Does Dennis deny these effects? Are they merely "apparent" in his view?

Regarding eternalism, Dennis continues, "There is no instant ('now') in the creation and there are no objective spatial relations between objects – only spacetime relations." This is partially false. Of course, there is indeed an instant "now" in creation – at the beginning! Perhaps what Dennis means is that the time of creation is reference-frame dependent in relativity – which it is. But that doesn't mean the moment doesn't exist. Furthermore, relativity (eternalism) does indeed maintain that there are no objective (invariant) spatial relations between objects – only spacetime relations. Dennis seems to deny this, but it is an integral part of relativity and is why things like length contraction and time dilation exist. And these have been confirmed by empirical experimentation.

He continues, "There are also no objective relative speeds." Clarification would have been helpful. What is an "objective relative speed?" I suspect that Dennis means that the difference in speeds between two objects will be judged differently by different observers. That's true for most speeds. But there is one objective speed: the round-trip speed of light is judged to be the same by all observers regardless of their motion, coordinate system, or synchrony convention.

We must note that Dennis's presentism is not compatible with the physics of Einstein. Dennis seems to think that spatial and temporal relations are individually invariant ("objective" or observer-independent). This implies that there is a unique "now" that is observer-independent – an objective, reference-frame-independent space of simultaneity. This is inconsistent with the relativity of simultaneity as expounded in chapter nine of Einstein's primer on relativity (Einstein 1916) and in chapter seven of *The Physics of Einstein* (Lisle 2018). Different observers will necessarily have different spaces of simultaneity if each observer stipulates that the one-way speed of light is isotropic relative to himself. This necessarily results in different clock synchronizations for observers in different reference frames. Thus, insisting on an isotropic one-way speed of light for each observer (ESC) implies that there cannot be an objective (invariant) space of simultaneity. Therefore, we must conclude the following:

Dennis's presentism is incompatible with the one-way speed of light being the same in all directions for all observers! If the one-way speed of light is isotropic for all observers, then different reference frames necessarily have different spaces of simultaneity. Alternatively, if there is only one actual, objective space of simultaneity – a universal "now" that is the same for all observers – then the one-way speed of light can be isotropic for only *one* reference frame and is therefore anisotropic for all others. In other words, if the one-way speed of light is isotropic as measured by Sarah's clocks, and if hers are objectively synchronized (thereby reflecting the only true "now"), then the one-way speed of light will *not* be isotropic relative to Michael who is moving relative to Sarah. *Therefore, Dennis's philosophy of presentism contradicts the very thing he attempts to prove in his own publication.*

The Conventionality Thesis and Relativity

Attempts like Dennis's to establish a non-conventional one-way speed of light cannot succeed if the physics of Einstein is accurate. The reason is that the conventionality of simultaneity follows inescapably from the relativity of simultaneity as we will demonstrate below. What is an isotropic synchrony convention for one observer will necessarily be a non-isotropic synchrony convention for another observer. In other words, if any ESC system is valid, then non-isotropic systems must also be valid since they are ESC relative to someone. Let us illustrate this by returning to our earlier scenario.

Consider Sarah, who is stationary relative to Earth, and her friend Michael, who moves at ½*c* relative to Sarah in the positive *x* direction. Furthermore, suppose that Sarah has synchronized her clocks under the stipulation that the one-way speed of light is *c* in all directions relative to her. Then, as measured by Sarah's clocks, light in the positive *x* direction moves ½*c* relative to Michael, who is himself moving at ½*c* in the positive *x* direction. Conversely, light moving in the negative *x* direction moves at 1.5*c* relative to Michael as shown in Figure 1. Thus, the one-way speed of light is non-isotropic relative to Michael – as measured by Sarah's clocks and rulers. Putting it another way, if what Sarah considers to be the space of simultaneous events is the same as the space that Michael considers to simultaneous events, then one of them must judge the one-way speed of light to be non-isotropic.

An isotropic synchrony convention for one observer will necessarily be non-isotropic for another observer who is in motion relative to the first. Thus, if ESC is a valid convention, then non-isotropic conventions must also be valid since they are ESC for some observer. There is nothing that logically prevents Michael from using Sarah's clocks and rulers to measure the one-way speed of light relative to himself. He would find that light is faster relative to him in the negative *x* direction than in the positive *x* direction. If Sarah is allowed to stipulate that the one-way speed of light is isotropic relative to her, why can't Michael stipulate that the one-way speed of light is isotropic relative to Sarah, and thus non-isotropic relative to himself? ESC relative to one person is ASC relative to another. This is why any attempt to disprove ASC that assumes ESC must fail in the context of relativity.

Conclusions

We have seen that Dennis's argument fails because it commits the fallacy of begging the question. It arbitrarily presupposes the ESC synchrony convention at the first step – the very thing it attempts to prove. Dennis's entire paper can be summed up in the following: "If we assume that the one-way speed of light is the same in all directions, then the one-way speed of light is the same in all directions." But this proves nothing beyond what it assumes and is reversable. I could equally well say, "If we assume that the one-way speed of light is different in different directions, then the one-way speed of light is different in different directions." This would be just as valid, and equally unhelpful.

We have seen that the conventionality of simultaneity follows inescapably from the relativity of simultaneity. That is, if what Sarah considers to be simultaneous is different from what Michael considers to be simultaneous since each assumes the one-way speed to be isotropic to herself/himself, then the one-way speed of light cannot be any more objective than simultaneity. What is isotropic relative to Sarah will not be isotropic relative to Michael using the same synchrony system. Thus, the conventionality thesis cannot be overturned without also refuting relativity – one of the most well-established branches of science.

I appreciate Dennis's interest in synchrony conventions. I would highly recommend to him and others interested in this subject to read the rich body of technical literature available on this topic. This is important so that authors don't make the kinds of mistakes we have uncovered here. It is very easy, even for physicists well versed in relativity, to unwittingly use an equation derived using ESC and mistakenly think that it is synchrony-independent. Or alternately, the authors assume something is true in another synchrony convention that in fact is only true of ESC. Students of this topic must understand where the equations of relativity come from – how they were derived and what they presuppose.

There have been many papers either advancing or attempting to refute the conventionality thesis. And indeed, nearly all those papers attempting to refute the conventionality thesis have inadvertently assumed ESC as part of their proof, thereby begging the question. Such errors are inevitably exposed by another author in a subsequent paper. The remaining attempts to refute the conventionality thesis generally impose some additional arbitrary constraints of a synchrony convention, such as claiming it must be reflexive, transitive, or time-reversable. But these amount to mere preferences, not requirements for logical consistency or consistency with observations. And they are quickly refuted in a subsequent paper (e.g., Sarkar and Stachel 1999). For an excellent summary of the history of the conventionality thesis, see *Concepts of Simultaneity: From Antiquity to Einstein and Beyond* (Jammer 2006).

It is also important to note that the conventionality thesis is not a creationist issue *per se*. Any physicist knowledgeable of relativity and synchrony conventions would have been able to spot the errors in Dennis's publication. A standard science journal might have afforded Dennis a more thorough peer-review process and faster feedback from physicists who specialize in this topic. Indeed, there are physicists who have made very strong arguments in favor of the conventionality thesis (e.g., Reichenbach 1957, Salmon 1969, Winnie 1970, Sarkar and Stachel 1999). Why did Dennis not attempt to refute one of their papers in a standard journal?

Indeed, non-standard synchrony conventions are not my invention but have been very thoroughly discussed in secular journals over the last hundred years. Anyone attempting to refute the conventionality thesis should become thoroughly acquainted with these arguments. Furthermore, I recommend submitting publications to standard journals, especially in response to physicists who have published thorough proofs of the conventionality thesis, where such papers can enjoy a thorough peer review from specialists in the field.

My unique contribution, the thesis that I am advocating, is that the Bible uses ASC when timestamping events. Nothing in Dennis's paper even touched on that issue. Even if Dennis had succeeded in proving that ASC is a non-physical synchrony convention (which he did not), would this even remotely suggest that the Bible cannot use it? After all, the Bible uses local time to describe events. And I would agree with Dennis that local time is not appropriate for computing physical speeds (as in an airplane that crosses time zones) since it does not preserve causality. Would Dennis argue that this makes the Bible wrong, or alternatively that the Bible must always use Greenwich standard time and never local time?

As Jammer (2006) documents, all ancient cultures used a visual synchrony convention (the same as ASC) in which the time of any cosmic event is concurrent with the time of its observation on Earth. According to Einstein, they were perfectly justified in using such a convention. Einstein preferred to use a different convention that now bears his name – not because of any logical or empirical necessity – but because the equations take a simplified form when isotropy is imposed. And there is nothing wrong with ESC. The problem occurs when people anachronistically assume that the Bible uses this modern convention when describing events. This creates a perceived starlight travel-time problem that I contend does not actually exist.

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Appendix A

Are ASC Speeds Physical Speeds?

In his Appendix A, Dennis attempts to prove that ASC speeds are not "physical speeds." But he makes a number of critical mistakes in his argument as will be shown below. Dennis previously stated, "Note that the definition of *physical* speed is *distance*, *D,* traveled in a time of *T*":

$$v = \frac{D}{T}$$

By this definition, speeds in both ESC and ASC are indeed physical speeds. They are each derived by dividing the distance traveled by the time it takes to travel that distance. We saw this in the derivation of the one-way speed of light above. The two conventions result in different one-way speeds (not just for light but for all phenomena) because the time coordinate is different between the two conventions while the spatial coordinates are unchanged.

A foundational mistake in Dennis's "proof" in his Appendix A is that he confuses the concept of distance with the concept of a spacetime interval. Indeed, Dennis variously refers to *R'* as an "interval," a "spatial interval," a "distance," and an "invariant interval." These are not the same. A distance could certainly be called a "spatial interval" but it is *not* an "invariant interval."

Recall that the spacetime interval (given in equation 1) is a *combination* of measurements of space and time between two events and is invariant (meaning it is the same for all observers regardless of their position or motion). However, the distance between two points involves only spatial terms (Δx, Δy, Δz; see equation 8). Distances are *not* invariant. Furthermore, there is no Δt in distance measurements; thus, they are not altered when a given observer changes synchrony conventions because the spatial coordinates remain the same.

When using ESC, the spacetime interval reduces to spatial distance if and only if $\Delta t = 0$. (Setting $\Delta t = 0$ in equation 2 reduces it to the square of equation 8.) This is a unique convenience of the ESC system and is not true in other synchrony conventions (equation 3 does not reduce to the square of equation 8 when setting $\Delta t = 0$). Thus, assuming that the spacetime interval equals distance when $\Delta t = 0$ tacitly assumes ESC. In any case, distances are *not* invariant; that is, the distance between two points depends on the state of motion of the observer.

First, Dennis considers the distance (R) between a light source and its reflection point as depicted in his Figure 2 as follows:

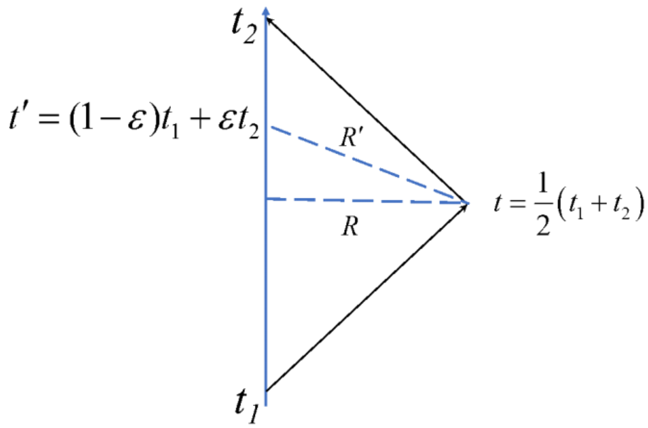

Figure 2

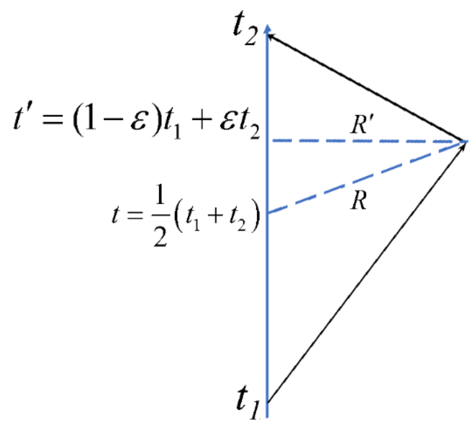

Figure 3

Dennis then asks, "The question is what is the **distance *R'***?" (emphasis added). He uses R' to denote the distance between two events in a non-Einstein synchrony convention (where $\varepsilon \neq ½$).[4] However, Dennis's Figure 2 is misleading. It uses ESC coordinates (depicting light beams at 45 degrees relative to the axes). While ESC is a perfectly fine convention, Dennis assigns the point of reflection as t, not t', thereby tacitly suggesting that the "true" time of reflection is according to ESC, which begs the question. Furthermore, Dennis labels intervals as distances; this makes R' appear longer than R since R' forms the hypotenuse of a right triangle of which R is one leg. But notice that the other leg of the triangle is along the t-axis. It is a dimension of time, not of space – thus it cannot add to the spatial length of R'. In fact, if Dennis had depicted the diagram using coordinates of a non-isotropic synchrony convention, then R would look longer than R' as we depict in Figure 3. So, which is it? In reality, R and R' are exactly the same length because the distance to the mirror is unaffected by the one-way speed of light as will be demonstrated below.

Conversion between ASC and ESC *only affects the time coordinates* for a given observer, not x, y, or z. By construction, $x' = x$, $y' = y$, and $z' = z$. This is covered in chapter 18 of *The Physics of Einstein* (Lisle 2018) on page 247 of the first edition. Lengths, widths, heights, and thus distances like R are unchanged when converting between synchrony conventions as we will prove below. Dennis attempts to prove otherwise, but he begins by using an incorrect equation. He writes that the *distance R'* is given by the "invariant interval" in his equation 3:

$$R'^2 = \Delta x^2 + \Delta y^2 + \Delta z^2 - c^2 \Delta t^2 \qquad (19)$$

[4] This can be confusing because normally primed coordinates are used to indicate coordinates in a different reference frame rather than coordinates in the same reference frame but under a different synchrony convention. Nonetheless, we will use Dennis's notation in this refutation.

Of course, that is wrong. The above is the formula for the spacetime interval between two events (S^2), ***not*** distance (neither R^2 nor R'^2). Distance is *not* invariant and is correctly defined by equation 8 above, *not* equation 2. Perhaps Dennis meant to imply that $\Delta t = 0$ since the spacetime interval is equal to distance for simultaneous events? But this is only true in ESC. Furthermore, when he uses the formula in his derivation that follows, he uses non-zero values for Δt, and thus his distance calculations are wrong. The spacetime interval is only equal to the distance when $\Delta t = 0$ by ESC.

Second, Dennis assumes the spacetime interval formula using *ESC* coordinates! (See equation 2.) Even if he really meant to solve for S' instead of R', he should have used the synchrony-independent equation 1, rather than equation 2. Again, Dennis has begged the question by assuming ESC coordinates in his attempt to prove that only ESC coordinates are legitimate. If he meant R' to refer to a spacetime interval in ASC, then equation 1 must be used.

In reality, distances are unchanged (for a given observer) when converting between ESC and ASC, as will be demonstrated shortly. Only time is affected. So, the correct formula for distance between two events is (squaring equation 8):

$$R'^2 = R^2 = \Delta x^2 + \Delta y^2 + \Delta z^2 \tag{20}$$

Again, note that there are no time coordinates (Δt) in the distance formula. Even if we give Dennis the benefit of the doubt and presume that he is actually attempting to compute the spacetime interval between two events instead of the distance using ESC, what he does next makes no sense. He takes the time of reflection as measured by ESC: $t = ½\,(t_1 + t_2)$, subtracts this from the time of reflection as measured by a non-isotropic synchrony convention: $t' = (1 - \varepsilon)t_1 + \varepsilon t_2$, and then substitutes this into his (incorrect) equation 3 as Δt. But that is not what Δt represents in the spacetime interval. Rather, Δt represents the difference in time between ***two*** events as measured by the same observer (using the same coordinate system and synchrony convention). That is, $\Delta t = t_2 - t_1$. Dennis treats it as if it is the difference in times between two synchrony conventions of *one* event, as if $\Delta t = t' - t$, which it is not. In reality, the total time between the event of light emission and its return to the source is: $\Delta t = t_2 - t_1 = 2R/c$.

In summary, Dennis used an incorrect equation for distance (that is actually an equation for the spacetime interval), he wrongly included the term Δt (a term that is not present in the distance formula), he used the wrong *value* for Δt as well, and he used the ESC form of the spacetime interval in his attempt to prove ESC – thereby begging the question. Consequently, what follows from those mistakes is also erroneous. Nonetheless, we can salvage Dennis's result (his equation 4) by keeping track of the incorrect terms (in red) derived from the erroneous addition of the term ($-c^2\Delta t^2$):

$$\begin{aligned} R'^2 &= \Delta x^2 + \Delta y^2 + \Delta z^2 - c^2\Delta t^2 \\ &= (R-0)^2 - c^2\left[t' - \frac{1}{2}(t_1+t_2)\right]^2 \\ &= R^2 - c^2\left[(1-\varepsilon)t_1 + \varepsilon t_2 - \frac{1}{2}(t_1+t_2)\right]^2 \\ &= R^2 - \frac{c^2}{4}\left[2(1-\varepsilon)t_1 + 2\varepsilon t_2 - t_1 - t_2\right]^2 \end{aligned}$$

$$R'^2 = R^2 - \frac{c^2}{4}[2(\varepsilon - 1)(t_2 - t_1)]^2$$

Notice that when these incorrect terms are removed, we get the correct result, consistent with equation 20, namely:

$$R'^2 = R^2 \tag{21}$$

Thus, following the correct mathematics, we can see that distances are unchanged upon conversion between synchrony conventions. This must be the case because synchrony conventions only involve differences in the time coordinates as explained in *The Physics of Einstein* chapter 17 (Lisle 2018). But due to the incorrect distance formula and the assumption of ESC, Dennis concludes that R and R' are different:

$$R' = 2\sqrt{\varepsilon(1-\varepsilon)}R \tag{22}$$

So, the above equation is wrong because Dennis has incorrectly added a temporal quantity to the distance formula. By analogy, this is like comparing two stationary cars that are exactly the same length, but arguing that one is actually much longer than the other because it is older. Time and length are independent and do not add in such a way.

Furthermore, it should be obvious that equation 22 is wrong by considering the situation in ASC coordinates in which $\varepsilon = 1$. The equation simplifies to: $R' = 0$. So, all distances in ASC would be zero if Dennis's derivation were correct, which is clearly absurd.

On the other hand, if Dennis really meant to compute the spacetime interval (S) instead of distance (R), then he begged the question by using the simplified form which assumes ESC by setting $\varepsilon = ½$, namely equation 2. That is the wrong equation for any other value of epsilon. If he had started using the correct formula, equation 1, and used this to compute R and R' respectively, he would find as we did above that $R' = R$. Let's demonstrate this beginning with equation 1. For light, $S = 0$, and since $\Delta y = \Delta z = 0$ in our scenario, we find:

$$S^2 = 0 \; = \; \Delta x^2 - c^2 \Delta t^2 - (2\varepsilon - 1)^2 \Delta x^2 \; + \; 2c(2\varepsilon - 1)\Delta x \Delta t \tag{23}$$

The equation is quadradic for Δx, resulting in two solutions for outgoing and incoming light, respectively:

$$\Delta x = \frac{c}{2\varepsilon}\Delta t \tag{24}$$

$$\Delta x = \frac{c}{2\varepsilon - 2}\Delta t \tag{25}$$

We can use either of these to solve for R and R'. Let's pick the first one, which represents the outgoing light beam. For ESC, $\varepsilon = ½$, $\Delta x = R$, and from the figure we see $\Delta t = t - t_1 = ½(t_1 + t_2) - t_1 = ½(t_2 - t_1)$ Substituting these values into equation 24 we obtain:

$$R = ½c(t_2 - t_1) \tag{26}$$

For the non-isotropic synchrony convention, we leave ε unspecified, $\Delta x = R'$, and from the figure we see $\Delta t = t' - t_1 = (1 - \varepsilon)t_1 + \varepsilon t_2 - t_1 = \varepsilon(t_2 - t_1)$. By substitution into equation 24 we find:

$$R' = \frac{c\varepsilon(t_2 - t_1)}{2\varepsilon}$$

$$R' = ½c(t_2 - t_1) \tag{27}$$

And so the value of R' in equation 27 is the same as R in equation 26. Therefore, $R = R'$. Starting from the correct formula without making any synchrony assumptions, we find that distances are unchanged upon conversion between synchrony conventions. Notice that ε does not appear in equation 27, thereby demonstrating that the distance R' does not depend on any choice of the one-way speed of light.

It should be obvious that synchrony conventions do not affect distances by the following thought experiment. Suppose we send a light pulse to a mirror at distance R which reflects back to the source. A clock at the mirror records the time of reflection. But the distance to the mirror can be computed without using this clock. Rather, the clock at the source which records the time of departure and the time of arrival of the reflected beam is used to determine distance. Namely, $R = ½c(t_2 - t_1)$. Whether the clock at the mirror records the time of reflection as $½(t_1 + t_2)$ or some other value is utterly irrelevant. The distance is unchanged. Putting it another way, if we discovered that the clock at the mirror was running slightly fast and so we reset it to the correct time, would that affect the distance to the mirror? Of course not.

Since he arrived at an incorrect value of R', Dennis concludes, "This shows that the distance R' to the light reflection in ASC is not the same as the distance R used to calculate the two-way speed-of-light." But we have just demonstrated the opposite: that $R' = R$. Dennis states, "What this means in principle is that the ASC synchrony convention does not maintain the *geometric* meaning of the spatial coordinate x." But we have demonstrated above that distances are identical between ASC and ESC. Thus, ASC does indeed maintain the geometric meaning of the spatial coordinates since they are identical to ESC spatial coordinates.

Dennis goes on to say, "If ASC takes seriously that the interval R' lies in a 'simultaneous' space, then R' should be used in calculating distances, rather than R." But as we demonstrated above, the spatial distance $R' = R$. The spacetime intervals Dennis labels in Figure 2 as R and R' are indeed surfaces of simultaneity in ESC and ASC, respectively. But their spatial distance is identical since distances are unaffected by the choice of synchrony conventions.

Dennis then states, "Using the value R in ASC calculations of the 'speed-of-light' is the reason that there is an *apparent* alteration of the 'speed-of-light.'" That is not correct and seems to be why Dennis thinks that speeds in ASC are "non-physical" – because he thinks that R is different from R'. But since we demonstrated above that $R = R'$, by Dennis's own reasoning, we have demonstrated that speeds in ASC are indeed physical speeds and that their different values for the one-way speed of light are real. The one-way speeds in a non-isotropic synchrony convention are different from speeds in the ESC system not because of any change in R, but because of differences in the time coordinate. $R = R'$, but (in general) $t \neq t'$.

The rest of Dennis's conclusions in Appendix A are likewise erroneous because they stem from his miscalculation of *R′*. Furthermore, his analysis in Appendix B commits this same error and thus his conclusions are similarly flawed as will be shown in our Appendix B.

Appendix B

Mathematics of ASC

In Dennis's Appendix B, he attempts to explore the mathematics of ASC in spherical coordinates. But several misunderstandings and contradictions appear in his analysis. He begins with the spacetime interval expressed using the ESC system in spherical coordinates:

$$ds^2 = -c^2dt^2 + dr^2 + r^2(d\theta^2 + \sin^2\theta d\varphi^2) \tag{28}$$

First, we note that the above equation assumes the ESC system. That's perfectly fine as long as we recognize that it will take another form when expressed using ASC coordinates. Second, this shows that the same underlying reality can be expressed using different coordinates and the formula will appear different. Namely, equation 28 and equation 2 express exactly the same underlying reality using different coordinates although both equations use the ESC system. Likewise, equations in ESC and ASC express the same underlying reality using different temporal coordinates due to their different definitions of simultaneity. Dennis apparently embraces the former while rejecting the latter, which is inconsistent.

Next, Dennis gives the transformation of time (*t*) to a synchrony convention in which the incoming and outgoing one-way speeds of light are permitted to differ for values of ε. He again uses primed coordinates to indicate different synchrony conventions and *not* to indicate different reference frames.

$$t = t' - (2\varepsilon - 1)r/c \tag{29}$$

Dennis refers to this as the ASC transformation. To be more precise, ASC would be the limit of this formula as $\varepsilon \to 1$. Under ASC, the transformation simplifies to following:

$$t = t' - r/c \tag{30}$$

Dennis states, "The intent of this transformation is to produce a nearly infinite incoming 'speed-of-light', i.e., a light ray that 'arrives' at the earth nearly 'instantaneously' after it was emitted. How is this *theoretically* achieved?" First, we again see hints of the *a petitio* fallacy. Namely, how does Dennis know that the trip is not *actually* instantaneous as opposed to "theoretically?" Of course, he can't know that empirically or logically. All we actually know experimentally is that round-trip journeys take time from our perspective. We often "stipulate" (as Einstein put it) the one-way speed to be *c* as a convenience, but not out of any observational or logical necessity.

Second, Dennis concedes that instantaneous travel is theoretically achieved. But it is more than that. In relativity, in the limit as a reference frame approaches the speed of light, travel time *actually* reduces to zero in that frame, thereby allowing instantaneous travel for any finite distance. In other words, from the light's point of view, all trips are actually instantaneous. Even if we disallow null intervals, any particle that travels at nearly the speed of light will arrive at its destination nearly instantly as measured by its own clocks. This is the well-established effect of time dilation.

Next, Dennis makes a critical mistake when he states, "We note that equation [29], on which ASC equations are based, actually concedes the one-way speed-of-light. This should be clear, since equation

[29] must use the one-way speed-of-light *c* to set the ASC clock 'fast.'" Here he refers to the one-way speed of light as *c* which is the symbol for the *round-trip speed of light* – not the one-way speed. Rather, epsilon (ε) is used to denote possible differences in the one-way speed of light, not *c*. And the ASC form is given by equation *30*, which does not involve the one-way speed (no ε) at all!

Rather, the difference between the ESC and ASC timing of events is related by the distance to those events divided by the *round-trip* speed of light (*c*). Furthermore, Dennis again begs the question: is the equation used to set ASC clocks fast, or ESC clocks slow? He arbitrarily assumes that ESC clocks are correct, and thus ASC clocks are fast; it doesn't seem to occur to him to consider the reverse: another example of confirmation bias. In reality, neither synchrony convention is any more objectively true than the other one. Neither one is logically prior to the other one. Nevertheless, in practice, astronomers always record the ASC time of any celestial event and then convert to ESC – the opposite of Dennis's claim.

Referring to equation 30, he goes on to state, "This shows that the amount an ASC clock is advanced is precisely the amount of time it takes the light to travel from a distance *r* to the origin." But this begs the question. Perhaps this actually "shows that the amount an ESC clock is retarded is precisely the amount of time it takes light to travel from a distance *r* to the origin assuming the one-way speed is *c*." Dennis arbitrarily assumes the one as the disproof of the other. That proves nothing and is completely reversable.

In his footnote 8, Dennis notes that equation 30:

> is also used as the definition of Eddington-Finklestein ingoing coordinates (EFC) used in the analysis of black holes. That coordinate system is based on ingoing light rays. It labels events by the time of their arrival at the origin, the location on the celestial sphere and a radial coordinate from the origin. The coordinates are useful in the analysis of black holes since the EFC describe the trajectory of photons falling into a black hole.

Yes, they are indeed useful! I have published on the advantages of using alternate synchrony/coordinate conventions when analyzing black holes (Hamilton and Lisle 2008). Dennis doesn't seem to have a problem with alternate synchrony conventions in that case. Why does he object to their use in creation-based young-universe models? Perhaps the answer is revealed in the rest of his footnote in which he states, "It is important to note that use of EFC does not imply that the time of arrival of a light ray is also the actual time of all events along the light ray. They merely identify events along a light ray." But what does Dennis mean by "actual time?" In relativity, the time between two events is not invariant but depends on the reference frame of the observer and the selected synchrony convention. This may be where Dennis's philosophy of presentism is causing some misinterpretations of the data.

Dennis states, "We note that equation [30] also describes an ingoing light ray traveling at a one-way speed-of-light (=*c*) arriving at the earth (*r=0*) at time $t = t'$." He has again begged the question by arbitrarily declaring that the one-way speed of light is *c* (the round-trip speed). In reality, equation 30 describes the relationship between the *t* coordinate (ESC) and *t'* (ASC) for a given observer. It could certainly be used to prove that incoming light has infinite speed by ASC, but that's not what it actually describes.

Dennis continues, "To summarize, the ASC transformation must use the isotropic Minkowski space to derive the ASC transformation which disguises the isotropy." This once again begs the question because Dennis has arbitrarily assumed that Minkowski space is isotropic in regard to the one-way speed of light because he assumed ESC coordinates. But this is the very thing he is supposed to be proving. His claim is arbitrary and reversable. I could just as well declare, "The ESC transformation must use the anisotropic Minkowski space to derive the ESC transformation which disguises the anisotropy."

Dennis states, "Another way of stating this is that the ASC transformation, equation [29]…." Actually, ASC is equation 30. He continues, "…requires use of the one-way physical speed-of-light *c*…." No, *c* refers to the *round-trip* speed of light, not the one-way speed. The one-way physical speed of light does not appear in equation 30. Dennis continues, "…to perform the mathematics. As such, ASC commits a serious logical lapse. It presupposes the Minkowskian spacetime and a one-way isotropic physical speed-of-light…." We have seen that this is incorrect. Rather, it is Dennis who has arbitrarily assumed an isotropic one-way speed of light in his attempt to prove an isotropic one-way speed of light.

Dennis continues, "…to derive the ASC formulae (cf. equation [29]), then denies it." This is not only false, but it again begs the question. Why arbitrarily assume that ESC is correct and that ASC is derived from it rather than the reverse? The ESC version of the spacetime interval can be derived from the ASC version using equation 30 just as easily as the reverse. Neither equation is empirically or logically prior to the other. Dennis believes that "this is a presuppositional defeat of ASC," but of course it isn't. Presuppositional reasoning does not mean that we simply presuppose that ESC is the only correct synchrony convention thereby disproving ASC. Rather, that is the fallacy of begging the question. Presuppositional reasoning involves asking what are the necessary preconditions required for knowledge, and Dennis hasn't done anything like that in his article.

Taking the differential of equation 29 and substituting into equation 27, Dennis obtains a synchrony-independent (with respect to the one-way speed of light in the *r* direction) version of the Minkowski metric in spherical coordinates:

$$ds^2 = -c^2dt'^2 + 2(2\varepsilon - 1)cdrdt' + 4\varepsilon(1-\varepsilon)dr^2 + r^2(d\theta^2 \ + \ \sin^2\theta d\varphi^2) \qquad (31)$$

Dennis calls this "the ASC coordinate form of the invariant Minkowski interval," or rather it would be this in the limit as $\varepsilon \to 1$. In such a case the equation simplifies to:

$$ds^2 = -c^2dt'^2 + 2cdrdt' + r^2(d\theta^2 \ + \ \sin^2\theta d\varphi^2) \qquad (32)$$

This is the spacetime interval in spherical coordinates using ASC for an observer at the origin. What Dennis states next about equation 31 is very important. He says, "**This coordinate transform has not altered the intrinsic geometry of Minkowski space**" (emphasis added). Quite right. Synchrony conventions do not alter geometry. They merely affect the numbers we use to describe such geometry. He continues, "(Just as transforming to polar coordinates in the Euclidean plane does not alter the geometry of the Euclidean plane; or representing the globe in terms of polar stereographic coordinates alters the spherical geometry of the globe.)" This is true. A sphere can be described in either spherical coordinates or rectangular coordinates. The equation will look quite different, but the sphere remains the same.

Then Dennis immediately contradicts himself, stating, "It should be mentioned here that ASC commits an abuse of coordinates when one performs the transformation in equation [29] and then only analyzes equations algebraically (coordinate symbols) while ignoring the geometry as embodied in equation [31]." But Dennis has just stated that the coordinate transformation ***has not altered*** the geometry! He can't have it both ways. Either he can complain that we haven't analyzed the alleged changes in geometry imposed by a different coordinate system, or he can claim that such a transformation does not affect the geometry, but not both.

We should also note that Dennis did *not* complain about the Eddington-Finklestein synchrony convention, which is essentially the ASC system for a black hole (Schwarzschild metric). Indeed, it is very common, particularly in general relativity, to use alternate synchrony conventions when convenient (Hamilton and Lisle 2008). We can always do this because, as Einstein pointed out, the one-way speed of light is not a property of nature but a stipulation by which we define "simultaneous" for some group of observers. Dennis apparently believes in some objective, observer-independent (invariant) form of simultaneity (his presentism). But this is contrary to the physics of Einstein; it violates the relativity of simultaneity as we demonstrated above.

Strangely, Dennis then mentions in a footnote, "It bears repeating that coordinates, per se, are amorphous and devoid of geometric or physical meaning." That's correct, of course. But then why has he just complained that we have not analyzed the "geometry embodied in equation [31]" (which uses ASC coordinates) when such coordinates are "devoid of geometric or physical meaning?" Again, he can't have it both ways. He continues, "Their physical meaning is derived via the coordinate independent invariant interval *ds*." Well yes, and *ds* does not change upon conversion between synchrony conventions. Only its expression in terms of the coordinate system will change, not its value.

In his footnote 10, Dennis states, "For those familiar with tensor calculus, this entire paper can be summarized as follows. ASC utilizes a coordinate transformation, $dx^{a'} = \frac{\partial x^{a'}}{\partial x^b} dx^b$, then only uses the new coordinates x'^a without transforming the metric to its representation in ASC coordinates, viz. $g_{ab}' = \frac{\partial x^c}{\partial x'^a} \frac{\partial x^d}{\partial x'^b} g_{cd}$, given in equation [31], to analyze the intrinsic geometry and physics." But coordinate transformations *have no effect on the intrinsic geometry and physics!* And Dennis had previously stated as much, saying, "This coordinate transform has not altered the intrinsic geometry of Minkowski space."

It appears that Dennis both affirms and denies that coordinate transformations affect the underlying geometry. To be clear, they do not. A sphere is still a sphere regardless of what coordinate system one uses to express it. Some coordinate systems may be more useful than others in a given scenario. But they are merely ways of assigning numbers to represent the position and time of an event. Ancient cultures universally used a visual synchrony convention in which an event is simultaneous with when its light is seen. Of course, this is ASC. Dennis is welcome to expound upon the merits of using a different synchrony convention; but this doesn't change the fact that ASC was the only convention in use until very modern times. It is therefore my position that the Bible likewise uses ASC. And in that system, there is no starlight problem.

Dennis then sets dt' = 0 in equation 31, to obtain the spacetime interval between simultaneous events in synchrony-free coordinates:

$$ds^2 = 4\varepsilon(1-\varepsilon)dr^2 + r^2(d\theta^2 + \sin^2\theta\, d\varphi) \tag{33}$$

We note that for ASC, $\varepsilon = 1$ and the infinitesimal interval for two simultaneous events simplifies to:

$$ds^2 = r^2(d\theta^2 + \sin^2\theta\, d\varphi) \tag{34}$$

We must note, however, that two events that are considered simultaneous by ESC will not (in general) be simultaneous in ASC. Furthermore, setting $dt' = 0$ does determine intervals that are simultaneous, but it is not the same as distance unless $\varepsilon = ½$ as we demonstrated in Appendix A and will revisit below. That is, assuming that $ds = dr'$ tacitly assumes ESC. Dennis then claims, "This shows that the *distance* from the origin of a point along a constant ray ($d\vartheta = 0$ and $d\varphi = 0$) is not measured by r, but rather by:

$$ds = 2\sqrt{\varepsilon(1-\varepsilon)}dr \qquad \text{”} \tag{35}$$

But this is the spacetime interval ds, *not* the distance dr'. Dennis has assumed that $dr' = ds$; this is the same error he made in equation 22. Only when using ESC does the spacetime interval conveniently reduce to distance when $dt = 0$. Dennis has again confused a distance with a spacetime interval. And since the rest of his derivation incorporates this error, it too is incorrect.

In reality $dr' = dr$. For that matter, $d\theta' = d\theta$, and $d\varphi' = d\varphi$. This is necessarily the case because synchrony conventions only differ in their time coordinate dt. Thus, an infinitesimal distance for any given observer is unaffected by his choice of synchrony conventions. We demonstrated this in Appendix A (showing that $R' = R$).

In his Appendix B, Dennis uses rho (ρ) to denote the radial distance in ASC coordinates (e.g., r'). Since he confused ds with the distance in ASC ($d\rho$), he concludes that $d\rho = 2\sqrt{\varepsilon(1-\varepsilon)}dr$, when in reality $d\rho = dr$. We will show Dennis's calculation in the lefthand column, along with the correct calculation in the righthand column.

Dennis's claim	Correct calculation	
$d\rho = 2\sqrt{\varepsilon(1-\varepsilon)}dr$	$d\rho = dr$	(36)
$ds^2 = d\rho^2 + \dfrac{\rho^2}{4\varepsilon(1-\varepsilon)}(d\theta^2 + \sin^2\theta\, d\varphi^2)$	$dL^2 = d\rho^2 + \rho^2(d\theta^2 + \sin^2\theta\, d\varphi^2)$	(37)
$C = \int ds = \dfrac{\rho}{2\sqrt{\varepsilon(1-\varepsilon)}}\int_0^{2\pi} d\theta = \dfrac{\pi\rho}{\sqrt{\varepsilon(1-\varepsilon)}}$	$C = \oint dL = \rho\int_0^{2\pi} d\theta = 2\pi\rho$	(38)
$A = \dfrac{\rho^2}{4\varepsilon(1-\varepsilon)}\int \sin\theta\, d\theta d\varphi = \dfrac{\pi\rho^2}{\varepsilon(1-\varepsilon)}$	$A = \rho^2 \oint \sin\theta\, d\theta d\varphi = 4\pi\rho^2$	(39)
$V = \dfrac{1}{4\varepsilon(1-\varepsilon)}\int \rho^2 \sin\theta\, d\theta\, d\varphi\, d\rho = \dfrac{\pi\rho^3}{3\varepsilon(1-\varepsilon)}$	$V = \oint \rho^2 \sin\theta\, d\theta\, d\varphi\, d\rho = \frac{4}{3}\pi\rho^3$	(40)

Equation 37 (righthand column) represents the distance formula in spherical coordinates. Equations 38, 39, and 40 are the circumference of a circle, the surface area of a sphere, and the volume of a sphere, respectively. Dennis laments that these are "non-Euclidean." But only his versions are non-Euclidean because he started with an incorrect formula in equation 36. Had he used the proper equation, he would have found that the formulae for circumference, surface area, and volume are perfectly Euclidean in ASC coordinates, as demonstrated in the righthand column. This would have to be the case because spatial coordinates for a given observer are unaffected by synchrony convention. Thus, whatever is spatially Euclidean in ESC is necessarily spatially Euclidean in ASC.

We again note that Dennis's conclusions in this section are contrary to his own (correct) claim that "**This coordinate transform has not altered the intrinsic geometry of Minkowski space**" (emphasis added). Thus, it cannot alter the circumference of circles, or the surface area or volume of spheres.

Next, Dennis computes the ASC expression for the spacetime interval using rectangular coordinates and makes a minor mistake in the algebra:

$$ds^2 = -c^2dt'^2 + \frac{2(2\varepsilon-1)}{c}\left(\frac{xdx+ydy+zdz}{r}\right)dt' - \frac{(2\varepsilon-1)^2}{c^2}\left(\frac{xdx+ydy+zdz}{r}\right)^2 + dx^2 + dy^2 + dz^2$$

which is very close to the correct formula:

$$ds^2 = -c^2dt'^2 + 2c(2\varepsilon-1)\left(\frac{xdx+ydy+zdz}{r}\right)dt' - (2\varepsilon-1)^2\left(\frac{xdx+ydy+zdz}{r}\right)^2 + dx^2 + dy^2 + dz^2 \quad (41)$$

He then extracts one of the cross terms in the metric:

$$g_{xy} = -(2\varepsilon-1)^2\frac{xy}{r^2}$$

Strangely, Dennis then states, "This shows that the *x*-axis and *y*-axis are no longer orthogonal." But that is not the case, and it is not clear why he thinks it is. I suspect Dennis has again confused a distance with the invariant spacetime interval. All the above equation demonstrates is that the product of *x* and *y* contribute to the spacetime interval in ASC coordinates. This does *not* mean that the spatial axes are no longer orthogonal. By construction, the *x* and *y* axes are orthogonal, which is to say that changing the *x* coordinate alone has no effect on the *y* coordinate, and vice versa. We demonstrated above that synchrony conventions have no effect on spatial geometry since $x' = x$, $y' = y$, and $z' = z$. Even Dennis himself admitted earlier that "this coordinate transform has not altered the intrinsic geometry of Minkowski space." So, again we see that Dennis both affirms and denies that coordinate transformations affect geometric realities.

It is easy to demonstrate that the *x*, *y*, and *z* axes remain orthogonal in ASC or for any value of epsilon by computing the proper distance – the spacetime interval for which $dt = 0$ in ESC. From the differential of equation 29 we have:

$$dt = dt' - (2\varepsilon-1)dr/c = 0 \quad (42)$$

$$dt' = (2\varepsilon - 1)dr/c \tag{43}$$

Since *dt* = 0, *ds* = *dL*, and we can substitute equation 43 into equation 41:

$$dL^2 = -(2\varepsilon - 1)^2 dr^2 + 2(2\varepsilon - 1)^2 \left(\frac{xdx + ydy + zdz}{r}\right) dr - (2\varepsilon - 1)^2 \left(\frac{xdx + ydy + zdz}{r}\right)^2 + dx^2 + dy^2 + dz^2 \tag{44}$$

$$dL^2 = (2\varepsilon - 1)^2 \left(-dr^2 + 2\left(\frac{xdx + ydy + zdz}{r}\right) dr - \left(\frac{xdx + ydy + zdz}{r}\right)^2\right) + dx^2 + dy^2 + dz^2$$

$$dL^2 = (2\varepsilon - 1)^2(-dr^2 + 2dr^2 - dr^2) + dx^2 + dy^2 + dz^2$$

$$dL^2 = dx^2 + dy^2 + dz^2 \tag{45}$$

This is just the distance formula, and since there are no cross terms (*dxdy*), the axes remain orthogonal under ASC, contrary to Dennis's assertion. Furthermore, since *ε* does not appear in the result, it follows that spatial axes remain orthogonal for any synchrony convention.

We can also show that orthogonal spatial vectors remain unchanged under synchrony conversion by direct inspection. Consider a unit vector $\boldsymbol{N_x}$ pointing entirely in the *x* direction, and another unit vector $\boldsymbol{N_y}$ pointing entirely in the *y* direction. Their values would be:

$$\boldsymbol{N_x} = (1, 0, 0)$$

$$\boldsymbol{N_y} = (0, 1, 0)$$

Obviously, the inner product of these two vectors is zero. Thus, they are orthogonal. Now consider these same vectors using ASC coordinates. Since only *t* changes, the values of these vectors remain the same, and thus their inner product is still exactly zero. Conversion between synchrony conventions does not affect spatial coordinates, only the time coordinate. A failure to recognize this seems to be the root of many of Dennis's mistakes in his conclusions.

And what of the temporal coordinate? In relativity, a given observer defines his *t*-axis as orthogonal to his *x*, *y*, and *z* axes. However, the spatial axes of observers in different reference frames will not, in general, appear orthogonal to their time axis. This is because the time axis rotates in the opposite direction as the *x*-axis for a Lorentz boost in the *x* direction. This can be explored in any introductory textbook on relativity, including chapter nine of *The Physics of Einstein* (Lisle 2018).

Likewise, when viewing the *x* and *t* axes of ASC using ESC coordinates, they will not *appear* orthogonal. However, the reverse is also true! That is, when viewing the *x* and *t* axes of ESC using ASC coordinates, they too will not appear orthogonal. The geometrical interpretation imposed upon the coordinates will depend on what synchrony convention the author has in mind.

So, when the computations are done correctly and without assuming any particular synchrony convention, we see that the spatial coordinates of both ESC and ASC are Euclidean, contrary to Dennis's claim.