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[1]The Nature of Time - A 21st Century View

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Abstract

1. This article is a logical analysis of historical records and reaches conclusions that are original.
2. Prior to 1905 it was generally believed that the universe had always existed. The exact age of Earth was not known.
3. The luminiferous æther theory explained how light was able to propagate through empty space.
4. In 1930 Alfred Korzybski published his book "Science and Sanity". In it he originated his aphorism —The Map is not the Territory.
5. Reality consists of physical reality — *the territory*— and observed reality — *the map.*
6. The Rossi-Hall experiment demonstrated that time dilation occurs physically and cannot be observed directly.
7. The universe came into existence when the big bang occurred.
8. When photons came into being, time came into being.
9. All mechanisms for measuring time experience time dilation.
10. The big bang caused major changes to science's understanding of the nature of the universe.
11. The speed of a photon through space equals a Planck length divided by a Planck time.
12. We don't really measure time, what we measure is the effect that time has on the instruments used to measure time.
13. Everything; in Relative Time is based on observers. If you remove all references to observers from either Special Relativity or Spacetime there is almost nothing left.
14. When the concepts of relative time were originated, *no thought was given to the possibility that time might consist of both observed time and physical time.*
15. Photons — and the resulting time — came into existence with the big bang
16. The movement of photons thru spacetime constitutes absolute time
17. Without events, nothing happens.
18. Every event has a frame of reference.
19. 'Now' can occur in physical time and in observed time.
20. A physical event always results in a physical 'now'.
21. Every event must have a frame of reference.
22. Objects that move through space experience time dilation but they do not observe it.
23. The observation of each observer is unique for that observer and need not be the same as either the actual event itself or the observation of another observer.
24. Each observer has his/her own observed 'now' which occurs in observer's frame of reference.
25. The duration of an observation has no direct relationship to the duration of the event nor need it have the same duration as that of another observer.
26. Each observer has her/his own frame of reference.
27. Time dilation is an aspect of physical time, not of observed time.
28. Observers have no way of knowing that they are experiencing time dilation.
29. The Lorentz transformation factor 'γ' is computed by dividing 'v^2' which is a vector by 'c^2' which is scalar. Both terms should be scalar.
30. Both 'v' and 'c' use clocks to determine their value and all clocks are subject to time dilation.
31. The Lorentz transaction is supposed to measure 'γ' but 'γ' is an element of the calculation!

Keywords

Absolute Time, Big Bang, Frame of Reference, Lorentz Transformation, Now, Photons, Spacetime, Special Relativity, Time, Time Dilation

Summary

The theory of Special Relativity was first published in 1905. At that time most scientists believed that the universe had always existed. Special Relativity was based in its entirety on observers — how else could scientists have known the nature of the universe?

Since that time a number of major changes have occurred regarding our understanding of the nature of the universe. The most notable of these was the discovery that the universe and its constituents came into existence about

13.8 billion years ago. Later, it was deduced that the Earth came into existence about 4.5 billion years ago. Originally, the Earth could not have included observers, who probably first appeared less than a billion years ago; so the universe must have existed for about 3.5 billion years ago without observers; however time must have been ticking during that entire period without them.

The nature of the time as it was when there were no observers must have been very different from the nature of time as it was understood by Special Relativity's observers. For example, time dilation must have existed before observers did so physical time must incorporate absolute time and Special Relativity's obsession with simultaneity, on which it depends so heavily, is no longer relevant.

This article reaches the conclusion that just as observed reality — rocks, trees and water — differs from physical reality — molecules, atoms and quarks — so observed time must differ significantly from physical time. This article explores those differences which constitute major changes in the understanding of Special Relativity.

Introduction

Prior to 1887, the luminiferous æther theory explained how light was able to propagate through empty space. Exactly who originated the æther theory is not known but it was discussed by Robert Boyle[1] in the 17th century and, although the æther theory was commonly accepted by most scientists, it was beginning to be questioned when Michelson and Morley[2] performed the experiment which led to the conclusion that æther didn't exist and caused scientists to consider how light could be propagated without æther. It also led to the publication in 1905 of Einstein's "On the Electrodynamics of Moving Bodies"[3], which soon became known as Special Relativity.

Initially Special Relativity was not universally accepted; Oliver Lodge [4], August-Jean Fresnel [5], and Hendrik Lorentz[6] did not immediately accept it. On the other hand Special Relativity received support from Henri Poincaré and Hermann Minkowski[7]]; in fact, for a while, there was a dispute between Einstein and Minkowski as to who had actually originated the concept. (Later Minkowski courteously conceded that Einstein had made his discoveries before he did).

Nature of the Time, as Understood in 1905

If one examines the timeline for scientific discoveries, as published in Wikipedia, there are no entries that provide a timeline that show how scientific estimates for either the age of the universe or the age of the Earth have changed over time. As a logical guess, it seems likely that in 1905 it was generally believed that the universe had always existed. Estimates of the age of the Earth could have been based on geological evidence although its exact age has probably been refined many times. It seems likely that scientists agreed that life did not start on Earth until many years after the Earth came into existence. It is certainly a fact that Special Relativity did not take into consideration the possibility that time might have existed before the existence of life on Earth and, when Einstein published his paper describing Special Relativity, science had not established an age for the universe.

20th Century Changes to the Understanding of the Universe

Our understanding of the universe was greatly expanded during the 20th century. One of the most important was quantum mechanics[8] but quantum mechanics is much too large and complicated a subject to be discussed in this article.

There are other important subjects, discussed below, which increased our understanding of the universe.

The Map is not the Territory

During the early part of the 20th century it became acceptable to think that reality had two aspects; one aspect consisted of observed reality — rocks, trees, and water etc. The other aspect — physical reality — consisted of molecules, atoms and sub-atomic particles.

In 1930 Alfred Korzybski published his book "Science and Sanity"[9]. In it he originated his aphorism "The map is not the territory". The 'map' consisted of observed reality; the 'territory' consisted of physical reality. His objective was to introduce the concept that the characteristics of observed reality and of physical reality were quite different.

In 1930 it was not recognized that, as an element of physical reality, time could be thought of as consisting of both observed time and physical time and Korzybski did not recognize that his concept could also be applied to time. This idea will be discussed in more detail below and it is relevant to note at this point that just as observed reality and physical reality have completely different characteristics, as will be shown below, so do observed time and physical time.

The Rossi-Hall Experiment [10]

The Rossi-Hall experiment was conducted in 1940 at Echo Lake in Colorado. It examined time dilation as it was experienced by muons.

A muon is an unstable subatomic particle with a mean lifetime of 2.2 µs. Muons can be generated by particle accelerators and their decay rate can be measured. Rossi and Hall were able to measure the lifetime of different muons, at different elevations, and relate the rate of decay to the rate that was mathematically estimated.

An important result of the Rossi-Hall experiment is that it demonstrated that the time dilation experienced by a muon is a phenomenon which could be measured and which occurred physically; it is not an aspect of observed reality, because it cannot be observed directly, nor is it merely a scientific theory such as length contraction.

The Big Bang [11 12]

It is not really relevant to ask whether or not the universe existed before the big bang occurred; perhaps it did, perhaps it didn't, but this article does not address that question; it assumes that the universe came into existence when the big bang occurred. When time came into existence is a different question; the answer to that question depends on exactly when photons came into existence — when photons came into being, time came into being — like the chicken and the egg — Planck may have recognized that relationship when he defined the speed of light.

Since Georges Lemaître [13] first noted in 1927 that an expanding universe could be traced back in time to a single point, scientists have built on his idea of cosmic expansion. The scientific community was once divided between supporters of two different theories, the Big Bang and the Steady State theory, but in 1964 Arno Penzias and Robert Wilson[14] discovered cosmic background radiation. Following this discovery the Steady State theory was mostly forgotten.

The big bang constituted an extremely important change to our understanding of the universe — it showed that the universe, as we know it now, has not always existed — it, and time, came into being about 13.8 billion years ago[15].

This should have affected the understanding of Special Relativity because a great deal of time elapsed between when time originated and when the observers who define the nature of Special Relativity first appeared. During this period, time must have existed but its nature would have been very different from the nature of time as defined by Special Relativity.

This time period is discussed in more detail in the section Physical Time vs Observed Time below.

The Hafele-Keating Experiment[16]

"In October 1971, Joseph C. Hafele, a physicist, and Richard E. Keating, an astronomer, took four cesium-beam atomic clocks aboard commercial airliners. One set went around the world going eastward, the other went westward. When the trips were over these clocks were compared with the clocks against others that had remained at the United States Naval Observatory. When reunited, the readings of the three sets of clocks were found to disagree with one another, and their differences were consistent with the predictions of special and general relativity."

The implication of this experiment is that all mechanisms for measuring time — and living creatures can be considered to be such mechanisms — experience time dilation. For measurements of the time experienced by objects travelling at slow speeds this constitutes a problem only if the accuracy of the measurement of the speed of the object is critical.

For objects which don't travel often at high speeds the amount of time dilation the objects experience is limited but what about airplanes or airplane pilots which don't travel at high speeds — comparatively speaking — but which do a great deal of such travel; could the cumulative effect be measurable?

A Proposed 21st Century Understanding of the Nature of the Time

Acceptance of the big bang theory essentially stabilized science's understanding of time and the changes to the 1907 understanding of time will be shown below to be substantial. One concept of these changes — Special Relativity — was proposed by Albert Einstein in 1905, a second — Spacetime — was proposed by Hermann Minkowski. The two concepts can be thought of as complementary rather than as contradictory; there are only a few areas where they disagree and many where they don't.

Neither Special Relativity nor Spacetime address momentum or gravity, implying that they don't address acceleration. As will be shown below, graphical representation of movement through space can be accomplished by assuming that an object moves from point A to point B. This only requires two axes the x-axis for distance and the y-axis for time which greatly simplifies many aspects of our understanding of time.

This article considers both Einstein's Special Relativity and Minkowski's Spacetime. No attempt is made to identify which is being considered at any point because in many cases it is not clear who originated a particular idea. For the sake of simplicity, for the remainder of this article I will refer to the combined concepts as Relative Time.

The Time/Space Relationship

Planck defined the speed of light as equal to a Planck length divided by a Planck time, but light is a perception, without observers it doesn't exist, so Planck's definition should be "The speed of a photon through space equals a Planck length divided by a Planck time."

How can Planck's definition relate to Relative Time's definition of spacetime? The most logical answer is that the speed of a photon defines both distance and time; when a photon moves through space it defines time; and when a photon experiences time it defines space.

Measuring Time

We don't really measure time, what we measure is the effect that time has on the instruments used to measure time.

One of these 'instruments' is the human body: the passage of time results in changes to the human body — we get older, our whole body grows as do our finger nails and our hair, women become pregnant and the duration of their pregnancy is a measurement of time — *in other words, as living creatures we experience time and we use our experience as a base (but not the only base) for measuring the duration of time.*

We also use devices to measure time; these devices are very different from the tools we use to measure matter because we don't use the devices directly to measure time; instead we have to interpret the measurements we get from them.

For example, it is probable that the first measurement of time was the sundial. The sundial is composed of a vertical stick which casts a shadow on a flat surface. A clever person conceived the idea of drawing a scale on the surface with markings which could be used to represent the time of day and its relation to the length of the year; and we can relate days and years to our personal experiences.

The shadow itself was not a characteristic of time, it had no meaning until it was interpreted using the markings on the surface. I doubt if the original markings defined hours, or days; they were added later, probably much later, and they became what could be considered to be the first clock; but physically, the markings, placed by that clever person, were what we used to measure time.

A second way of measuring time is to use a pendulum. A pendulum is also a very simple device; a weight at the end of a wire swings back and forth. It didn't become a device for measuring time until Galileo Galilei observed that the duration of the swing back and forth was not related to the weight of the object nor to the length of the arc of the swing; instead it was based on the length of wire which holds the weight. Galilei had discovered that the duration of the swing can be varied by changing the length of the wire, and his discovery resulted in the creation of a pendulum clock.

The measurement of this duration became a measurement of time, thus the time measured by a pendulum is based on the physical laws that govern the swinging of a pendulum. The swinging pendulum is not a measurement of time. It was the cleverness of Galilei to realize that this characteristic of a swinging weight could be mechanically used to measure time that resulted in a pendulum clock.

A third, more recent, way of measuring time is based on the observable decay of the cæsium atom which occurs at very regular predictable intervals. Scientists count these intervals and have determined that a specified number of these intervals can be used to provide a very accurate measurement of time. Again, we define a physical characteristic of matter as a measurement of time; we are not actually measuring time itself.

Measuring Velocity

According to Relative Time, "*Nothing can travel faster than the speed of light*." But Newton showed that "*The velocity of an object can only be determined relative to the velocity of another object*."

How can we know whether an object is moving faster than the speed of light if we can't measure its velocity?

It may be that the Lorentz transformation, which is discussed below, can provide a solution!

Assumptions.

The following assumptions are used for the remainder of this article.

- Two, and only two, mathematical equations are referenced. They are:
  - Planck's definition of the speed of light which equals a Planck length divided by a Planck time, or a tick
  - Lorentz transformation, which is

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$$

- There are three experiments, plus derivatives of them, which apply to Relative Time. The experiments are:
  - The Michelson-Morley experiment.
  - The Rossi-Hall experiment.
  - The Hafele-Keating experiment.
- The Age of the Universe
  - The Universe came into existence about 13.8 billion years ago, the Earth came into existence about 4.5 billion years ago.

- It is unlikely that observers, as referenced in Relative Time, appeared less than a billion years ago, so the Earth, and time, existed without observers for approximately 3.5 billion years.
- During the period when there were no observers, observed time didn't, and couldn't, exist, only physical time existed.
- During the period when Earth existed without observers there was only a single frame of reference which included the entire universe.

- *The remainder of this article consists of the application of logic to the assumptions listed above.*

Physical Time vs Observed Time

Everything; everything in Relative Time is based on observers. If you remove all references to observers from either Special Relativity or Spacetime there is almost nothing left.

The Earth came into existence about 4.5 billion years ago[17]; but when did observers appear on earth? And what constitutes an observer? Those are obviously debatable questions for which there do not appear to be answers, but it seems very likely that 'observers' first appeared on Earth less than a billion years ago. That means that the Earth existed for millions of years without observers and during that period, time must have existed and the nature of that time must have been physical time; but the nature of that time has never been given serious consideration.

When the concepts of Relative Time were originated, the characteristics

of physical time were not recognized as such; instead these characteristics were transformed into observed time and *no thought was given to the possibility that time might consist of both observed time and physical time*. Before observers appeared on Earth, the only kind of time that existed was physical time; after observers appeared, physical time continued to exist but observed time could then begin.

The result has been that the nature of time has been misunderstood, as can be seen when the difference in the characteristics of physical time and of observed time are considered separately, as will be done below.

For the sake of simplicity, since Physical Time is a concept introduced in this article, its characteristics will be addressed first. The characteristics of Observed Time are necessarily different and they will be addressed last.

Graphic Representation of Physical Time

As discussed above, physical time can be represented graphically on a two dimensional graph; the x-axis shows distance; the y-axis shows time. Speed, which is scalar, is an aspect of physical time and can be represented on such a graph.

Velocity, on the other hand, is a vector which requires a three dimension graph because it has direction as one of its components. Direction is a construct which requires an observer to define the location of the axes which define direction — without observers, if a moving object is travelling at a constant speed, the direction in which it is moving has no meaning or relevance — it has a speed, but not velocity.

References to dimensions in Special Relativity or Spacetime articles will be assumed to be scalar, not vector. Restricting the discussion here to scalar functions greatly simplifies the mathematics necessary to understand Relative Time.

Where articles refer to the velocity of an object or to dimensions, the vector reference can easily be transformed to scalar.

Characteristics of Physical Time

Because physical time existed for billions of years before observed time existed, there are certain characteristics that it must have had. These characteristics consist of:

- Absolute time
- Physical Events
- Physical 'Now'
- Physical Frame of Reference
- Physical Time Dilation

Some of these characteristics also are present, with different definitions, in observed time. Where present, they are defined below.

Absolute Time

Photons must have come into existence during the big bang. Time could not have existed until photons existed, and vice versa. Since astronomers have been observing light — meaning photons — which originated during, or shortly after, the big bang — it is logical to assume that photons have been moving through space continuously since the big bang, at the rate of one tick for each Planck length. These continuing ticks can be considered to constitute absolute time and, since this ticking started with the big bang it is logical to assume that that was when absolute time began. If we knew how far these photons have travelled, we would know when they were created and vice-versa.

Since absolute time existed before the existence of life it must be a constituent of physical time. Absolute time must be synchronized. Application of Occam's Razor to the concept of unsynchronized time gives support to that concept.

It is relevant to mention that application of the Lorentz transformation to the speed of photons demonstrates that photons are not subject to time dilation.

Physical Events

Events are what happens — without events, nothing happens. The duration of a physical event is defined by absolute time — discussed above. When an event happens is defined by 'now' — as discussed below.

An event modifies physical reality — if it doesn't it can't be considered to be an event! The change in physical reality that results from a physical event can be considered to be the record of the event.

Events happen whether or not they are observed.

Physical 'Now'

'Now' is a concept that doesn't exist in Relative Time. The reason has been that without absolute time there has been no way of defining when 'now' occurred. The definition of time was based on observed time which differed for each observer. With the introduction here of the concept of absolute time, 'now' becomes a viable concept.

My article "The Nature of Time"[18] discusses 'now' as it applies to a pile driver. The stroke of the pile driver is a physical event which generates a sound. The time when the stroke of the pile driver occurs is defined by physical 'now'. It is observed by a number of observers, each of whom hears the sound the pile driver makes at a different time, defined by the 'now' associated with the distance of the observer from the pile driver.

The same principle can be applied to the speed of light. Assume a solar flare. It takes about seven minutes for the flare to be observed on Earth — knowing the speed of light and the distance of the Earth from the sun, the 'now' when the flare actually occurred on the sun can be calculated. This 'now' is physical 'now'. Each person who observers this flare has his/her 'now' for the event.

The same flare could be observed on Mars. When it was observed would be the observed 'now' for Mars. Assuming a clock on Mars — and assuming that the setting of the clock had been corrected for the time dilation experienced in transporting the clock to Mars — the solar flare would be equivalent to the pile driver except it would be based on the speed of light, not the speed of sound. The observers could be located either on Earth or on Mars.

Physical Frame of Reference

Every event must have a frame of reference however, the frame of reference for a physical event has components that can't be observed and therefore cannot be components of an observed frame of reference. These components are: Absolute Time and Time Dilation.

Therefore, the frame of reference for an event must be the universal frame of reference which applies to all physical events.

Physical Time Dilation

Objects that move through space experience time dilation but they do not observe it. The Lorentz transformation describes the computation of time dilation but not describe physically how it occurs.

In my paper "A Logical Examination of the Nature of Time"[19] I introduce a 'Time Distance Diagram' which illustrates — physically — what occurs when a particle experiences time, one tick at a time.

The x-axis of the diagram is distance and the unit of measurement is a Planck length. The y-axis is time and the unit of measurement is a Planck time, or a 'tick'. The diagram illustrates when a particle experiences time. It is based on the calculation by the Lorentz transformation on what happens when a particle which is travelling at 80% of the speed of light experiences time; tick by tick.

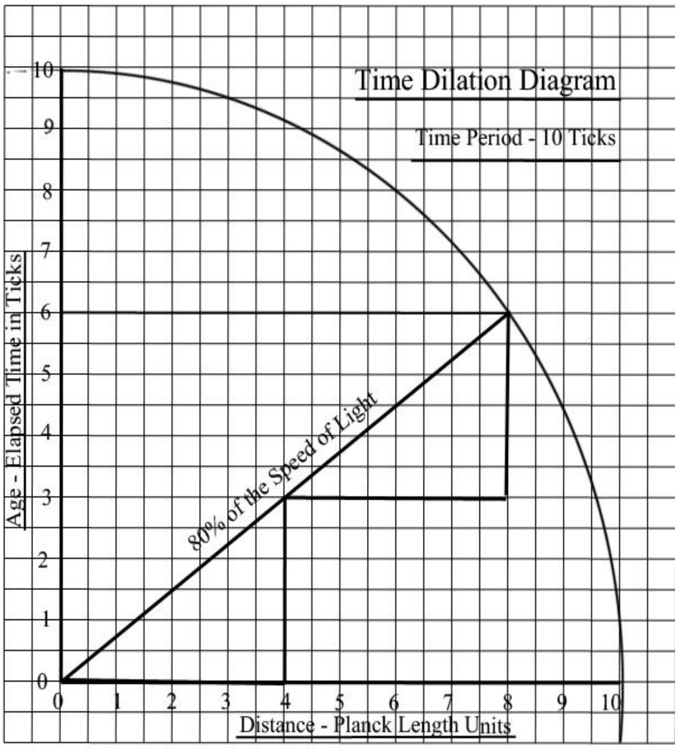
It is also based on the proposed concept that when a particle experiences time it either moves a tick through time or a Planck time through space; it cannot do both. Which it does is based on its speed expressed as the probability v/c derived from the Lorentz transformation. It needs to be understood that the diagram is based on probability not the exact computation of time dilation.

On the diagram, as an average, for every three ticks of time, the particle moves four Planck lengths through space. By re-drawing the diagram it can be used for any desired speed.

Characteristics of Observed Time

Observed time is the time experienced by observers. Since the time experienced by any observer is affected by the time dilation associated with the movement of the observer through space, the time experienced by an observer can only be measured by a clock which is also subject to time dilation.

The 'now' that is observed by observers neither occurs when physical 'now' occurs nor need it have the same duration, but it is also measured by absolute time. An event can be observed by multiple observers, each of whom has his/her own 'now' for the event.



Observed Events

By definition, the observation of an event is what an observer observes. It is a truism that the observation of each observer is unique for that observer and need not be the same as either the actual event itself or the observation of another observer.

The observation of an event does not modify physical reality, unless one considers modification of the mind of the observer to be a modification of physical reality.

Observed 'Now'

For any event which is observed, observer has his/her own 'now'. The now for an observer is unique for that observer and is not the same as either the physical 'now' for the event or the 'now' of another observer.

Also, the duration of such an observation has no direct relationship to the duration of the event itself nor need it have the same duration as that of another observer.

Observed Frame of Reference

Each observer has her/his own frame of reference and his/her own personal clock. Time ticks one Planck time after another. Time dilation results from the 'decision' of a particle to move through time or through space — as discussed in my article "*A Logical Examination of the Nature of Time*"[19]. The 'decision' is based on the speed of the particle expressed as a percentage of the speed of light.

Time Dilation

The most commonly used definition of time dilation is "a difference of elapsed time between two events as measured by observers [] moving relative to each other".

This definition is not relevant for the following reasons:

- Time dilation must have existed in the period before observers appeared on earth, so time dilation must be an aspect of physical time, not of observed time. This statement is supported by the Rossi Hall experiment which proved that the rate of decay resulting from time dilation is a physical phenomenon not an observed phenomenon.
- As discussed above, we experience time we do not measure it. Assuming a space ship is moving at 80% of the speed of light, its time dilation factor is .6. The clocks on board the space ship reflect that time dilation as does the aging of the observers on board. Thus, the observers have no way of knowing that they are experiencing time dilation. When they return to Earth they can compare their clock to clocks on earth and then — and only then — are they aware that they experienced time dilation.
- The Lorentz transformation makes no reference to combining the relative speed of two objects to get a single time dilation factor. If the events referred to by the definition consist of two space ships travelling in opposite directions — each travelling at 80% to the speed of light, their relative velocity is 160% of the speed of light. This is not physically impossible because neither object is travelling faster than the speed of light but it logically wrong because the Lorentz transformation doesn't provide for speeds faster than the speed of light.

  If the two objects were travelling towards each other at the speeds used above, rather than away from each other, the original definition given above, would show that neither object experienced any time dilation. This completely contradicts the Rossi-Hall experiment.

- Without going into the details, the whole concept of the twins paradox is also completely wrong. The time dilation factor of the two twins cannot be exchanged. My paper "A Logical Examination of the Nature of Time"[18] demonstrates the fallacy of the twin's paradox and gives a correct explanation of the twin's experience.

Lorentz Transformation

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$$

The Lorentz Transformation, as illustrated above, appears to be very simple. Since 'v' and 'c' are both measurements of time, 'γ' would appear to be dimensionless; but is it? 'v' is a vector and 'c' is scalar; I am not a mathematician but can one divide a vector by a scalar? If it is mathematically valid, is the result dimensionless? If so, what is the resulting dimension?

But there is a second problem with the calculation. Both 'v' and 'c' use clocks to determine their value and all clocks are subject to time dilation. Since the referenced clocks are presumably located on earth the relevant time dilation incorporates the speed of earth through space, which is not a constant because Earth is not travelling through space in a straight line. The resulting 'γ' is probably very small, but maybe it is not because we do not know what this speed is.

This raises another problem — the Lorentz transaction is supposed to measure 'γ' but we are actually using 'γ' in our calculation! Logically, this constitutes a problem. Also since, by definition 'v' and 'c' have different values, when calculating $(v-\gamma v)^2 / (c-\gamma c)^2$ we have to be getting into binomials which greatly complicates our computation Probably the best solution of the above problems is to either ignore the time dilation associated with the speed of Earth through space or make a guess as to its value.

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