The Special Theory of Relativity is a House of Cards Built on a Parlor Trick and Sustained by Circular Reasoning

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A simple change in experimental design shows that the relativity principle developed by Galileo and Newton applies only to the *observed* motion of physical objects. Their *actual* motion is different in every inertial reference frame. The difference in motion is hidden by the human condition and an inadequate experimental design. The new design distinguishes between an *inertial* reference frame and a *physical* reference frame, such as a spaceship. The same experiment is conducted in one inertial reference frame and then moved intact to another. The special theory's own postulates are used to determine the *changes* in motion which must occur in response to the *change* in the spaceship's velocity. The *changes* required by the postulates are different from what the spaceship observer sees. The special theory treats a *change* in velocity differently than a *difference* in velocity between the same two reference frames. Applying the postulates to the *change* in velocity causes the first postulate of relativity to refute the premise of equal merit. The first postulate requires changes in response to the *change* in motion which the spaceship observer cannot detect. His observation is invalid. The second postulate then refutes the first postulate. The second postulate imposes a constant speed on light which alters the time interval between emission and impact when the experiment is moved to the second reference frame. This difference cannot be corrected by time dilation without making the experiment using a physical object produce a different time interval in the second reference frame. The change in experimental design also reveals a previously unrecognized circularity between an observer's own state of motion and his perception of motion. This circularity has undesirable consequences. It blinds an observer to changes in motion which are caused by a change in his own state of motion. It also causes the observer to see changes in motion for objects whose motion has not changed. And it reveals that each observer in a different inertial reference frame has his own definition of motion which is unique to him and entirely subjective. Such observations are virtually worthless for scientific purposes. Lastly, the paper discloses how unquestioning belief in the theory's own postulates and premises has controlled the design of experiments and the interpretation of data to prove the theory's validity. The role of circular reasoning helps explain how an internally contradictory theory has experienced more than a century of empirical validation. This paper demonstrates its case simply by making two changes in experimental design. There are no flights of fancy into new theoretical realms to be found in this paper. The results of the experiments are based entirely on the special theory's own postulates. The foundational beliefs of the special theory itself determined the outcome of this paper.

1. INTRODUCTION

Einstein's special theory of relativity is based on a combination of Galileo's and Newton's relativity principle and Maxwell's equations.

The relativity principle developed by Galileo and Newton addressed only the motion of physical objects. It is based on the fact that any experiment involving the motion of physical objects will produce the same result in every inertial reference frame.The laws that govern the motion of physical objects are called the laws of mechanics[i] and their consistency of form in all inertial reference frames is called the relativity principle:

Einstein's first postulate of relativity expands the relativity principle into a universal principle of motion. It is declared to apply not only to electricity and magnetism but to all phenomena involving motion, including even phenomena not yet discovered.[iii]

Einstein's second postulate is based on the definite constant speed of light as predicted by Maxwell's equations.[iv]

Because experiments in all inertial reference frames are believed to produce the same result, the special theory's premise of equal merit treats all observations made in inertial reference frames as being equally valid.[v] Considering that the theory's predictions are produced by the process of reconciling conflicting observations of the same experimental events, the possibility for observation error should warrant consideration. Instead, the premise of equal merit simply defines observation error out of existence. Barring a malfunction of the experimental apparatus, observations made in all inertial reference frames are declared on their face to be equally valid.

Based on the belief that motion can exist only relative to the reference frame of an observer[vi] and due to its focus on inertial motion, the special theory uses inertial reference frames as the only venue for conducting experiments and making observations. That experimental design omits information from non-inertial reference frames. Einstein deferred the issues of non-inertial motion to the general theory. However, as this paper shows, some of the information which is required to understand the nature of inertial motion can be found only in a non-inertial reference frame.

This paper demonstrates its case simply by making two changes in experimental design. The results of the experiments are determined entirely by the special theory's own postulates. There are no flights of fancy into new theoretical realms to be found in this paper.

The first change in the experimental design is to replace the customary light bulb with a tightly focused optical laser. This reduces the ambiguity sometimes found in the special theory regarding the direction in which the observed light is propagating. The second change is to provide experimental data which is not available to observers in inertial reference frames. To do so, the experimental design takes advantage of the difference between a *physical* reference frame and an *inertial* reference frame. The two are different in kind and should not be lumped together or confused with each other.

A physical reference frame, such as a spaceship, can change its own velocity from that of one inertial reference frame to that of another. This allows an observer to make the same experiment using the same equipment in one reference frame and then *change its own velocity* to make the same precise experiment in a different inertial reference frame. This breaks the quarantine between the different reference frames by establishing a direct link between them. Each reference frame's state of inertial motion is identical to that of the other except for the *change* in the spaceship's velocity.

As shown in Section 3, this new link discloses two important new insights. First, it discloses that the special theory interprets a *change* in velocity differently than it interprets an equal *difference* in velocity between the same two inertial reference frames. Second, it discloses a previously unrecognized circular dependence between an observer's state of motion and both his definition of motion and his sensory perception of motion. This circularity leads to two kinds of observation error. One is that it renders the spaceship observer selectively blind to the effects of a change in his physical reference frame's velocity. The other is that it causes the spaceship observer to perceive changes in motion of objects whose motion has not changed.

As mentioned above, The Galileo/Newton relativity principle is the prime foundation of the special theory. It is the basis for the first postulate. The fact that experiments involving the motion of physical objects will provide the same *observed* results in all inertial reference frames has been taken to mean that the *actual motions* of the objects are the same in all inertial reference frames. However, Section 4, by applying the new design to a physical object, discloses that the *actual motion* of the physical object will be different in every inertial reference frame. Only the *observations* made in different inertial reference frames will be the same. This unveils the relativity principle as a clever parlor trick the human condition has played on us mere humans. The sameness of observed results in every inertial reference frame isn't a fundamental principle of motion; it's due to the circular relationship between an observer's state of motion and his perception of what constitutes motion. As often happens in mundane existence, perception is not reality.

Section 5 then applies the same experimental design to an experiment involving the propagation of light. What that discloses is that light can't even do the parlor trick. If an experiment is conducted in one reference frame and then moved to another, it will provide the same observed trajectory but it cannot produce the same elapsed time between emission at the source and arrival at the target. Unlike a physical object, light is subject to the second postulate. It has a definite, constant speed. A change in its source's velocity will change the length of the light's trajectory (which the spaceship observer will not detect) but will produce a different interval of time for the light to complete the trip. The elapsed time is an observed result. Because an observed result is changed when the velocity of the source is changed, even the "same *observed* result" requirement of the relativity principle cannot be met. As a result, light cannot even do the parlor trick. As shown in Section 5, this problem cannot be resolved by invoking the theory's prediction of time dilation.

Section 6 exposes an innate inconsistency between how the special theory treats the motion of some locations in an observed reference frame versus how it treats the motion of other locations in the same reference frame. This inconsistency is innate to observations made from inertial reference frames. It is an unrecognized side effect of that experimental design.

Section 7 then provides an example of how a change in an observer's state of inertial motion will cause him to perceive illusionary changes in the motion of objects whose motion has not changed.

Finally, Section 8 discloses the role of circular reasoning in the design and conduct of experiments used to validate the special theory for more than a century. Circular reasoning occurs when an unquestioning subconscious acceptance of the beliefs being examined is allowed to influence the experimental design and the interpretation of empirical data used to examine them. The presence of circular reasoning is clearly disclosed both in the experimental design and in the interpretation of empirical data for experiments used to validate the special theory.

2. AN OVERVIEW OF THE SPECIAL THEORY OF RELATIVITY

Einstein's theories of relativity are the very foundation of modern physics.[vii] His special theory of relativity is the basis of our understanding of such fundamental phenomena as motion, time, space and mass. His general theory of relativity provides our understanding of gravity. Professional physicists consider Einstein's theories of relativity as having been consistently sustained by experimental validation over the past century. They are considered to be the gold standard of generally accepted theory.

Prior to Einstein's theories of relativity both Galileo and Newton had determined that the laws of physics that govern the motion of physical objects take the same form in all inertial reference frames. In other words, if you are in a reference frame that is either stationary or in motion at a constant speed in a straight line, any experiment you make involving the movement of physical objects will produce the same result as it would if performed in any other inertial reference frame. You will feel that your reference frame is stationary and any experiment you conduct with moving physical bodies will produce the same result as if your reference frame were stationary. More specifically, it means that the mathematical equations that describe the result will take the same form regardless of your reference frame's state of inertial motion. The laws that govern the motion of physical bodies are called the laws of mechanics[viii] and their consistency of form in all inertial reference frames is called the relativity principle:

"**The basic laws of physics are the same in all inertial reference frames**."[ix]

Note that the relativity principle is based on the laws of mechanics and the work of Galileo and Newton. It had nothing to do with the propagation of light until Einstein concluded that it is a basic law of physics which should apply to all forms of motion.

In 1864, the renowned physicist James Clerk Maxwell produced his insightful and comprehensive theory of electromagnetism.[x] His theory showed that the movements of electrically charged particles create electromagnetic waves which propagate through empty space at a precise, constant speed of 299,792,458 m/s.[xi] Because that was exactly the same as the previously determined speed of light, Maxwell realized that light could be considered to be an electromagnetic wave and that it always will propagate through empty space at that precise speed.[xii] Maxwell also predicted the existence of other kinds of electromagnetic waves which were not visible to the human eye. We now know of many kinds, such as radio waves, microwaves, infrared, ultraviolet, X-rays and gamma rays.[xiii] All electromagnetic waves propagate through empty space at the same speed. They differ only in their respective frequencies (or wavelengths) which alter the manner in which they interact with matter. The problem raised by Maxwell's equations was that they did not take the same form in all inertial reference frames.[xiv]

If light was a wave, as shown by Maxwell's equations, that wouldn't necessarily be a problem. Generally accepted theory would require it to have a stationary, physical medium of propagation, just as does every other kind of wave. The particles in a physical medium propagate waves by moving in accordance with the laws of mechanics,which are the basis of the Galileo/Newton relativity principle. Thus, it was generally accepted that there must exist some kind of undetectable medium for the propagation of light that permeated all of open space. It was called the ether.[xv] The reference frame for which Maxwell's equations took their simplest form was taken to be the one which was at rest in the ether.[xvi] The additional terms required for other reference frames were to adjust for their movement relative to the ether. This would account for the differences in the form of Maxwell's equations and would resolve the apparent conflict with the Galileo/Newton relativity principle.

To resolve the matter, an endeavor began in the late 1800s to detect the existence of the ether and to determine the speed at which our own reference frame, the Earth, is moving through it. The most famous and most conclusive experiment was conducted by A. A. Michelson and E.W. Morley in the 1880s.[xvii] Unfortunately, what their experiment proved was that there was no ether. There was no explanation for how light could propagate through empty space or why Maxwell's equations took a different form in different inertial reference frames. This was one of the great puzzles of physics at the beginning of the 20th century.[xviii]

Einstein solved the puzzle using his famous thought experiments.[xix] Einstein concluded that the inconsistencies in Maxwell's equations resulted from the assumption that an absolute space exists.[xx] In his famous 1905 paper, Einstein proposed eliminating both the ether and the corresponding belief in the existence of a reference frame at rest.[xxi] Based on this proposal, Einstein stated his two postulates of relativity. His first postulate declares:

"**The laws of physics have the same form in all inertial reference frames**."[xxii]

As discussed above, the first postulate extends Galileo's and Newton's relativity principle, which was based on the laws of mechanics, to govern the motion of all physical phenomena, including not only electricity and magnetism but even phenomena not yet discovered.[xxiii] Any experiment involving motion will produce the same result in all inertial reference frames regardless of what is in motion and what caused it to be in motion. Motion exists only relative to a defined frame of reference and inertial motion exists only relative to an inertial reference frame.

Einstein's second postulate of relativity, which is based on Maxwell's equations, specifically addresses the propagation of electromagnetic waves:

"**Light propagates through empty space with a definite speed *c* independent of the speed of the source or observer**."[xxiv]

These two postulates are the conceptual foundation of Einstein's special theory of relativity. Related foundational premises which underlie and add specificity to the postulates include:

- The Galileo/Newton relativity principle applies to objects which are subject to the laws of mechanics. Thus, any phenomenon which meets the Galileo/Newton relativity principle must behave as if it possesses mass and experiences momentum. By extending the relativity principle to the propagation of light, Einstein's first postulate requires light to respond to a change in the velocity of its source in the same manner as if it were a physical object being launched from the source.[xxv]

- There is no such thing as an absolute state of rest.[xxvi] This is the single, most important hypothesis underlying the theory. It is the basis for the first postulate.[xxvii]
- All inertial motion is relative and can be identified only in terms of motion relative to a specified reference frame. This follows from the nonexistence of a unique reference frame which is at absolute rest.[xxviii]
- Since observations made in all inertial reference frames produce the same result, observations made from all inertial reference frames have equal merit (i.e., are equally valid).[xxix] For brevity, this is referred to in this paper as the premise of equal merit.
- Since observations made in all inertial reference frames produce the same result, an observer in any inertial reference frame who measures the speed of light will obtain the same number c = 299,792.5 km/s.[xxx] For brevity, this is referred to in this paper as the premise of will measure c.

These are the beliefs which must be valid in order for the special theory to be valid.

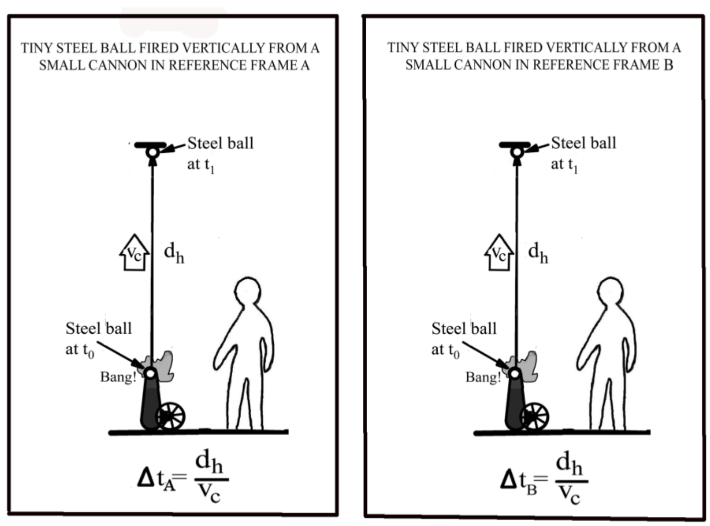
3. AN OVERVIEW OF THE GALILEO/NEWTON RELATIVITY PRINCIPLE

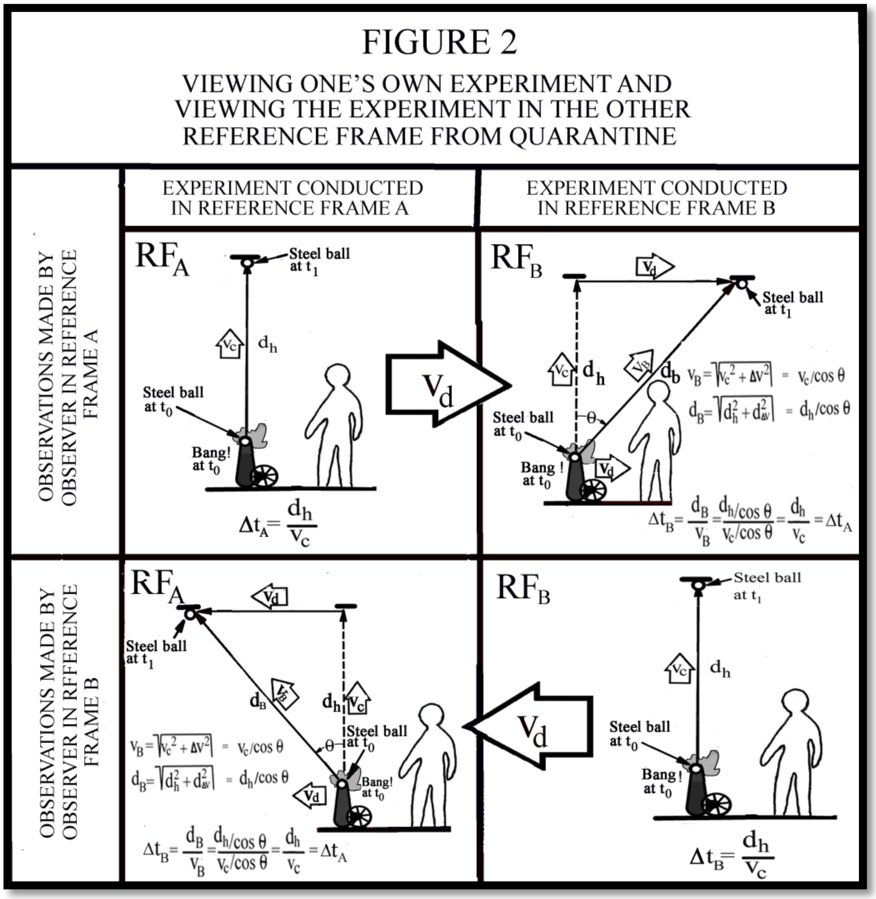
The relativity principle produced by Galileo and Newton states that experiments involving the motion of physical objects will produce the same result in all inertial reference frames. For example, Figure 1 shows two observers in different inertial reference frames conducting the same experiment. It consists of firing a tiny steel ball from a tiny cannon. The cannon is on the floor of a spaceship and is pointed vertically at a target on the ceiling. The observer in reference frame B will observe the same result as the observer in reference frame A regardless of the difference in their relative inertial motion. The result will be the same in every inertial reference frame.

However, as shown in Figure 2, if each observer observes the experiment being conducted in the other observer's reference frame, the result each observer sees will be different from what happens in his own reference frame. For example, suppose that the observers in the two reference frames are moving away from each other at velocity v_d. (v_d is the difference between their respective, but unknown, inertial velocities.) Each observer will feel as if he is stationary and will see the cannon in the other reference frame moving at v_d relative to him. According to the special theory, the difference in the steel ball's trajectory results from the cannon's motion relative to its observer. The premise of equal merit holds that all four observations shown in Figure 2 are equally valid. The difference in the steel ball's trajectory when viewed from another reference frame is caused by the difference in its momentum which is caused by the difference in the cannon's velocity relative to the observer. The steel ball in the experiment conducted in reference frame B (lower right hand box) will travel on a diagonal trajectory in observer A's reference frame because the cannon which fires it is in motion in observer A's reference frame (upper right hand box). The steel ball in the experiment conducted in reference frame A (upper left hand box) will travel on a diagonal trajectory in observer B's reference frame because the cannon

FIGURE 1

ANY EXPERIMENT INVOLVING THE MOTION OF PHYSICAL OBJECTS WILL PRODUCE THE SAME RESULTS IN ALL INERTIAL REFERENCE FRAMES





which fires it is in motion in observer B's reference frame (lower left hand box). Each observer sees the steel ball fired by the cannon in his own reference frame travel vertically because that cannon is not in motion in his reference frame.

4. A PEEK INSIDE THE GALILEO/ NEWTON RELATIVITY PRINCIPLE

The special theory is based exclusively on experiments made in inertial reference frames with the results being observed by observers in the same or other inertial reference frames. All an observer in an inertial reference frame can know about the motion of another inertial reference frame is by observing its motion relative to him. Because each observer sees himself as being stationary (v=0) and the other as being in motion (v>0), each observer interprets the other reference frame as moving faster than his. Thus, the special theory's predictions of time dilation, space compression, and increasing mass are attributed to an *increase* in velocity relative to the observer. However, if two inertial reference frames are in different states of inertial motion, it is axiomatic that one of them is moving faster than the other and the other is moving more slowly. As a simple matter of mathematics, it is no more possible for each observer to move faster than the other than it is for all of the children in Lake Wobegone to be more intelligent than their average. However, since neither observer can know which inertial reference frame he occupies, there is no way for them to recognize that mathematical fact. But that mathematical fact means that the theory's predictions of time dilation, increasing mass and length shortening must occur whether the "other" inertial reference frame is at a higher or a lower inertial velocity than that of the observer's reference frame. According to the special theory and simple mathematics, time dilation, reduction in length and increasing mass must place limits not only on how fast one can go but on how much he can slow down.

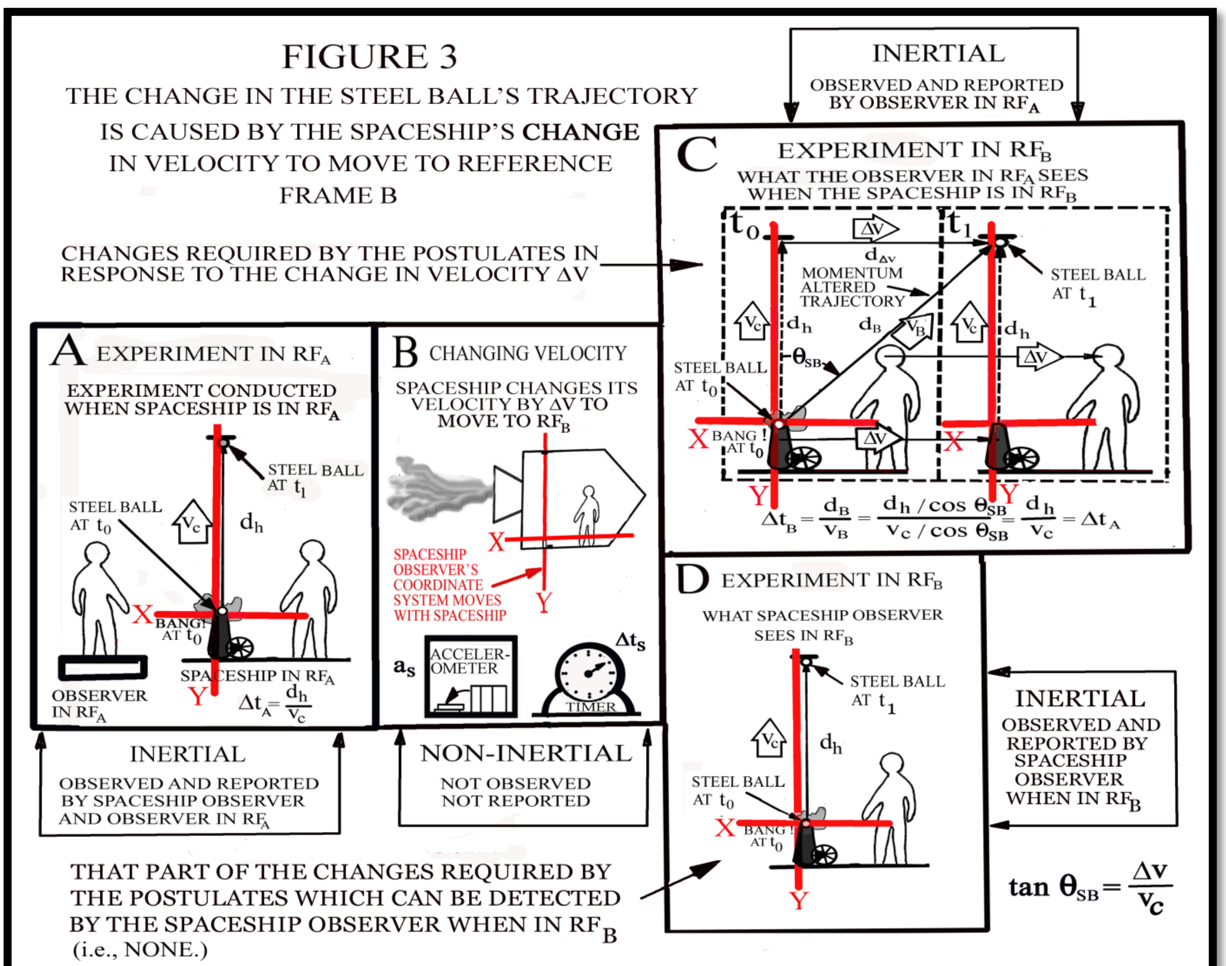
Experiments and observations made exclusively in inertial reference frames are innately insufficient to capture a full empirical description of the phenomena being observed. They address only *differences* in motion between different inertial reference frames. They do not consider the effects of the *change* in motion which must take place in order to move from one inertial reference frame to another. The only way to compare what the postulates require in response to a *change* in motion with the observed effects of a *difference* in motion between the same two reference frames is to break the quarantine between them. And the way to break the quarantine is to take advantage of the difference between a *physical* reference frame and an *inertial* reference frame.

Figure 3 does the same experiment shown in Figures 1 and 2 but uses a spaceship to conduct the experiment in reference frame A before moving it to reference frame B. It then conducts the same experiment in reference frame B.

Box A in Figure 3 shows the results of the experiment when conducted in reference frame A. Note that the experiment is identical to the one shown on the left side of Figure 1. In Box A of Figure 3, an observer has been added to reference frame A. He will remain in reference frame A when the spaceship moves to reference frame B.

Box B of Figure 3 shows something that observations made exclusively from inertial reference frames cannot detect. In order to get from reference frame A to reference frame B, it is necessary for the spaceship to change its velocity. In so doing, some things happen which are exclusive to the spaceship and the spaceship observer. The spaceship observer feels acceleration as the spaceship is changing its velocity. No one else does. His accelerometer tells him that he is accelerating at a constant rate a_s. His timer tells him the interval of time Δt_s which is required to become stationary relative to the objects in reference frame B. The product of a_s and Δt_s tells him the magnitude of his change in horizontal velocity Δv. Not surprisingly, Δv is the same as the difference in velocity v_d between the two reference frames. However, the fact that it is a *change* instead of a *difference* is significant. The *change* in the spaceship's velocity can have an effect only on the spaceship and on that which resides inside of it. Nothing outside of the spaceship has changed its state of motion.

When the spaceship arrives in reference frame B, the spaceship observer shuts down its rocket. The *change* in the momenta of the spaceship, laser, target and observer is what maintains their new velocity after the rocket has been extinguished (laws of mechanics). The same holds true for the steel ball



after it leaves the cannon and no longer is in contact with it (laws of mechanics).

As shown in Box C, when the spaceship observer conducts the experiment in reference frame B, the observer who remained in reference frame A sees exactly what the observer in reference frame A did in Figure 2 (upper right hand box). And as shown in Box D, the spaceship observer, who now is in reference frame B, sees the same result the observer in reference frame B did in Figure 1.

However, Box B shows something entirely new. It is something which clearly must happen in order to move the spaceship from reference frame A to reference frame B. But it happens in a non-inertial reference frame. Empirical information is not even collected in non-inertial reference frames, let alone being reported and included in the interpretation of the data which are reported. *But what is shown in Box B is crucial information about why the change in trajectory occurs and in which of the two reference frames the change must happen.*

When the velocity of a physical object is changed, the laws of mechanics require it's momentum to *change* by ΔP = m Δv, where m is the object's mass and Δv is the *change* in its velocity.[xxxi] What happens in Box B is what *changes* the horizontal *velocity* of the spaceship and everything in it. It also is what changes the *momenta* of the spaceship and everything in it. Unlike the interpretation of the *difference* in velocity which was observed in Figure 2, the *change* in the steel ball's trajectory in Figure 3 is caused by the *change* in velocity from moving to reference frame B; The change in trajectory does not happen in reference frame A, where it is observed. It occurs in reference frame B, where the change in momentum is in effect.

Note that in Figure 3 the observer who remained behind in reference frame A is the one who sees the change in the steel ball's trajectory. Also note that the spaceship observer does not detect any change after he and the spaceship have moved to reference frame B, despite the fact that that is where the laws of mechanics (i.e., the source of the relativity principle and the first postulate's foundation) require the change to happen.

The questions this raises are:

- "Why is it the observer who remained in reference frame A who correctly observes the change in the steel ball's trajectory which is caused by the spaceship's move to reference frame B?" and
- "Why can't the spaceship observer detect what the laws of mechanics say must happen in his own physical reference frame after he moves it from inertial reference frame A to inertial reference frame B?"

The answers to those questions can be found only by observing and recording what happens in the non-inertial reference frame shown in Box B. When the spaceship observer moves his physical reference frame from inertial reference frame A to inertial reference frame B, he takes his human senses and the coordinate system he uses to recognize and measure motion along with him. As shown in Figure 4, this imposes a circular dependence between his own state of motion and his definition of what constitutes the presence, direction and amount of motion.

The reason why the observer who remained behind in reference frame A can see the change in trajectory is because he and his coordinate system did not change. The reason why the spaceship observer cannot see the change in trajectory is because the tools he uses to sense and define motion have made identically the same change in velocity as the spaceship, cannon, target and steel ball. When the physical reference frame in which the laboratory is located changes its own motion from one inertial reference frame to another, there is no means by which an observer in the laboratory can detect the change in motion *after it is in effect* (i.e., from the vantage point of the new *inertial* reference frame).

Note that the same circularity described in Figure 4, which masks the change in the steel ball's trajectory, also masks the change in its horizontal momentum. Because Δv changes the horizontal velocity of both the spaceship and the spaceship observer, as well as that of the steel ball, the spaceship observer also cannot detect the change in the steel ball's horizontal momentum. If he held his hand out to contact the ball, he would feel only the vertical momentum

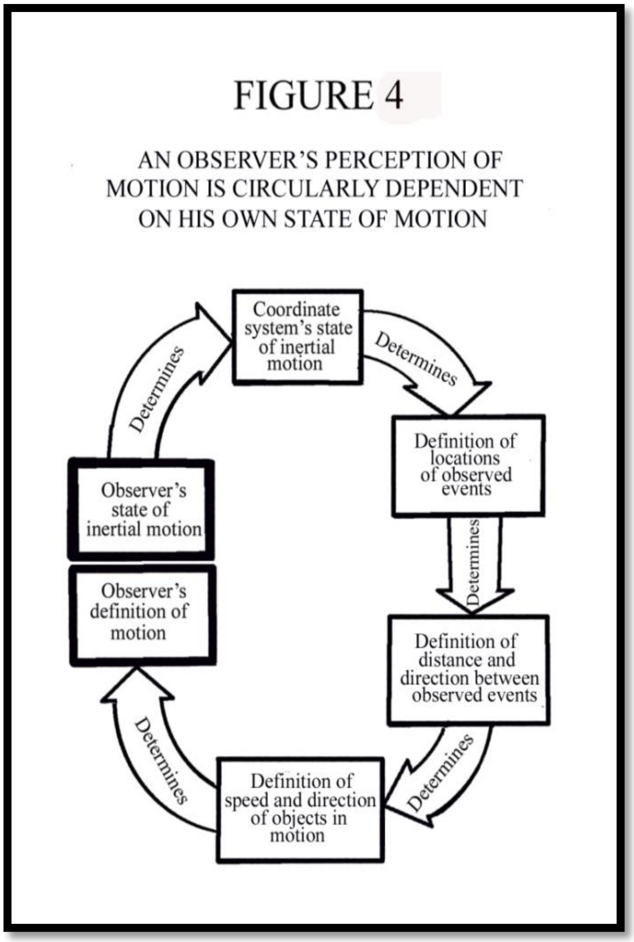


FIGURE 4

AN OBSERVER'S PERCEPTION OF MOTION IS CIRCULARLY DEPENDENT ON HIS OWN STATE OF MOTION

imposed by the powder charge in the cannon. Again, that doesn't mean that the change in horizontal momentum doesn't happen. The laws of mechanics require it to happen. The spaceship observer can't detect it simply because of his own change in horizontal velocity hides the effect of the steel ball's change in horizontal velocity and the corresponding change in its horizontal momentum.

What is shown in Figures 3 and 4 unveils the fact that the Galileo/Newton relativity principle is based on a subtle parlor trick the human condition has been playing on us mere humans.

- For the same experiment involving the motion of physical objects, the *actual* result will be different in every inertial reference frame. Only the *observed* result remains the same. The difference between what happens and what is observed is caused by the circularity between an observer's state of motion and his perception of motion (an unrecognized flaw in experimental design).
- The human body experiences the same physical sensations in every inertial reference frame. It cannot tell one from another (human condition).
- When in an inertial state of motion, the five senses of the human body cannot detect any motion other than relative to the human who harbors them (human condition).
- When an observer changes from one inertial reference frame to another, he takes his human senses and the coordinate system he uses to identify locations and define motion along with him (an innate flaw in experimental design coupled with the limitations of the human condition).
- Each observer's definition of motion in a given inertial reference frame is entirely subjective and is determined by his own state of motion. Such observations are innately unreliable for scientific analysis (a result of both the human condition and experimental design).
- The method for identifying motion is restricted to experiments conducted in and observations made from inertial reference frames. Such observations can detect only *differences* in inertial motion. Thus, they fail to discern that the special theory treats a *difference* in the source's velocity between any two reference frames differently from how it treats an equal *change* in the source's velocity between the same two inertial reference frames. Based on the premise of equal merit, a *difference* in momentum, which is caused by a *difference* in the source's velocity, occurs in the reference frame in which the *difference is observed.* The laws of mechanics require the *change* in an object's trajectory, due to a *change* in its source's velocity, to occur in the reference frame in which the *changed velocity is in effect*. This is the reverse of how the special theory treats a *difference* in inertial velocity (an unanticipated effect of an inadequate experimental design).

Note that the observer in any inertial reference frame has arrived there by *changing* his velocity from another reference frame. Thus, the circularity problem exposed in Figures 3 and 4 applies to observations made from virtually any inertial reference frame.

With apologies to Shakespeare and Hamlet, one might say that there is more motion in inertial reference frames than is dreamt of in our philosophy.

5. WHY LIGHT CANNOT EVEN DO THE PARLOR TRICK (LIGHT HAS A CONSTANT SPEED)

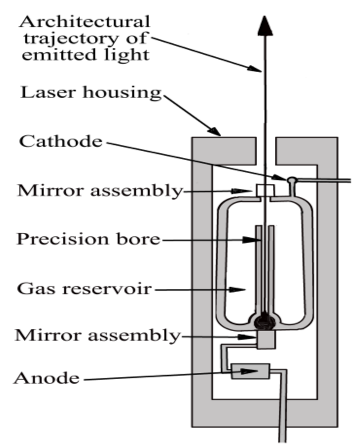
This experiment is identical to the one shown in Section 4, which used vertically oriented cannon to fire a steel ball, except that a vertically oriented laser is used to fire a quick burst of light. The laser is substituted for the light bulb customarily used in textbook illustrations to reduce ambiguity regarding the vector direction in which the light being observed is propagating. As shown in Figure 5, absent interference from other forces, the light a laser emits will propagate on a specific vector trajectory. That trajectory is determined by the laser's physical architecture. That is why one can refer to the "direction" in which a laser is "pointed". However, by knowing about a laser's architectural trajectory, one can know that *if* light responds to momentum, a change in the laser's horizontal velocity will change the angle between its architectural trajectory and the trajectory traveled by the light it emits. That effect is due the change in the light's momentum, which is interference from another source.

Just as in the steel ball experiment, the experiment using the laser is done first when the spaceship is stationary in reference frame A. As shown in Box A of Figure 6, the laser is oriented to emit a quick burst of light vertically to strike a target on the ceiling of the spaceship. Δt_A, the time required for the light to complete the trip in reference frame A, is equal to the distance d_h between the laser and the target divided by the speed of light *c*. Since the premise of equal merit requires that what is shown in Box A is a valid description of reality, it is assumed that the light burst shown in Box A actually travels on the laser's architectural trajectory.

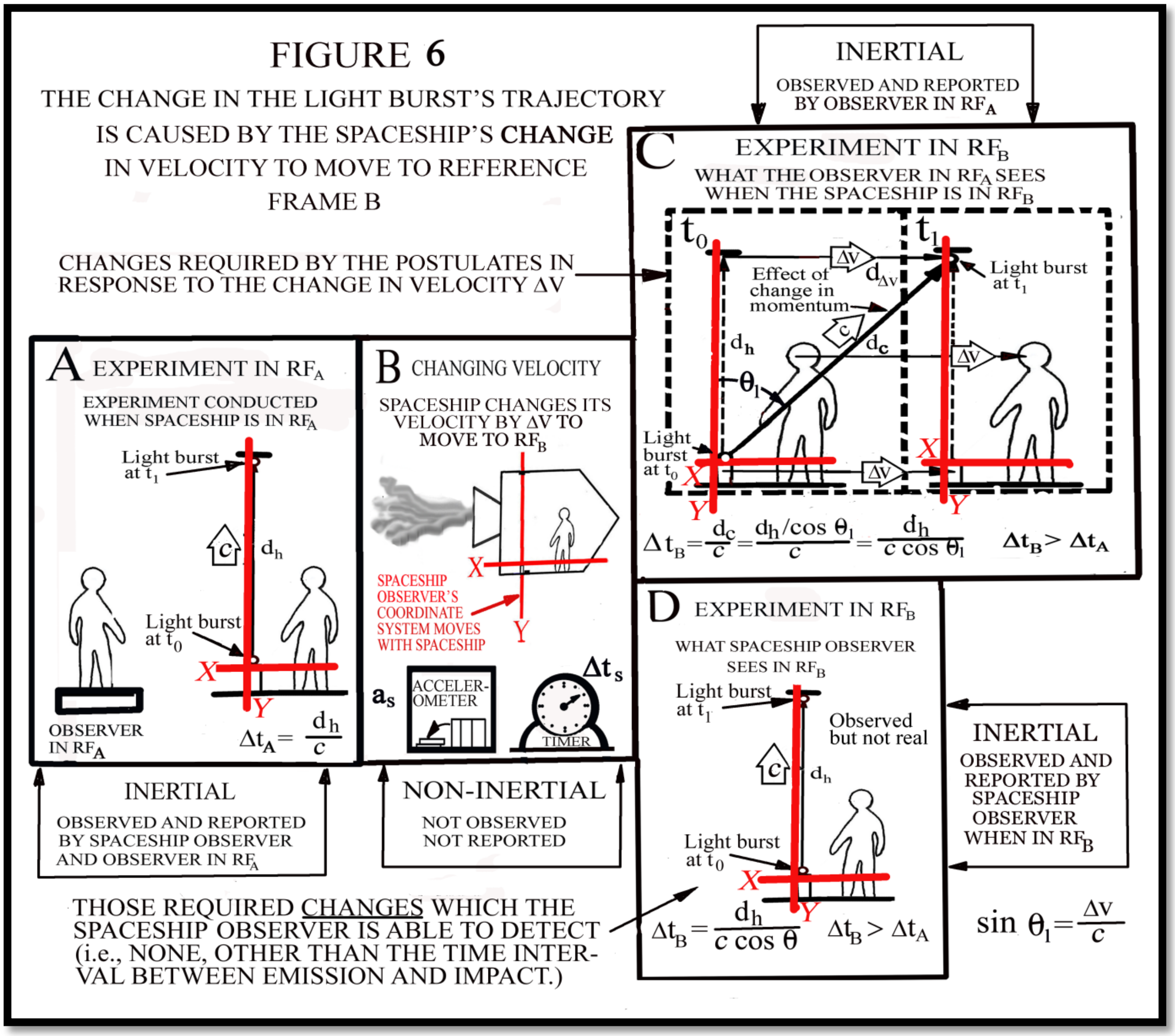
As shown in Box B, the spaceship observer uses the spaceship's rocket to change its velocity by Δv to move from reference frame A to reference frame B. As before, he leaves reference frame A's observer behind to keep an eye on things from reference frame A's point of view. Also, as before, the spaceship observer's sensation of acceleration is unique to him. He also is unique in taking his human senses and the coordinate system he uses to define motion along with him. And he is the one who is best situated to observe and record the rate of acceleration and the time interval during which it was applied. This is information which is neither collected nor reported in experiments customarily used to examine inertial motion.

FIGURE 5

A Laser's Trajectory is Determined by its Architecture



As shown in Box C, what happened in Box B has *changed* the horizontal velocity of the spaceship and of everything inside it. That *changes* the laser's momentum and, according to the first postulate, also *changes* the light burst's momentum. Thus, as the light departs from the laser, it no longer will travel on the laser's architectural trajectory; the light now must travel on a new trajectory in response to the *change* in its momentum. The new trajectory will be a combination of the *change* in the light's horizontal velocity Δv and the speed of light *c*. However, unlike the steel ball, the light's velocity will not be the vector sum of its previous vertical velocity and the momentum-induced *change* in the laser's horizontal velocity. According to the second postulate, light



must continue to propagate on its new trajectory at its definite constant speed *c*. Thus, the angle of the light's divergence from the laser's architectural trajectory θ_l, will have a *sine* equal to the change in horizontal velocity Δv divided by the speed of light *c*. Recall from Figure 3 that the angle of divergence θ_{SB} shown in Box C, relative to the direction in which the cannon was pointed, had a *tangent* which was equal to Δv divided by v_c. Δv was the change in the cannon's horizontal velocity and v_c was the vertical velocity imposed by the gunpowder in the vertically pointed cannon.

The result of the light's restriction to a definite constant speed is that, unlike the steel ball, the length of its trajectory is increased by the effect of the *change* in its momentum but its speed is not. The interval of time it takes to complete its trip from laser to target Δt_B in reference frame B must increase.

$$\Delta t_B = \frac{d_c}{c} = \frac{d_{h}/\cos\theta_l}{c} = \frac{d_h}{c\cos\theta_l}$$

$$\Delta t_B > \Delta t_A$$

As shown in Box D, the spaceship observer remains blissfully unaware of the change in the light burst's trajectory. This is because, as shown in Box B, The spaceship observer and his coordinate system experience identically the same change in horizontal velocity as the spaceship, laser and target. The spaceship observer feels the same as when he was in reference frame A and his coordinate system shows no changes in horizontal position from what they were in reference frame A. He still is in thrall to the illusion cast by the human condition's parlor trick. However, if he has a really good mechanical timer, he will notice that there is something wrong with the experiment's elapsed time. It is longer than it was in reference frame A. That is an empirical result which is not the same as in the previous inertial reference frame. Thus, the experiment involving light does not satisfy the relativity principle. The constant speed imposed by the second postulate refutes the first postulate. Also, the failure to satisfy the relativity principle invalidates the basis for the premise of equal merit. Experiments involving the propagation of light do not produce even the same *observation* in different inertial reference frames, let alone producing the same actual motion. With the loss of the relativity principle and the premise of equal merit, the special theory collapses like the proverbial house of cards.

This is the point in the discussion when the true believers in relativity will explain time dilation to this poor, uninformed amateur analyst. However, both the steel ball experiment and the light experiment have made the same change in velocity Δv from the same reference frame A to the same reference frame B. Indeed, the spaceship observer made both the steel ball experiment and the light experiment in reference frame A before changing the spaceship's inertial velocity to that of reference frame B. He then did both experiments again. As shown in Figure 3, the steel ball experiment produces the same apparent trajectory to the spaceship observer in reference frame B (Box D) as it did in reference frame A (Box A). Assuming the spaceship observer has a really good mechanical timer, the steel ball experiment also will produce the same time interval in reference frame B as it did in reference frame A. For the steel ball experiment, the illusion created by the human condition's parlor trick is fully intact. However, the light experiment fails the time interval test. It creates the same illusion for its trajectory but comes up with a different elapsed time (Box C of Figure 6). Now, here's the rub for the true believers; for the same inertial reference frame, there can be only one rate at which time passes. If the clock is adjusted to produce the correct answer for the light experiment, the steel ball experiment will fail the "same observed result" test for its elapsed time. There simply is no way one can play with the clock to produce the right answer for both experiments. It's a simple matter of mathematics. The propagation of light has a definite constant speed. Steel balls fired from a tiny cannon do not.

One reasonably might wonder why I am fixated on having a really good mechanical timer. The reason is that mechanical timers are immune to both changes in inertial velocity and differences in inertial velocity. Their timing may be affected during acceleration, if it is extreme enough, but not when in inertial motion. However, as shown in Box C of Figure 6, a light clock slows down as its inertial velocity is increased. If the instant of emission is "tick" and the instant of impact is "tock"' the distance light travels between the "tick" and "tock" events will increase but the speed at which it travels between those two events will not increase. The greater the increase in the light clock's inertial velocity, the more inaccurate it will become. Also, it is mathematically clear in Box C of Figure 3 that the only way for the steel ball to give the correct time interval is for time to pass at the same rate in reference frame B as it does in reference frame A.

I'm sorry, true believers. Time dilation is dead. When faced with a *change* in the physical laboratory's inertial velocity, the observer in the laboratory cannot detect the changes in the *trajectory* of either a steel ball or of a burst of light which are mandated by the first postulate. Even if the first postulate is correct, the premise of equal merit is invalid. In the case of light, the second postulate's constant speed then produces a different elapsed time in every inertial reference frame, thereby refuting the first postulate's claim that the relativity principle applies to the propagation of light. And there is no way to adjust the clock in the second inertial reference frame to provide the same elapsed time for both the experiment using the steel ball (matter) and the experiment using the burst of light (energy). Time dilation has died because it is unable to resuscitate itself.

This would seem to be a good place to conclude and retire. But, like the guy who gives the spiel in the commercials, I feel compelled to cry "Wait! There's more!" It still is worth understanding why observations made exclusively from inertial reference frames and interpreted under the influence of the premise of equal merit can be even worse than worthless. They not only fail to produce all of the information needed to understand the phenomena being observed, they also can be downright misleading, as shown in the next two sections.

6. OBSERVATIONS MADE FROM INERTIAL REFERENCE FRAMES TREAT RELATIVE MOTION INCONSISTENTLY

The concept required to appreciate this problem is to recognize that an inertial reference frame is simply a state of motion. Its coordinate system spreads out in three-dimensional space to the very ends of the universe. Everything in the universe that is stationary relative to that coordinate system is in that same inertial reference frame. Every other reference frame also has its own coordinate system which extends to the very ends of the universe. If two inertial reference frames are in a given state of motion relative to each other, the entire universe-wide coordinate system of each reference frame is in the same state of motion relative to the entire universe-wide coordinate system of the other.

This experiment shows the observations made in one inertial reference frame, shown in gray, of an experiment made in another inertial reference frame, shown in black. The experiment consists of a laser situated at one location in the black reference frame’s coordinate system which emits a burst of light. The burst of light subsequently strikes a target situated at another location in the black reference frame’s coordinate system.

Figure 7 shows the locations of the two events as recorded by the observer in the gray reference frame. He sees a laser located at coordinates 1, 1 in his reference frame emit a burst of light at time t_0. At time t_1, he sees the burst of light strike a target located at coordinates 3, 1 in his reference frame. During that interval of time, the light was seen to travel horizontally a length of two units of distance.

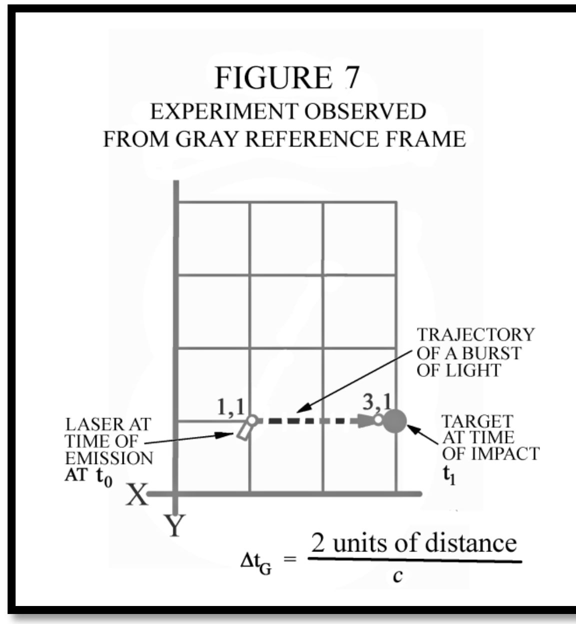


FIGURE 7
EXPERIMENT OBSERVED FROM GRAY REFERENCE FRAME

Figure 8 shows where the laser and target are located in the black coordinate system. In the black reference frame, the light travels diagonally a distance of approximately 2.236 units of distance.

For illustrative purposes, it is assumed that both reference frames have identical coordinate systems and their X and Y axes are superimposed at the instant when the light is emitted.

As shown in Figure 9, the gray reference frame is moving upward and to the left relative to the black reference frame. A twelve-square section of each coordinate system is shown for reference. The X axis is at the bottom of each twelve-square section and the

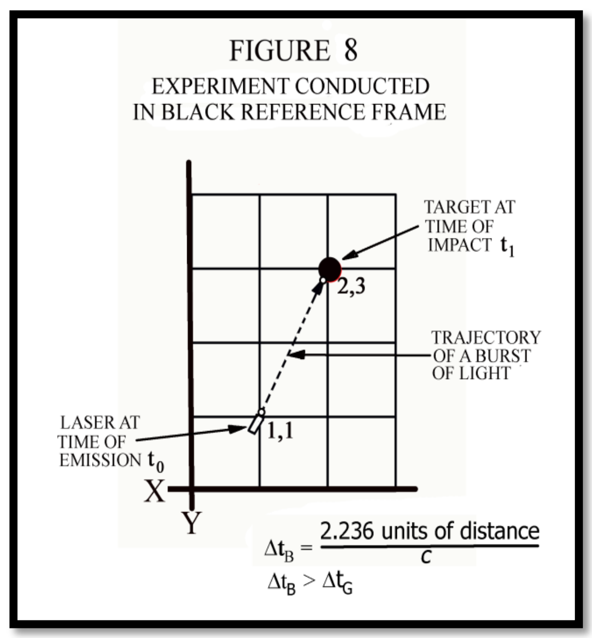


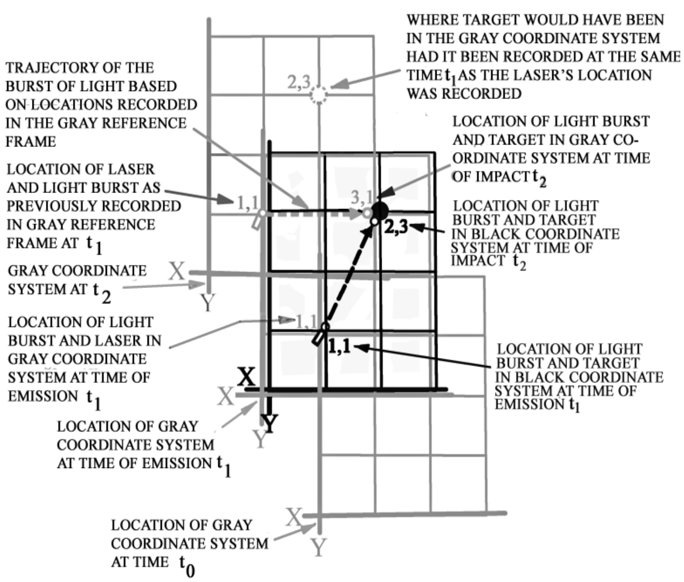
FIGURE 8
EXPERIMENT CONDUCTED IN BLACK REFERENCE FRAME

Y axis is at the left side. The location of the gray reference frame relative to the black reference frame is shown at three equally spaced instants in time, t_0, t_1 and t_2. For illustrative convenience, the interval of time between them is equal to the time required for the light to travel from the laser to the target in the black reference frame. At t_0, the origin of the gray reference frame is below and to the right of the origin of the black reference frame. At time t_1, their origins and axes are superimposed. That is the instant in time when the laser emits the burst of light. Each observer observes that event as occurring at coordinates 1, 1 in his reference frame.

At time t_2, the gray reference frame's coordinate system has moved upward and to the left to its top position in the illustration. At that instant, the burst of light strikes the target. The black reference frame's observer sees and marks that event in his coordinate system at coordinates 2, 3. The gray reference frame's observer sees and marks the location of that event at coordinates 3, 1 in his coordinate system.

FIGURE 9

RELATIVE MOTION BETWEEN DIFFERENT INERTIAL REFERENCE FRAMES IS INCONSISTENTLY RECOGNIZED



The gray observer calculates that the light traveled two units of distance in his reference frame during the interval of time between the two events. The black observer calculates that the light traveled diagonally approximately 2.236 units of distance in his reference frame between those same two events. Since the light traveled farther in the black reference frame between the same two events than it did in the gray reference frame, one must conclude that time passes more slowly in the gray reference frame than it does in the black reference frame.

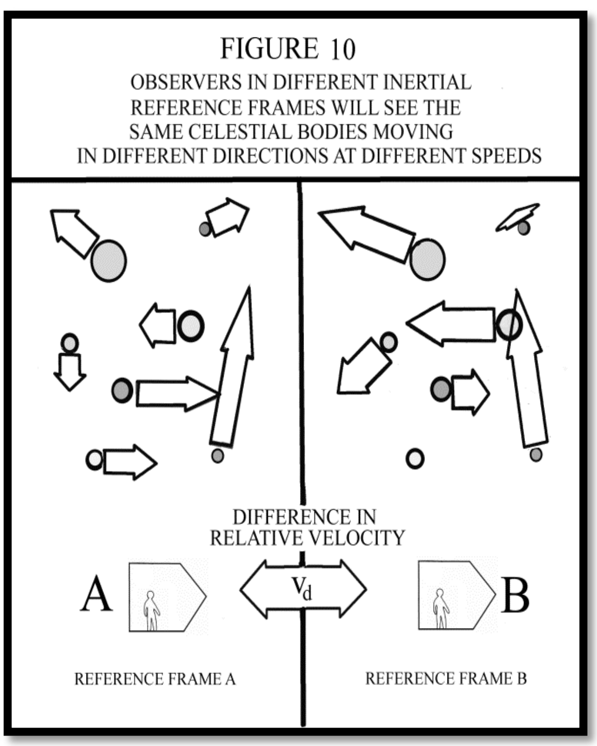
One might stop at this point and declare a victory for the special theory. However, there is one little glitch to deal with. The only way the *laser* could remain at coordinates 1, 1 *in the gray reference frame* at time t_2 is if that part of the gray reference frame had remained stationary relative to the black reference frame during the interval of time between t_1 and t_2. But if it had done so, the entire coordinate system of the gray reference frame would have to remain stationary relative to the entire coordinate system of the black reference frame. And, if it had done that, the target would be at 2, 3 in the gray reference frame at time t_2 instead of being at 3, 1. Recording events which occur at different points in time in a different reference frame as if their locations were stationary in the observer's reference frame treats the relative motion between the coordinate systems of the two reference frames differently for some observed events than for others. This location recording error is innate to observations made in inertial reference frames of events which are separated in time and occur in another reference frame.

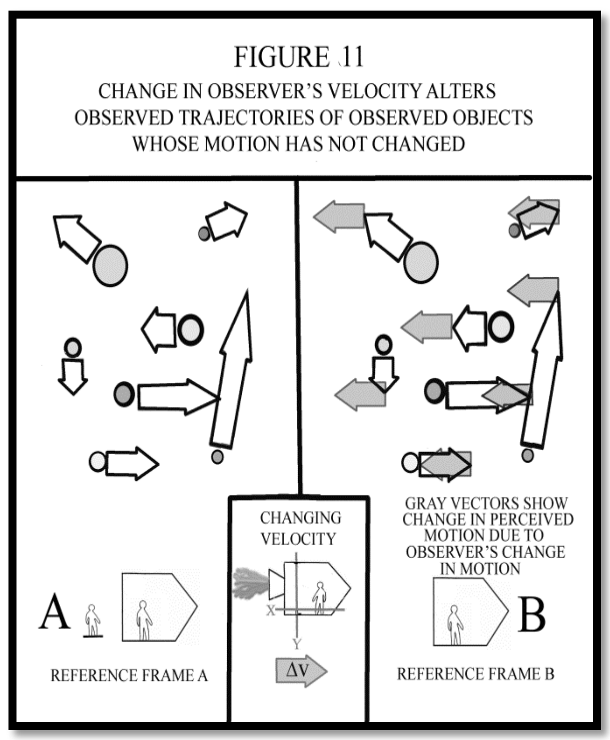
7. WHAT AN OBSERVATION IS BELIEVED TO MEAN DEPENDS ENTIRELY ON ITS INTERPRETATION

Figure 10 shows two spaceships which are stationary in two different inertial reference frames. The reference frames are named A and B. They are in motion relative to each other at a constant velocity v_d. v_d is the difference between their respective inertial velocities. Because each reference frame is in motion relative to the other, the observers will see the same celestial bodies but will perceive them as moving in different directions at different speeds. This is business as usual for the special theory. Observers in each inertial reference frame will see the celestial bodies in space moving in different directions at different speeds than observed by observers in other reference frames. According to the premise of equal merit, the motions of the celestial bodies actually are different in each different inertial reference frame.

Figure 11 takes a different approach to describing how the two different reference frames relate to each other. It shows a single spaceship in reference frame A on the left side of the illustration. When in reference frame A, the observer in that spaceship sees the same celestial display as shown for the observer in reference frame A in Figure 10. The observer in the spaceship then uses the spaceship's rocket to change its velocity by Δv to that of reference frame B. Note that Δv has the same magnitude as v_d. However, it now can be recognized as the *change* in velocity which is required to move from reference frame A to reference frame B. The distinction between a *change* in velocity and a *difference* in velocity is that the special theory treats a difference in inertial velocity as working the same way in both directions. A change is not subject to that ambiguity. If the spaceship observer *changes* the spaceship's inertial velocity horizontally to the right by Δv, as shown in the middle box in Figure 11, he will take his coordinate system and his human senses along with him. This will alter his perception of the motions of the celestial bodies he saw when he was in reference frame A. That alteration will be unique to him and totally subjective. The motions he observes in reference frame B will become the vector sums of what he observed when in reference frame A (the white vectors) and the change in his definition and perception of motion caused by his own change in inertial velocity (the gray vectors).

The net effect of their vector summation is shown in Figure 12. Not surprisingly, it is no different from what is shown in Figure 10, except for the explanation (Figures 11 and 12), or lack thereof (Figure 10), of what *causes* the difference in the observations. In Figure 10, the special theory defines both observers' observations as having equal merit. The motions of the celestial bodies actually are different in reference frame B than they are in reference frame A. However, as shown in Figures 11





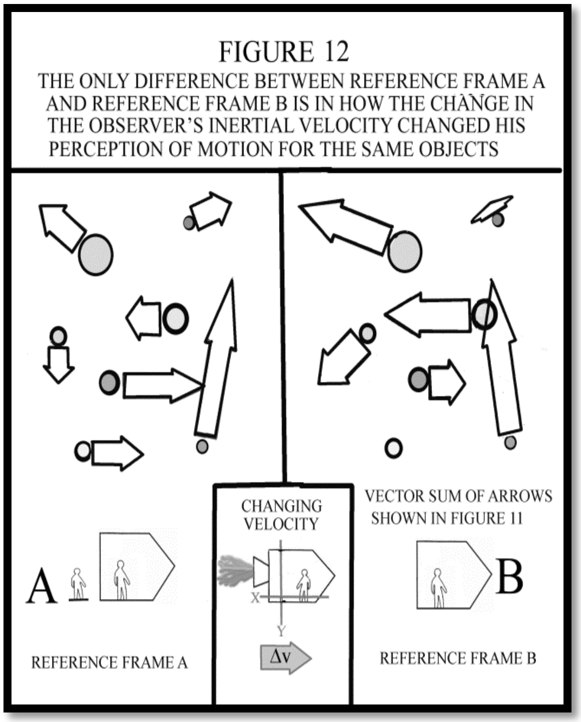


FIGURE 12
THE ONLY DIFFERENCE BETWEEN REFERENCE FRAME A AND REFERENCE FRAME B IS IN HOW THE CHANGE IN THE OBSERVER'S INERTIAL VELOCITY CHANGED HIS PERCEPTION OF MOTION FOR THE SAME OBJECTS

and 12, the motions of the celestial bodies haven't changed; the observer has experienced a personal and entirely subjective change in his definition and perception of motion. The spaceship observer and his spaceship are the only things that have changed their inertial velocity. One would need an almost limitless amount of rocket fuel and a virtually uncountable number of rocket engines to change the motions of all of the visible celestial bodies in the universe.

Given the circumstances of this thought experiment, Occam's razor would suggest that the difference between the motions of the celestial bodies observed in reference frames A and B of Figure 12 is caused by simple observation error when the observer is in reference frame B. If the observations in Box A were correct, the observations in Box B must be incorrect. To conclude otherwise not only flies in the face of Occam's razor but requires a strong dose of magical thinking (yet another attribute of the human condition).

8. A CENTURY OF VALIDATION BY CIRCULAR REASONING

Figure 13 shows how subconscious reliance on the special theory's own system of beliefs has influenced the design of experiments and the interpretation of empirical data which have consistently validated it.

The box at the left of Figure 13 provides an overview of the special theory's foundational beliefs. At the top are its postulates. Next are other premises which support, clarify or are derived from the postulates. These are the beliefs which must be valid in order for the special theory to be valid. At the bottom of the left-hand box are the theory's predictions about the nature and consequences of inertial motion.

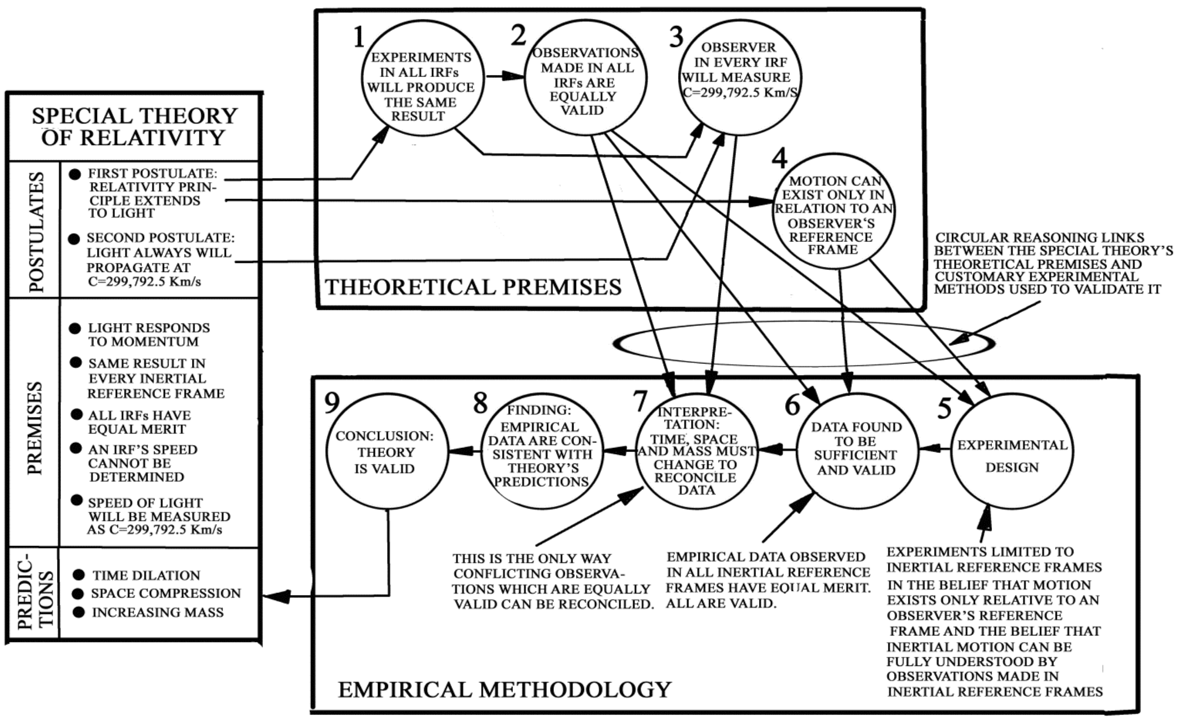
The circles in the box on top show some of the key beliefs which guide how the theory reaches its predictions. The circles in the bottom box show the key steps involved in the design and conduct of experiments involving inertial motion.

The lines between the circles in the top box and those in the bottom box show where subconscious acceptance of the theory's own foundational beliefs can guide empirical analyses to a preordained validation. For example, the influence of the belief in circle 4 on experimental design is hard to dismiss. An experimental design based entirely on experiments conducted in and observations made from inertial reference frames clearly is based on the expectation that they will capture all of the data which are necessary to understand motion (circle 4) and that the resulting data will fully and accurately describe the phenomena being examined (circles 1 and 2). It also is clear that the beliefs in circles 2 and 4 play a decisive role in validating observations of the same events which provide conflicting information on the direction and distance traveled by the same emission of light (circle 6). Given the "validated" empirical data, the implicit beliefs in circles 2 and 3 leave no alternative to concluding that the theory's predicted time dilation, length shortening and increased mass are the only means for reconciling the empirical data.

Customary experimental practice appears to be governed by a subconscious belief that the concepts underlying the special theory are unquestionably valid. This subconscious conviction affects experimental design, validation of conflicting observations as having equal merit and interpretation of the resulting empirical data.

FIGURE 13

THE INFLUENCE OF CIRCULAR REASONING ON EMPIRICAL VALIDATION OF THE SPECIAL THEORY OF RELATIVITY



Experimental designs which address inertial motion are confined exclusivity to inertial reference frames (A comparison between how the theory treats a *change* in velocity with how it treats a *difference* in inertial velocity between the same two reference frames can be made only by considering what happens in a non-inertial reference frame).

Conflicting observations of the direction and distance traveled by phenomena under study are accepted as having equal merit (the observations were made in inertial reference frames). Interpretation of the empirical data begins with an assumption that the phenomena being observed behaved in accordance with the postulates and premises (e.g., it is assumed that the light responded to momentum in accordance with the *difference* in its source's velocity relative to the *observer*).

Given the above influence on experimental methodology, it is not unreasonable to expect that the explanation of any differences in the empirical observations can be found only in the theory's predicted environmental conditions (time dilation, space compression and increased mass). The conclusions to be reached by such an empirical methodology are virtually inevitable. The theory consistently will be affirmed.

However, as shown in Figures 3 and 6, if the postulates are correct it is the *change* in velocity required to move from one reference frame to another which changes the observed phenomena's behavior. Because of the circularity between an observer's state of motion and his definition of motion, observers in different inertial reference frames will disagree with each other because of observation error. Each observer has his own entirely subjective definition of motion which is different from the entirely subjective definition of the other. Whichever of the two is correct, the other must be incorrect.

9. CONCLUSIONS

What this paper shows is that two changes in the experimental design of Dr. Einstein's famous thought experiments will cause the special theory's postulates and premises to contradict each other. The two changes are:

- The omnidirectional light source available in the early 20th century is replaced with a directional light source, the optical laser.
- A distinction is made between a physical reference frame, such as a spaceship, and an inertial reference frame, which is simply a state of motion.

Using a laser as the light source imposes the discipline of having to recognize that the propagation of light is a definite, constant vector phenomenon, not simply a definite, constant scalar speed. That eliminates the ambiguity over the trajectory of the same unit of light which is being observed simultaneously from different reference frames.

The distinction between a physical reference frame (e.g., a spaceship) and its state of motion (i.e., an inertial reference frame) permits the same experiment to be made in one inertial reference frame and then be moved, intact, to another. Both the magnitude and the vector direction of the spaceship's change in motion are defined. While the states of inertial motion of the two reference frames may not be known, the *change* in motion from one to the other is absolute, not merely relative. The two postulates of relativity then can be used to determine what change must occur in the laser's trajectory in the second reference frame relative to what it was in the first one. That, in turn, permits a comparison between what the postulates say must happen and what the spaceship observer will *observe*. What that discloses is that if the observation made in the first reference frame is correct and the postulates of relativity are correct, the spaceship observer's *observation* in the second reference frame will be incorrect. He will fail to detect the change in the light's trajectory due to the change in the spaceship's momentum. That is because the coordinate system he uses to define locations has changed its own state of motion to match that of the spaceship, observer, laser and target. The method of defining motion by means of changes in location has been corrupted by making the system used to identify locations subject to the observer's state of motion. Such a circular method of measurement is innately meaningless.

Based on the results presented in this paper, the following conclusions can be made:

1. The special theory of relativity is a house of cards based on a parlor trick and sustained by circular reasoning.
2. When a laser's own inertial motion is changed, the change in its trajectory which is required by the postulates of relativity cannot be detected by an observer who is in the same physical reference frame as the laser. That observer will suffer from observation error caused by the change in his own state of motion and the corresponding change in the coordinate system of his and the laser's reference frame. Thus, the premise of equal merit is refuted by the very postulates upon which it has been based.
3. Because the premise that light always will be measured to travel at its definite speed c depends on the premise of equal merit, the premise of will measure c also is invalid. The speed of light is constant, but what is observed depends on the observer's entirely subjective definition of motion.
4. Because both the premise of equal merit and the premise of will measure c are invalid, the special theory and its predictions are invalid.
5. Physical objects provide the same observed results in all inertial reference frames because a change in their momentum changes both their trajectory and their speed in the same proportion. However, the second postulate requires light to propagate through empty space at the same constant speed c. Thus, even if light responded to momentum, its change in trajectory would not be matched by a corresponding change in its speed. The interval of time between when a unit of light is emitted and when it arrives at the target would change as the reference

frame's state of inertial motion changes. *Experiments involving the propagation of light can provide the same apparent trajectory in different inertial reference frames but cannot produce the same time interval.* Thus, the second postulate of reletivity refutes the first postulate. The results of experiments made in different inertial reference frames will be different. The special theory is rendered invalid by conflicting requirements at its very foundation.

6. Because the special theory and its predictions are invalid, time, space and mass are restored to their historical status as the universal constants of physics (i.e., time does not slow, length does not shorten and mass does not increase with motion).
7. Because neither time nor space are affected by motion, the relationships described by the special theory which make them appear to be interchangeable are invalid. The concept of space-time is inoperable.
8. Mass and energy are different in kind and are not interchangeable. Mass is a scalar phenomenon and is inert until pushed by energy. Energy is a vector phenomenon which changes the state of motion of mass.Their innate characteristics and their effects on their environment are polar opposites.
9. Because the first postulate is invalid, there is no basis for maintaining that light, which has no mass, responds to momentum.
10. Light clocks are inaccurate at high inertial velocities. Mechanical clocks are not.
11. Because string theory depends absolutely upon the validity of the special theory of relativity as written, string theory is DOA.[xxxii]
12. The belief that the motions of celestial bodies actually are different when being observed from different inertial reference frames is invalid. That belief is based on the invalid premise of equal merit. There are no multiple universes.
13. Interpretations of experiments involving the motions of celestial bodies over the past century need to be reexamined.
14. The human condition has significantly undermined the scientific method for the past century. Its influence on scientific decisionmaking needs to be better understood and guarded against.
15. Empirical observations do not constitute proof. All they can do is indicate what might be true subject to the adequacy of experimental design, the capabilities of available technology and the validity of interpretations of whatever empirical data happened to be detected. This is not a critique of the scientific method; it is an unavoidable consequence of the human condition.

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[i] Douglas G Giancoli, *Physics*, 4th edition (Englewood Cliffs, New Jersey: Prentice Hall, 1995), 744-745.

[ii] Ibid., 743.

[iii] Ibid., 750. Goldsmith, Dr. Donald, and Robert Libbon, *Einstein: A Relative History* (New York: Simon & Schuster, Inc., 2005), 70.

[iv] Cox, Brian and Jeffery Forshaw, *Why Does* $E=MC^2$*: (and why should we care?),* (Cambridge, Massachusetts: Da Capo Press, A Member of the Perseus Books Group, 2009), 39-45. Giancoli..,. *Ph;/' ysics*, 745. Gribbin, John and Mary Gribben, *Annus Mirabilis: 1905, Albert Einstein, and the Theory of Relativity* (New York: Chamberlain Bros., Penguin Group, Inc., 2005), 96-97.

[v] Giancoli, *Physics*, 744-745. Goldsmith, *Einstein: A Relative History*, 48. Gribbin, John, *Annus Mirabilis:* 96-97.

[vi] Goldsmith, *Einstein: A Relative History*, 67-70.

[vii] Knight, Randall K., *Physics for Scientists and Engineers: a strategic approach (San Francisco, California*: Pearson Publishing, Inc., publishing as Addison Wesley, 2004), 1149.

[viii] Giancoli, *Physics*, 744-745.

[ix] Ibid., 743.

[x] Perkowitz, Sidney, *Empire of Light: A History of Discovery in Science and Art* (New York: A John Macrae Book, Henry Holt and Company, 1996), 61.

[xi] Cox, Brian, *Why Does* $E=MC^2$, 28, 41. Goldsmith, Dr. Donald, *Einstein: A Relative History*, 49. (Note that the value for the speed of light *c* is expressed as 299,792,458 m/s, 299,792.5 km/s, or $3.00\text{x}10^8$ m/s depending on the reference source. All are essentially the same number with only slight differences in rounding.)

[xii] Cox, Brian, *Why Does* $E=MC^2$, 28.

[xiii] Giancoli, *Physics*, 745. Perkowitz, *Empire of Light*, 61-63.

[xiv] Giancoli, *Physics*, 745-746.

[xv] Aczel, Amir D., *God's Equation* (New York: Four Walls Eight Windows, 1999), 22. Cox, *Why Does* $E=MC^2$, 29. Giancoli, *Physics*, 745.

[xvi] Giancoli, *Physics, 745.*

[xvii] Perkowitz, *Empire of Light*, 65-68. Giancoli, *Physics,* 746-749.
[xviii] Giancoli, *Physics*, 749.
[xix] Aczel, *God's Equation*, 24. Rigden, John S, *Einstein 1905: The Standard of Greatness* (Cambridge, Massachusetts: Harvard University Press, 2005), 84. Giancoli, *Physics,* 751. Hey, Tony and Patrick Walters, *Einstein's Mirror,* (New York: Cambridge Press, 1997), 7.
[xx] Giancoli, *Physics,* 750.
[xxi] Ibid. Goldsmith, *Einstein: A Relative History*, 67.
[xxii] Giancoli, *Physics,* 750. Goldsmith, *Einstein: A Relative History,* 70.
[xxiii] Ibid.
[xxiv] Giancoli, *Physics*, 750.
[xxv] Giancoli, *Physics*, 743-744.
[xxvi] Hey, *Einstein's Mirror*, 43. Goldsmith, *Einstein: A Relative History,* 67.
[xxvii] Giancoli, *Physics,* 750.
[xxviii] Goldsmith, *Einstein: A Relative History*, 67.
[xxix] Ibid., 48. Gribbin, *Annus Mirabilis,* 96-97. Giancoli, *Physics.* 745.
[xxx] Goldsmith, *Einstein: A Relative History*, 49.
[xxxi] Giancoli, *Physics*, 166-167.
[xxxii] Smolin, Lee, *The Trouble with Physics; the rise in string theory, the fall of a science, and what comes next* (New York: Houghton Mifflin Company, 2006), 223.