Chapter 19

THE 'DIFFICULTIES' WHICH TRIGGERED SPECIAL RELATIVITY

By 1905, theoretical physics appeared to some scientists to be in a state of complete disarray. Vestiges of Newton's absolute space and absolute time remained. The concept of stationary ether continued to confuse and distort almost everything. The paradoxical null result of the M & M experiment was still an unexplained enigma. Above all, there appeared to be mathematical 'difficulties' between the mechanics principle of Galileo's Relativity and Maxwell's electrodynamic equations (which implied the constant transmission velocity of light at c) that mystified Einstein and the entire scientific community.

A. The theoretical background for Einstein's mathematical 'difficulties.'

Anyone who has read Albert Einstein's early writings on physics must conclude that he was greatly disturbed by several problems (or 'difficulties,' as he called them), which he perceived to exist in physics during the early part of the first decade of the twentieth century. In this Chapter 19 we shall discuss and analyze those perceived 'difficulties' that apparently led Einstein to construct his Special Theory of Relativity.

Despite Lange's abstract invention of relatively moving inertial reference frames in 1885, there still remained in physics vestiges of Newton's concept of 'absolute space' at rest. The most obvious example of this was the concept of stationary ether, which was generally considered to be an absolute frame of reference at rest in space from which measurements might be made.[1] Faraday, Maxwell and many other physicists had incorrectly based their theories on the existence of this 'specially favored' reference frame.

The paradoxical null results of Michelson's experiments, and many similar light

[1] This, of course, was a fallacy of logical thinking on its face, because by convention other reference frames were composed of ponderable matter and had a unique specific velocity, but by definition the hypothetically material ether was stationary and not ponderable.

experiments during the latter part of the 19th century, which attempted to detect and measure the absolute motion (velocity, direction and distance traveled) of the Earth with respect to the ether at rest, must have been particularly troubling for Einstein. At the turn of the century, the paradox of the M & M null results in particular remained a disturbing enigma for the scientific community. The absolute theories of Lorentz and Fitzgerald, which arbitrarily attempted to explain away such paradoxical null results in order to defend and save the concept of stationary ether as an absolute reference frame, would not have been acceptable because they were so *ad hoc*. For Einstein, the concept of stationary ether must be abandoned (or at least ignored), measurements of space needed to be drastically changed and redefined, and the baffling mystery of the M & M null results (and their theoretically missing time intervals) must be more plausibly explained.

In the physics of Einstein's early days, there were similar vestiges of Newton's concept of 'absolute time.' For example, Michelson's experiments and Lorentz's theories attempted to deal with, measure, describe and explain 'absolute time intervals' for light rays to propagate with respect to the stationary ether. In addition, all distantly separated light events in the Cosmos were often intuitively assumed to occur at absolutely the same instant in time (simultaneously). For example, the twinkling of a distant star and its perception by an observer on Earth were assumed by many to be simultaneous events. This false and imprecise assumption was mathematically exemplified by the Galilean transformation equations for time: $t = t'$ and $t' = t$.[2] For Einstein, measurements of time also needed to be drastically redefined and made more precise.

[2] As we shall discover in Chapter 25, these imprecise approximations of the time of occurrence of a distant event had been well known by mathematicians such as Poincaré for many decades, but they were consciously ignored for purposes of mathematical simplicity. (see Neffe, p. 129; Miller, p. 176)

As previously mentioned in Chapters 14 and 17, the classical Galilean transformation equations did not describe the theoretical mathematical increase in the electromagnetic mass (actually resistance) of a charged body or particle when its velocity is increased. Einstein believed that this mathematical 'difficulty' needed to be rectified by a modified set of transformation equations that would describe this theoretical phenomenon. (Goldberg, pp. 131 – 141; D'Abro, 1927, pp. 157 – 160) There were also other problems and paradoxes in physics that disturbed Einstein. (see Chart 19.3)

Yet, by far the most important 'difficulty' which baffled Einstein and the entire scientific community in 1905 was the apparent contradiction between two revered mathematical principles of physics: the Galilean transformation equations of mechanics which mathematically describe Galileo's Relativity, on the one hand, and Maxwell's electromagnetic equations which *inter alia* implied that the velocity of light had a constant velocity of *c en vacuo*, on the other hand.

What exactly was this apparent contradiction or paradox? The Galilean transformation equations, which describe the velocity of material objects relative to inertial frames of reference, "give rise to a certain addition law of velocities, the relation commonly used in everyday life." (E. B., 1969, Vol. 19, p. 96)

> "For example, if a man walks along a moving train with a velocity of 2 mph relative to the train, in the direction of motion of the train, and if the train moves with a velocity of 60 mph along the tracks, then the velocity of the man relative to the tracks will be, it is said, 62 mph." (*Id.*; see Figure 19.1A)

Based on the above examples, Rohrlich logically concluded: "The speed of an object is a relative quantity depending on the frame relative to which it is measured."[3] (Rohrlich, p. 52; also see Figure 7.1)

[3] Strangely enough, we shall discover in Chapter 21D that this conclusion is also valid for a ray of light when it propagates relative to a material body which moves linearly with respect to the light ray.

But what happens if, in place of the walking man, there is a light ray traveling through the train? (see Figure 19.1B) "[I]t would be expected that [the light ray's] velocity also would be different if it is measured relative to the train or relative to the tracks."[4] (E. B., 1969, Vol. 19, p. 96) Rohrlich agreed:

> "Elementary reasoning according to Newtonian mechanics requires that if the speed of light is *c* as measured in a particular reference frame then it cannot also be the same number *c* relative to a different frame."[5] (Rohrlich, p. 52)

"However, experiments show that the speed of light is the same in all inertial systems of reference. Consequently, the Galilean principle of relativity…and the constancy of the light velocity in an inertial frame of reference seem to be empirically incompatible." (see E. B., 1969, Vol. 19, p. 96) In other words, the mechanics law for the addition of velocities empirically does not apply to the velocity of light. What could be the answer to all of these paradoxes?[6]

Remember that Maxwell interpreted his electromagnetic equations to mean that a 'disturbance' was created in the material ether, and that this disturbance of matter was instantly transmitted in the form of electromagnetic waves (light) in all possible directions through the stationary ether at the constant velocity of *c* (300,000 km/s). (Chapter 6A) Maxwell also "pictured light waves as travelling on…some medium [such as water waves move on water]. That medium was called the [luminiferous] ether. [Thus] *c* is the speed of light relative to the ether." (Rohrlich, p. 52)

By the late 1880's, Maxwell's equations, and his interpretations of them, were

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[4] Rohrlich also reasoned that: "If the source of the light (a lamp, say) is used as a reference frame then the speed of light should have one value relative to a source at rest and another value relative to a moving source." (Rohrlich, p. 52) On the other hand, we will explain in Chapters 21 and 22 why these expectations do not occur with a ray of light, regardless of the motion of its emitting body.

[5] However, as we will paradoxically discover in Chapter 21, the correct statement is that a ray of light can have the same transmission velocity of *c* in or through any different reference frame, but almost never the same propagation velocity relative to different reference frames.

[6] We shall discover the detailed answers in Chapters 21, 22 and 23.

accepted as valid by much of the scientific community. But then the question arose: if the velocity of a light ray at *c* is a constant velocity with respect to the material medium of stationary ether, then must not such light ray have a different velocity with respect to each material body that is moving linearly at velocity v relative to the stationary ether? For example, pursuant to the Galilean transformation equations of mechanics, the velocity of a light ray at *c* should *a priori* be either *c* + v or *c* – v with respect to a material body (i.e. the Earth) moving linearly at v relative to the light ray. Such different velocity should also depend upon the direction of such body's motion relative to the direction of propagation of the light ray. (*Id*.)

Thus, the scientific community concluded that the velocity of a light ray was not always constant. However, this conclusion appeared to contradict Maxwell's equations, and the constancy of the velocity of light that they implied. Michelson's paradoxical null results only added to the scientific confusion, because they implied that the velocity of light emitted for a moving body (Earth) was always *c* in every direction. How could a light ray propagate over an absolute greater distance in the direction of the Earth's solar orbital motion, but no greater time interval was detected by Michelson's apparatus?

Finally, the scientific community concluded that there was only one preferred reference frame "in which the measured speed of light is exactly *c*; that is…ether…at rest." (Resnick, 1968, p. 17; also see Rohrlich, p. 52) In all other inertial reference frames which moved relative to the ether frame, they assumed and concluded that the transmission velocity of a light ray must vary "from *c* + v to *c* – v" depending upon the linear direction of motion of the inertial reference frame relative to the direction of the propagating light ray. [7] (Resnick, 1968, p. 16) Thus, by the 1890's it appeared that with respect to linearly moving bodies, either: 1) the varied mathematical computations (c + v and c – v) based on the Galilean transformation equations of mechanics and relativity were incorrect; or 2) Maxwell's equations, which mathematically required that the velocity of light transmitting *en vacuo* must always remain a constant c, were incorrect. But how could this be? Both concepts had proved their worth over extended periods of time. [8]

Remember that in Chapter 6, we also discussed the fact that the fictitious concept of stationary ether was actually irrelevant to the validity of Maxwell's equations. In the absence of ether all that remains is empty space, so Maxwell's equations really implied that the constant transmission velocity of light is c relative to its medium of the vacuum of empty space. However, these facts were apparently not by realized by Einstein nor by the scientific community in 1905.[9]

B. Einstein described his mathematical 'difficulties,' including those with respect to the classical addition of velocities.

Einstein referred to the aforementioned mathematical paradoxes and apparent contradictions as the 'difficulties,' and he concluded:

> "There is hardly a simpler law in physics than that according to which light is propagated in empty space. Every child knows that this propagation takes place

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[7] These conclusions were, of course, ludicrous on their face, for two reasons: 1) there is no ether frame from which to absolutely measure a different velocity of light…thus such measurement is only a figment of one's imagination; and 2) how can the speed of a moving body in empty space and at a distance change the velocity of anything moving or transmitting toward or away from it…a rocket, a planet, or a ray of light?

[8] Strangely enough, as we shall soon discover in Chapters 21 and 22, both concepts were actually correct.

[9] Why were such facts not realized? Because Einstein (like most other scientists even to this day) probably never read Maxwell's original papers. Miller concluded that before 1905, Einstein's familiarity with Maxwell's theory of electromagnetism appears to be limited to a few chapters from an 1894 text by August Föppl on the Hertz-Heavyside version of Maxwell's theory, which Einstein read just enough of in June 1902 in order to qualify as a patent clerk. (Miller, p. 142)

> in straight lines with a velocity *c* = 300,000 km/sec…[10]
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> "Who would imagine that this simple law has plunged the conscientiously thoughtful physicist into the greatest intellectual difficulties?"[11] (Einstein, *Relativity*, pp. 21 – 22)

In an attempt to describe and explain the mathematical 'difficulties' that he imagined—the apparent conflicts and irreconcilability between the Galilean transformation equations and Maxwell's equations for the constancy of the velocity of light at *c* previously discussed—Einstein concocted the following analogies and examples.[12]

In Chapter 6 of his book, *Relativity*, entitled "The Theorem of the Addition of Velocities Employed in Classical Mechanics," Einstein constructed the following attempted analogy to Galileo's 1632 sensory and empirical concept of relativity. Einstein supposed that a railway carriage was traveling along a straight railway embankment at a constant velocity (v), and that a man inside the carriage walked the length of the railway carriage at a constant velocity (w) in the direction of the carriage's uniform motion. (see Figure 19.1A) Einstein then asked the question: What will be the total velocity (W) of the man relative to the embankment? He added the two uniform velocities (v) and (w) together to arrive at the total, v + w = W. Einstein then asserted that, "this result…expresses the theorem of the addition of velocities employed in classical

[10] Take particular notice that Einstein refers to the 'propagation velocity' of light at *c*, rather than the correct concepts: the emission velocity and the transmission velocity of light at *c* relative to its medium. In fact, there is no specific law for the **propagation** velocity of a light ray over varying distances and relative to linearly moving reference bodies. In Chapters 21 and 22 we shall demonstrate how and why Einstein's misunderstanding of these concepts of velocity for a light ray was the basic false premise upon which his entire Special Theory of Relativity was predicated.

[11] Einstein also described these mathematical paradoxes, which he called the 'difficulties,' with respect to inertial reference bodies: "…assuming that the Maxwell…equations hold for a reference body *K* [at rest], we then find that they do not hold for a reference body *K'* moving uniformly with respect to *K*, if we assume that the relations of the Galilean transformations exist between the coordinates of *K* and *K'*." (Einstein, *Relativity*, p. 58) However, very importantly, Maxwell's equations for the constant transmission velocity of light at *c* have nothing to do with reference bodies, coordinates between reference bodies or transformation equations.

[12] Many of Einstein's analogies and analyses in his Special Theory are strained, artificial, irrelevant or invalid, and we shall point out these flaws as we proceed.

mechanics." (Einstein, *Relativity*, pp. 18 – 19) Let us now scrutinize the above attempted analogy to Galileo's Relativity and Einstein's characterization of it, to see if they are correct.

In his attempted analogy to Galileo's Relativity, Einstein merely added the constant velocities of two material objects (the carriage and the man) together in order to compute a third constant velocity (W) of the man relative to the embankment. Remember that we also used this type of simplistic computation; a) in Figure 7.1 in order to demonstrate that the velocities of material objects can be added together or subtracted from one another in order to compute their total velocity relative to another material object; and b) in Chapter 14 with respect to the translations and measurements computed by the Galilean transformation equations. Regardless of the fact that Einstein's algebraic computation, v + w = W, was correct, his addition of constant velocities has absolutely nothing to do with Galileo's empirical concept of relativity (as Einstein implied), nor any of its purposes. (see Chapters 5 and 13)

In Einstein's attempted analogy to Galileo's Relativity, the relatively stationary embankment played the part of the relatively stationary dock on the inertially moving Earth. The railway carriage played the part of the ship moving at a constant uniform velocity away from the relatively stationary dock. (Figure 5.3) But the uniformly walking man was not accelerating on the inertially moving carriage, so he played no part in Galileo's Relativity. Remember that one major purpose of Galileo's Relativity was to empirically demonstrate that accelerated motions occurring on one inertially moving body are empirically the same as accelerated motions occurring on a different spatially separated inertial body with a different velocity.[13] However, there is no way that a man walking at a uniform velocity on one inertially moving carriage could ever empirically demonstrate this mechanical covariance (or equivalence) of accelerations occurring on different spatially separated inertially moving bodies. Nor could the uniformly walking man demonstrate the empirical invariance of Newton's second law of motion on different inertial bodies, or sensorally demonstrate that the man could not tell if the train was at rest or uniformly moving in a straight line.

Galileo's Relativity involved two different accelerated events on two different inertial bodies (Earth and a sailing ship) separated by a distance, not one non-accelerated event (a uniformly walking man) on one inertially moving body (a carriage). Galileo's concept of relativity was also purely an empirical and sensory concept, not a mathematical one. A mathematical 'theorem of the addition of velocities' of a passenger's uniform velocity added to the ship's uniform velocity relative to the uniform inertial velocity of the Earth had no purpose within the concept of Galileo's Relativity. The magnitudes of uniform or inertial velocities were never specified (even abstractly) in Galileo's Relativity, because they were irrelevant to its purposes. For the same reasons, they were never added together. (see Figure 19.4 and Chapter 5) Thus, Einstein's attempted analogy had absolutely no relevance to Galileo's Relativity or its purposes.

The only 'velocity' that was ever relevant to any form of relativity in the 19th century occurred when the Galilean transformation equations were invented after 1885 and were applied to Lange's relative inertial reference frames in an attempt to mathematically describe and measure relative motions. (Chapters 13 and 14) With these

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[13] In other words, the variable magnitudes of $F = ma$, $a = F/m$, and $m = F/a$ are mechanically equivalent or covariant (and Newton's second law of motion is invariant) on each inertial body.

equations there was only an abstract algebraic computation of the uniform translation or distance traveled (vt) by the inertially moving frame away from the relatively stationary frame, so that there could be a one-to-one mathematical point translation (transformation) of accelerated motions from the 'stationary frame' to the 'moving frame,' and vice-versa. This algebraic translation of position, of course, could never demonstrate the empirical or mechanical covariance of accelerations in different reference frames (inertial bodies), nor could it demonstrate the sensory equivalence of the different inertial reference frames.

Even with the Galilean transformation equations, one constant uniform velocity was rarely, if ever, added to another constant uniform velocity in order to compute a third constant uniform velocity, the way Einstein did in his attempted analogy. What purpose would this computation serve? [14] It would only be relevant to descriptions or measurements of motions and positions of reference bodies. But, again, these purposes had nothing to do with Galileo's Relativity.

Normally, the only addition or computation of velocities in Lange's model of inertial reference frames was made in order to describe or measure accelerations on one inertial reference frame (at one position) and to mathematically translate such accelerations to the other inertial reference frame (at a different position). Such identical accelerations would obviously always remain mathematically invariant (the same) in either reference frame. This dubious mathematical exercise and its mathematical result was sometimes confusingly misnamed Galilean Relativity, but it had nothing to do with Galileo's empirical and sensory concepts of relativity. (see Goldberg, p. 374) Einstein's

[14] Of course, in this mathematical model, the velocities of the two inertial frames could be abstractly added together: $v_1 + v_2 = v_3$. But this would serve no purpose for the concept of Galileo's Relativity. Nor did Einstein's similar addition of two uniform velocities in order to produce a third relative velocity serve any purpose with respect to Galileo's Relativity or even with respect to the Galilean transformations.

above attempted analogy to Galileo's Relativity also had little or no relevance to the Galilean transformation equations or their purposes, either.

It becomes obvious that Einstein was dealing with and confusing three completely different and separate concepts: 1) Galileo's empirical and sensory concept of relativity, 2) Lange's abstract model of relative uniform motions along with its Galilean transformation equations, which described and measured accelerations, and produced the abstract algebraic concept of Galilean Relativity, and 3) the simplistic computation or addition of velocities of material objects. (see Chart 13.2 and Figure 7.1) Einstein's above analogy was really only relevant to the third concept, but he attempted to characterize it as being relevant to the first two concepts as well.[15]

Why then did Einstein invent this irrelevant analogy to Galileo's Relativity in both its empirical and mathematical forms? Because he needed the empirical concept of Galileo's Relativity for his Special Theory in order to claim that his Special Theory had an <u>empirical foundation</u>. Because he also needed the Galilean transformation equations in order to <u>blame</u> for the variations of light's velocity from *c* to *c* – v and *c* + v, and as transformation equations which he could later modify to create the Lorentz transformations. Also, because in the next Chapter 7 of *Relativity* he would theoretically substitute a ray of light transmitting at the <u>constant velocity</u> of *c* for the uniform velocity of the walking man in yet another false analogy to Galileo's Relativity, in order to attempt to relate electromagnetism and the velocity of light to Galileo's Relativity. An accelerating man or some other accelerating material object in Einstein's first analogy would not satisfy Einstein's relativistic agenda, because it would not be analogous to the

[15] Einstein arbitrarily switched back and forth between these three different concepts whenever it suited his relativistic agenda.

constant velocity of light at *c*.

Thereafter, in Chapter 7 of *Relativity*, Einstein theoretically substituted a constantly transmitting ray of light at *c* for the uniformly walking man his first analogy.[16] Einstein stipulated that "the tip of the ray will be transmitted with the velocity *c* relative to the embankment," and asserted that "the ray of light plays the part of the man walking along relatively to the carriage" in his prior analogy.[17] (Einstein, *Relativity*, p. 22) The carriage continued traveling down the stationary embankment at velocity (v) in the same direction as the propagating light ray. (*Id*.; see Figure 19.1B) Let us now analyze and scrutinize this attempted analogy by Einstein.

When Einstein stipulated that the ray of light had a constant transmission velocity of *c* relative to the embankment, he was incorrectly assuming that the embankment was absolutely stationary in space, like the ether. But we know that the embankment (on the Earth) moves at 30 km/s relative to the Sun; at about 225 km/s relative to the core of the Milky Way Galaxy; and at a myriad of other velocities relative to other planets, stars, and galaxies. (Chapter 10A) So the velocity of the light ray relative to the moving embankment in Einstein's example was actually propagating at *c* + v or *c* – v, depending upon at which relative velocity (v), and in which direction, one assumes the embankment on the Earth to be moving through the cosmos. (also see Figure 19.2)

Was Einstein's substitution of the light ray at the constant transmission velocity of *c* for the uniformly walking man a valid analogy in any sense? The answer is, no. The constant transmission velocity of the light ray at *c* relative to the medium of empty space

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[16] This time the carriage, the man, the embankment, and the light ray all theoretically existed in a vacuum, because this is the medium relative to which light transmits or propagates at *c*. (see Einstein, *Relativity*, p. 22)

[17] Notice that in this analogy Einstein used the word 'transmitted' instead of 'propagated' in order to describe the 'velocity *c*' of the light ray.

(the vacuum) is immediately and by definition an ‘invariant’ quantity, and an ‘invariant quantity’ by definition does not and *a priori* cannot vary from one material reference frame to another. In other words, an invariant quantity cannot empirically vary or be mechanically ‘covariant.’ On the other hand, the motion of a material body (the walking man) is not immediately and by definition an invariant quantity. The motion of the man may accelerate and it could empirically vary or be mechanically covariant from one reference frame to another.[18]

If the light ray was emitted in the moving carriage and if it really played the part of the man in Einstein’s prior analogy, then its transmission velocity at *c* should be added to the velocity of the carriage v to determine its total velocity W relative to the embankment: $W = c + v$. (see Chapter 7A) But *a priori* this would have violated Einstein’s second postulate concerning the independence of the velocity of light from the motion of its source body (the carriage).[19] (see Chapter 20F) So Einstein avoided these potential contradictions by merely stipulating that: “the tip of the ray will be transmitted with velocity *c* relative to the embankment.”[20] (Einstein, *Relativity*, p. 22) Because of all of these obvious ‘errors’ by Einstein, one senses that he might have been trying to mislead the reader with his contrived analogies.

Einstein then asked a different question than in his prior analogy with the walking

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[18] Also, in Galileo’s Relativity, no man walking on the uniformly moving ship was ever required to maintain a uniform velocity. He could have stopped, walked slower, or run at varying speeds down the center of the ship or the carriage. And he could have moved this way and that, or in a serpentine motion, or he could have stopped and walked in the opposite direction. In other words, the velocity of a man on an inertial body in Galileo’s Relativity was never required to maintain a constant quantity.
[19] It would also have violated the first part of Einstein’s second postulate (the absolute constancy of light’s velocity at *c en vacuo*), and likewise would have violated his conjecture that no physical computation of velocities can exceed *c*. (see Chapter 29)
[20] However, again, since the embankment was really moving in common with the Earth at v, Einstein’s stipulated value for the light ray relative to both the carriage and the embankment should have been $c \pm v \pm v_1$, depending upon relative directions of motion.

man: "What is the velocity of propagation [w] of the ray of light relative to the carriage?"[21] Einstein determined, according to the so-called 'Galilean Addition of Velocities,' that the velocity of the ray of light (w) relative to the carriage is c - v.[22] (see Figure 19.1B) He then concluded that: "the velocity of propagation of a ray of light relative to the carriage thus comes out smaller than c."[23] (Einstein, *Relativity*, p. 22) Thus, according to Einstein, the application of the 'Galilean Addition of Velocities' to the above situation would cause Maxwell's constant velocity for the transmission of light at c to mathematically vary (to c – v or c + v) relative to linearly moving material objects (i.e. the moving carriage) depending upon their relative directions of motion.[24] (*Id*., pp. 22 – 23; see Figures 19.1 & 19.2)

Here Einstein was not really treating the ray of light like the walking man. The velocity of the walking man inside the moving carriage relative to the embankment was some value of v + w = W. But the walking man's constant velocity of w relative to the carriage would be w = W – v. Why did Einstein never ask a question with regard to this last velocity like he did in Chapter 6? Because if he had the result would have been

[21] This time Einstein arbitrarily referred to the velocity of propagation rather than the velocity of transmission as he did with respect to the embankment as if they were both the same concept (which they are not).
[22] We have referred to the Galilean addition of velocities as 'so-called,' because Galileo never created such a concept and Galileo's Relativity does not contain such a concept.
[23] Strangely enough, this last velocity of propagation (c – v), smaller than c, is correct, as we shall explain in Chapters 21 and 22. Einstein was also unwittingly correct when he asserted that the propagation velocity of light varies relative to linearly moving bodies, but he did not realize this fact. (Chapter 21) However, none of such varying velocities of propagation create a contradiction to Maxwell's equations, nor to the constant transmission velocity of a ray of light at c relative to its medium of empty space, as we shall also explain in Chapters 21 and 22.
[24] By c, Einstein was asserting that the transmission velocity of a light ray relative to the stationary embankment was 300,000,000 m/s. By c – v, Einstein was asserting that the transmission velocity of a light ray relative to the carriage moving in the same direction at 30 m/s was 300,000,000 m/s minus 30 m/s, a total of 299,999,977 m/s, or less than c. Likewise, by c + v, Einstein was asserting that the transmission velocity of a light ray relative to the carriage approaching the light ray at 30 m/s was 300,000,000 m/s plus 30 m/s, a total of 300,000,030 m/s or more than c. In other words, Maxwell's constant transmission velocity of light at c appeared to vary depending upon the magnitude and direction of motion of material bodies.

equivalent for the ray of light (w = *c* – v or *c* + v) and for the walking man (w = W – v or W + v).[25] In other words, it would have resulted in a very natural relative velocity in both cases.[26] (see Figure 7.1)

Finally, Einstein concluded that his 'addition of velocities' result with regard to the light ray (W = *c* – v) "comes into conflict with the principle of relativity." [27] (Einstein, *Relativity*, p. 22) Why? Einstein then explained his conclusion:

> "For, like every other general law of nature, the law of the transmission of light *in vacuo* must, according to the principle of relativity, be the same for…[both the moving carriage and the relatively stationary embankment]. But, from our above consideration, this would appear to be impossible. If every ray of light is propagated relative to the [stationary] embankment with the velocity *c* then for this reason it would appear that another law of propagation of light[28] must necessarily hold with respect to the [moving] carriage—a result contradictory to the principle of relativity. [29] (Einstein, *Relativity*, pp. 22 – 23)

C. Einstein decided to reconcile the theories of relativity and of the velocity of light.

It is obvious from his above statements, that Einstein's application of the material principle of Galileo's Relativity, and his application of the Galilean transformation equations of mechanics, to the constant transmission velocity of light at *c*…created

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[25] The reason why we cannot exactly specify the magnitude of any of these velocities is because we do not know the absolute velocity v of the Earth through the Cosmos, nor its absolute direction of motion, nor the absolute point of emission of the light ray, nor its absolute direction of propagation, and neither did Einstein. (see Chapters 10A and 22) Einstein's abstract algebra masks all of these questions and unknown quantities.

[26] All of these very natural relative velocity results would be completely consistent with Galileo's Relativity and with the Galilean transformation equations, so Einstein would have had no justification to modify them. For this reason, he avoided disclosing their existence.

[27] Here, Einstein was referring to his expanded definition of the 'principle of relativity,' the first postulate in his Special Theory, which incorrectly applies to the velocity of light. (see Chapters 20E and 24)

[28] Notice that in this paragraph Einstein indiscriminately refers to the 'law of the transmission of light' and the 'law of propagation of light' as if they were the same concept. But they are entirely different concepts, as we shall discover in Chapters 21 and 22. Einstein obviously wanted the ray of light to propagate at velocity *c* relative to both the stationary embankment and the linearly moving carriage. But this would be an impossible absolute concept, as we shall soon discover in Chapter 21E. Also, again, there is no specific law for the propagation of light relative to linearly moving objects like the carriage.

[29] In essence, Einstein's analysis amounted to the same thing as stating that the linear motions of distant material bodies determine the transmission velocity of light.

mathematical 'difficulties' for Einstein that baffled both him and the scientific community. How could the transmission velocity of light at *c* be both constant and yet appear to mathematically vary with respect to material objects moving at different linear velocities? What could be the answer to this mathematical paradox, this 'difficulty?'[30] At this point, Einstein concluded that:

> "In view of this dilemma there appears to be nothing else for it than to abandon either the principle of relativity or the simple law of the propagation of light *in vacuo*."[31] (Einstein, *Relativity*, p. 23)

Nevertheless, after numerous rationalizations, Einstein ultimately decided not to abandon either concept. Instead, he chose to radically change the classical mechanics 'principle of relativity' (Chapter 24) and to extend it to the phenomena of optics and electrodynamics, based on the following dubious and incorrect ground:

> "…classical mechanics…supplies us with the actual motions of the heavenly bodies…
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> "The principle of relativity must therefore apply with great accuracy in the domain of *mechanics*.[32] But that a principle of such broad generality should hold with such exactness in one domain of phenomena [mechanics], and yet should be invalid for another [electrodynamics and optics], is *a priori* not very probable." (Einstein, *Relativity*, p. 17)

Einstein then decided that his two postulates (his radically expanded principle of relativity and his concept of light propagating at velocity *c*) should apply both to mechanics and to the velocity of light, because they were only "apparently

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[30] It took the author several weeks of concentrated thought and analysis to finally discover and understand the correct answer.

[31] But little did Einstein realize, there is no simple law of the propagation of light *in vacuo* relative to linearly moving bodies, such as a moving carriage. There is only Maxwell's constant emission velocity of light at *c* relative to its point of emission in space, and Maxwell's constant transmission velocity of light at *c* relative to the medium of the vacuum of empty space through which light passes. (see Chapters 21and 22)

[32] This is a non sequitur. No classical principle of relativity (including Galileo's Relativity) has anything to do with "the actual motions of the heavenly bodies." Their motions are determined solely by their masses, their inertia, Newton's first, second and third laws of motion, and Newton's laws of gravity.

irreconcilable:"

> "These two postulates suffice for the attainment of a simple and consistent theory of the electrodynamics of moving bodies based on Maxwell's theory for stationary bodies."[33] (Einstein, 1905d [Dover, 1952, p. 38])
>
> "*in reality there is not the least incompatibility between the principle of relativity and the law of propagation of light*, and that by systematically holding fast to both these laws a logically rigid theory could be arrived at.[34] This theory has been called the *special theory of relativity*…" (Einstein, *Relativity*, p. 24)

In order to defend Maxwell's theory of the constant velocity of light at velocity *c*, and to attain his 'consistent' theory of Special Relativity, Einstein claimed that what was needed was a "modification" to the 'Galilean Addition of Velocities' and the Galilean transformation equations.[35] (Einstein, *Relativity*, pp. 34 – 35) Einstein's "modification" of the Galilean transformations turned out to be his Lorentz transformation equations for space (distance) and time (intervals):

$$x' = \frac{x - vt}{\sqrt{1 - v^2/c^2}} \qquad\qquad t' = \frac{t - v/c^2.x}{\sqrt{1 - v^2/c^2}}$$

(*Id.*, p. 37)

Actually, Einstein must have realized that the real culprit that was causing his mathematical 'difficulties' was the relative motion between the stationary embankment and the carriage moving linearly at v. If he could somehow mathematically eliminate the time intervals and the space intervals described by the Galilean transformations, then he could negate the relative motion between inertial reference frames and with it the troublesome addition of velocities so that the velocity of light could algebraically remain

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[33] Maxwell's theory of electricity was not about stationary bodies (electrostatics), and his theory of light only referred to stationary ether, not ponderable stationary bodies.

[34] This incorrect conclusion by Einstein was based upon a myriad of false analogies, false assumptions and the misanalysis of the situation by Einstein, which will become obvious as we proceed with other chapters.

[35] Einstein's radical "modification" of the classical Addition of Velocities is discussed and explained in Chapter 29. His "modifications" of the Galilean transformations is discussed in Chapter 27.

a constant *c* for all inertial frames and observers. Einstein called this mathematical result: 'co-variance.' (*Id*., pp. 47 – 48) Thus, Einstein's 'modifications' of equations and his reconciling of theories was only his means of attaining this co-variant end result.

Einstein's above described rationalizations, modifications, and his Lorentz transformations resulted in an elaborately constructed *ad hoc* mathematical theory and produced many bizarre mathematical consequences. (Einstein, 1905d [Dover, 1952, pp. 38 – 65]) These radical Lorentz transformation equations and their mathematical consequences, in turn, purported to modify Newton's laws of motion, and purported to produce entirely new laws of physics…with seemingly endless ramifications.[36] However, as we shall discover in later chapters, all of these rationalizations, modifications and mathematical consequences were totally *ad hoc*, artificial, invalid, unnecessary, unwarranted and completely irrelevant to anything.

D. Possible solutions for Einstein's mathematical difficulties.

In 1968, Resnick (an ardent believer in Einstein's Special Theory) restated the 'difficulties' concerning the velocity of light, which faced the scientific community during the last part of the 19th century and the early part of the 20th century. (see Memo 19.3) In an ether frame at rest, an observer would *a priori* "measure the speed of light to be exactly *c*." (Resnick, 1968, p. 16) This (theoretically impossible) measurement would be exactly consistent with Maxwell's equations for electromagnetism with respect to the (non-existent) stationary ether frame. (*Id*., p. 17) But, continued Resnick, in an inertial reference frame "moving at a constant speed v with respect to this <u>ether frame</u> an observer would measure a <u>different speed</u> for the light pulse, ranging from *c* + v to *c* – v

[36] In light of all of Einstein's aforementioned false analogies, misassumptions and misanalysis, one must also ask the question: Was this not Einstein's secret plan in the first place?

depending on the direction of relative motion, according to the Galilean velocity transformation[37]…Hence, the speed of light is certainly not invariant under a Galilean transformation."[38] (*Id.*, p. 16)

This misanalysis by Resnick concerning different transmission velocities for a light ray under a Galilean transformation was the theoretical position of the late 19th and early 20th century scientific community, including Einstein. Unfortunately, it continues to be the theoretical position of the scientific community during the early 21st century.[39]

The choices that the scientific community appeared to face during the late 19th and early 20th century are stated as follows. 1) If the transmission velocity of a light ray did vary relative to different linear uniform velocities of each inertial reference frame in the Cosmos, then Maxwell's equations for electromagnetic waves (light) at the constant transmission velocity of *c* must be flawed. Why? Because according to the Galilean transformation equations, the algebraic form of Maxwell's electromagnetic law of physics (the constant transmission velocity of light at *c*) would not be invariant or constant when transformed (translated) from one inertial reference frame to another.[40] It

---

[37] This impossible and ridiculous analysis with respect to a non-existent 'ether frame' results in an absolute concept, as will be explained in Chapter 21E. Resnick's notion of an observer measuring the velocity of a light ray in the way described is, of course, pure fantasy; much less with a rigid meter rod and a clock, as Einstein has suggested. Also, the Galilean transformation was not really a mathematical velocity transformation equation (as Resnick asserts). Rather it was a mathematical equation which translated coordinates and which described an acceleration in one inertial reference frame relative to another inertial reference frame

[38] The correct analysis should be: the constant transmission velocity of light at *c* is an invariant property of light, and an invariant property cannot be translated so as to vary from one inertial reference frame to another. If one attempts to transform the invariant transmission velocity of light at *c*, the relative propagation velocities (c – v and c + v) of the light ray will be the natural result. (see Chapters 21 and 22)

[39] Such analysis is totally incorrect, as will be fully explained in Chapters 20 through 24 to follow.

[40] Remember that Galileo's Relativity empirically demonstrated and the so-called Galilean transformations mathematically implied that, although the magnitudes of accelerated motions may vary in different inertial frames (vis. they are mechanically covariant), the algebraic form of Newton's 2nd law remains invariant in all inertial frames of reference. The early 20th century scientific community must have asked: Why should the laws of electromagnetics be any different?

would change from *c* to *c* – v or *c* + v.[41] On the other hand, 2) it was claimed that if the transmission velocity of a light ray at *c* did not vary relative to the different uniform velocities of each inertial reference frame in the Cosmos, then the principle of Galileo's Relativity and the Galilean transformation equations must be flawed, because based on them the velocity of light varies from *c* to *c* – v or *c* + v relative to different inertial reference frames.

These dubious (or rather spurious) choices posed a serious dilemma for the scientific community of the late 19th and early 20th century. Was the established principle of Galileo's Relativity (in its empirical or mathematical form) irreconcilable with the established law of Maxwell's equations (the constant transmission velocity of light at velocity *c*)? Which cherished law of physics was invalid? [42]

Conventional wisdom suggested three possible solutions for these mathematical 'difficulties.' As described by Resnick: "The fact that the Galilean relativity principle does apply to the Newtonian laws of mechanics but not to Maxwell's laws of electromagnetism requires us to choose the correct consequences from amongst the following possibilities." (Resnick, 1968, p. 17)

> "1. A relativity principle exists for mechanics, but not for electrodynamics; in electrodynamics there is a preferred inertial frame, that is the ether frame.
>
> "2. A relativity principle exists both for mechanics and for electrodynamics, but the laws of electrodynamics as given by Maxwell are not correct. (*Id*.)
>
> "3. A relativity principle exists both for mechanics and for electrodynamics, but the laws of mechanics as given by Newton are not correct."[43] (*Id*., p. 18)

[41] The scientists, of course, failed to come up with a theory for how the inherent transmission velocity of a light ray could vary because of the linear motion of distant bodies.
[42] Einstein, like the other scientists of his day, asked the question: Could this dilemma and these two established laws of physics (vis. Galileo's Relativity in any form and Maxwell's equations) be reconciled; or must one be abandoned? (see Einstein, *Relativity*, p. 23)
[43] Dingle added to this possibility that there might be "some unknown effect of motion that had been neglected." (Dingle, 1972, p. 162)

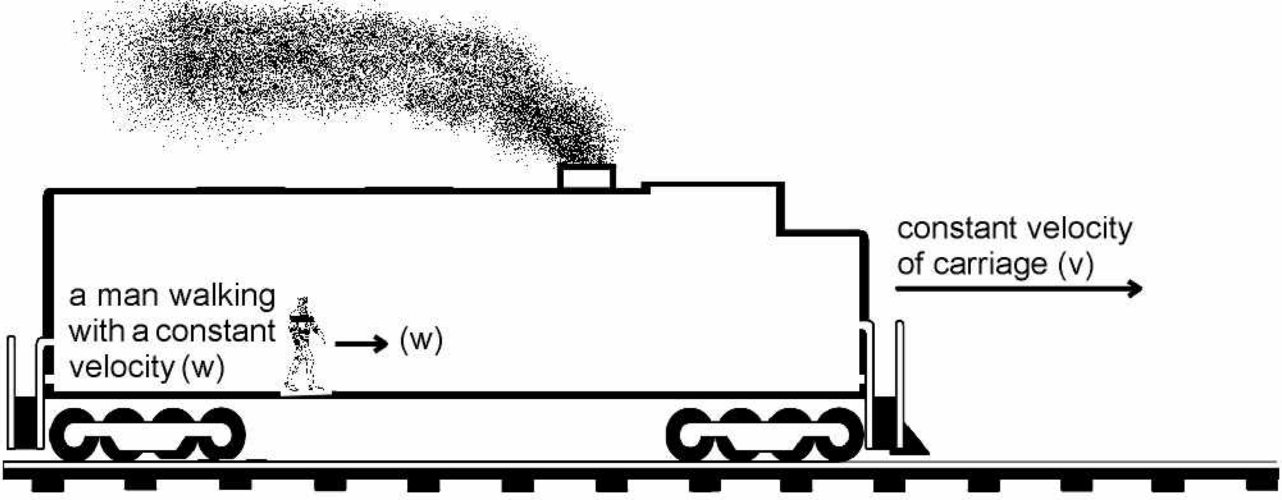
In 1905, Einstein sought to resolve the 'difficulties' with the velocity of light that he imagined by adopting the third of the above possibilities. He called this attempted reconciliation and resolution his 'Special Theory of Relativity.'

However, there is also a fourth possibility that is asserted by the author, but it was apparently never considered:

4. A relativity principle exists for mechanics, but it is irrelevant for optics and electrodynamics, and light transmits at a constant velocity of *c* with respect to its medium of the vacuum of empty space. However, such constant velocity of light at *c en vacuo* also becomes part of a relative velocity (*c* ± v) when light is propagated over changing distances and time intervals relative to material bodies moving linearly at v.

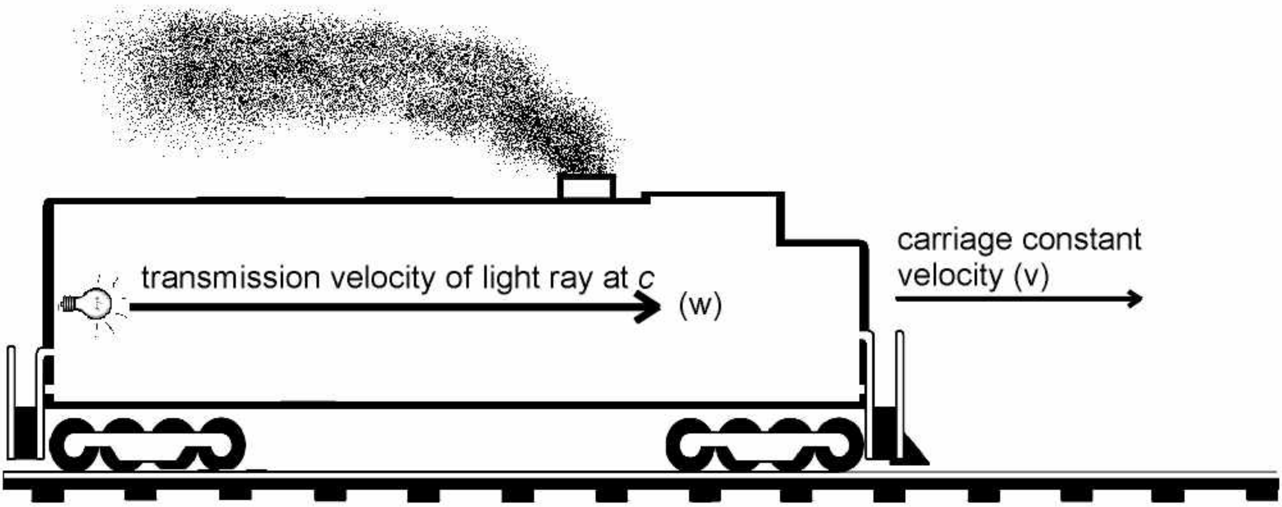
This fourth possibility totally eliminates the paradox of the aforementioned 'difficulties' without any strained logic or contrived *ad hoc* hypothesis, such as a contraction of matter or Special Relativity. It is discussed and explained in detail in Chapters 21 through 24 of this treatise.

As will become more and more obvious as we proceed, the 'difficulties' which triggered Special Relativity, and Einstein's Special Theory itself, strangely enough, resulted in no small measure because of the confusing, misleading and conflicting definitions of scientific and mathematical terms, such as relativity, transformations, frames of reference, covariance, inertial motion, mechanics, distance, velocity, and especially the constant velocity of light. They also resulted because of the misanalysis and misapplication of many false concepts (such as ether) and of many material concepts with respect to the non-material phenomena of EM and light.



According to Einstein, the total velocity of the man relative to the embankment is:
W = v + w

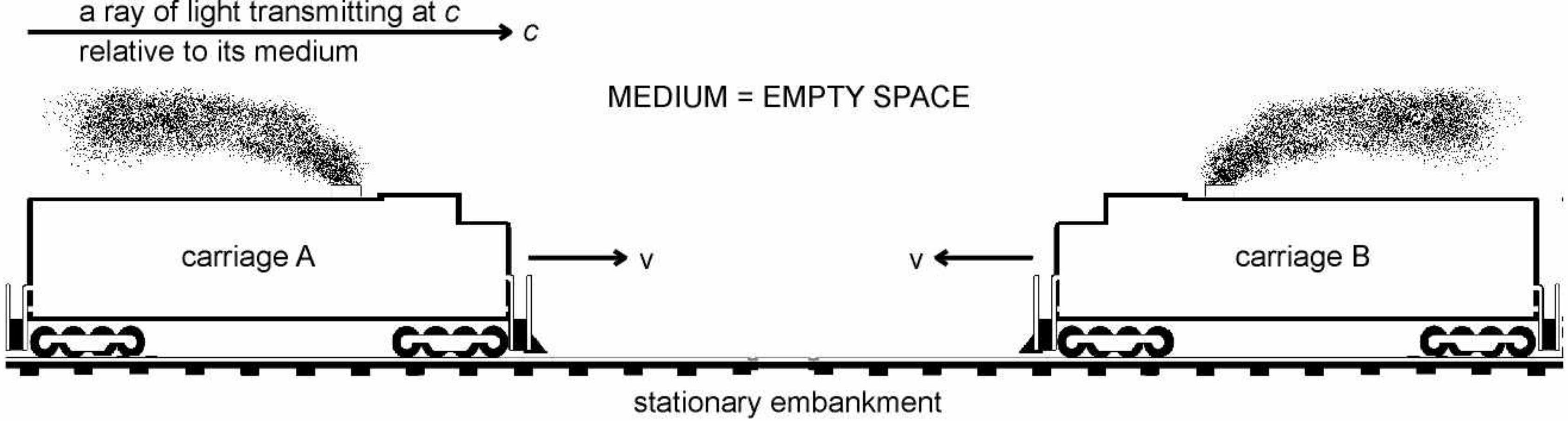
Figure 19.1A



According to Einstein, the transmission velocity (w) of the tip of the light ray relative to the linearly moving carriage at (v) is: w = *c* - v. Strangely enough, this computation is correct.

Figure 19.1B

Figure 19.1 Einstein's Example Of The Mathematical 'Difficulties' Which Occur When His Galilean Addition Of Velocities Is Applied To A Moving Man, A Moving Carriage, An Embankment At Rest, And A Ray Of Light Transmitting At Velocity *c*



A. The mathematical expression which Einstein used to describe the transmission velocity of the light ray relative to the 'stationary' inertial frame of reference of the embankment, was *c* (300,000 km/s).

B. According to Einstein, the mathematical expression which described the transmission velocity of the light ray relative to the frame of reference of carriage A moving inertially straight ahead at velocity v, was c - v, or less than 300,000 km/s.

C. According to Einstein, the mathematical expression which described the transmission velocity of the light ray relative to the frame of reference of carriage B moving inertially in the opposite direction at velocity v, was c + v, or greater than 300,000 km/s.

But how could this be? How could the constant transmission velocity of a light ray at *c* have various different velocities relative to linearly moving material bodies? To Einstein, these mathematical results appeared to contradict Maxwell's equations, where the transmission velocity of light was always a constant *c*.

Figure 19.2 Einstein's Mathematical 'Difficulty' That The Velocity Of Light Did Not Appear To Hold The Same Invariant Mathematical Form (*c*) In All Galilean Inertial Frames Of Reference

MEMO 19.3

There were actually three major categories of paradoxes, or 'difficulties,' concerning the relationships between light and matter that confronted Einstein and the rest of the scientific community in 1905: one was theoretical, one experimental, and one mathematical. We shall now briefly describe and discuss each category.

1. Theoretical Difficulties: There was, of course, the mythical concept of ether, which distorted most theories and the analysis of many experiments. For example, many light experiments were analyzed in terms of whether the hypothetically stationary ether was partially or completely dragged along by the motion of matter through it. Maxwell even theorized that light was a disturbance of the stationary ether.

All physical theories (including electrodynamics and optics) were based on and explained by the concepts of mechanics.[1] For example, the velocities of all material objects were considered to be relative quantities depending upon the material frames of reference with respect to which they were measured. (Rohrlich, p. 52) But Maxwell's velocity of light at *c* was a constant quantity, rather than a relative quantity that depended upon its motion.[2]

> "Elementary reasoning according to Newtonian mechanics requires that if the speed of light is *c* as measured in a particular reference frame then it cannot also be the same number *c* relative to a different frame."[3] (*Id*.)

2. Experimental Difficulties: The velocity of light from a star appeared to have the same value when it was received by a telescope on Earth, regardless of the orbital motion of that reference frame toward or away from the star. This was the paradoxical conclusion of Bradley's 1728 aberration of starlight experiment, and of Arago's 1810 focus of a lens experiment. It was also a conclusion of Fizeau's 1851 moving water experiment when starlight was used as a light source to measure its velocity in two different directions of the moving water. (see Chapter 7) These conclusions were not consistent with the Newtonian measurements of velocity in different reference frames. (see Figure 7A) How could a light ray contact the Earth at the same velocity *c* regardless of the Earth's different velocities v relative to the light ray? (see Lindley, p. 55) We shall explain this paradox in Chapter 22E.

In the 1887 Michelson and Morley experiment, light appeared to have the same velocity in all directions regardless of the rotational velocity of the Earth or its orbital velocity of 30 km/s around the Sun. The results of this experiment added several more paradoxes: Why was the motion of the Earth not added to the velocity of light? How could light travel a greater distance in the direction of the Earth's motion without a greater time interval being detected? How could Michelson's experiment fail to detect the motion of the Earth through space? (see Feynman, 1963, p. 15-2; Chapters 9 – 12)

3. Mathematical Difficulties: The mathematical difficulties that Einstein imagined to exist are described in detail throughout this Chapter 19 and later chapters.

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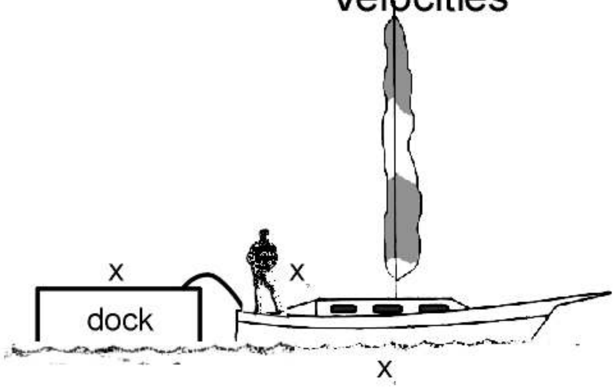
[1] In Chapters 22, 23 and later chapters we will explain why many of the concepts of matter and mechanics (including frames of reference, coordinates, transformation equations, Galilean Relativity, and the classical addition of velocities) are not applicable to the transmission velocity of light.

[2] What material reference frame could the velocity of light at *c* be measured relative to? The only one appeared to be the theoretical reference frame of stationary ether. (Rohrlich, p. 52)

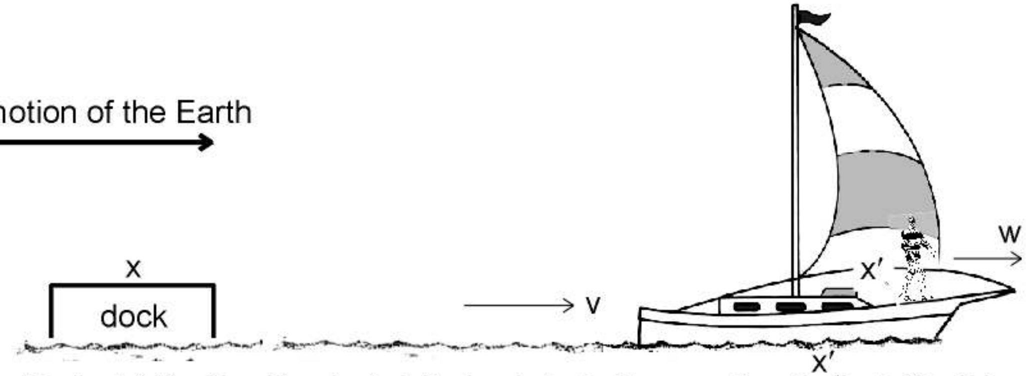
[3] In Chapter 21 we will explain the reasons for this paradoxical false assumption.

Figure 19.4 The Difference Between The Separation Or Addition Of Distances In Galileo's Relativity And Lange's Model Of Galileo's Relativity, And Einstein's Addition Of Velocities

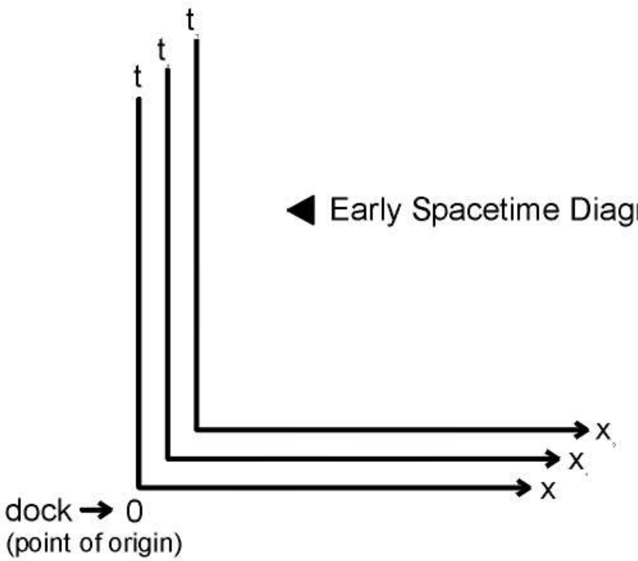


Three different terrestrial inertial systems relatively at rest: the Earth (dock x), the boat (x_1), & the man (x_2)

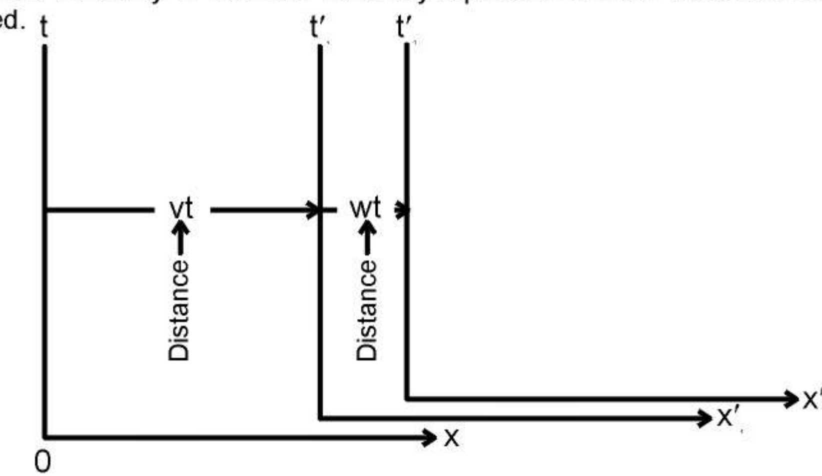
inertial motion of the Earth



The boat (x'_1) sails uniformly straight ahead at velocity v away from the dock (x) which remains stationary relative to the moving boat and the man. The man (x'_2) walks uniformly straight ahead toward the bow of the boat at inertial velocity w relative to the moving boat. In Galileo's Relativity the distance vt might be added to distance wt to establish the <u>position</u> of the man. In 1905 Einstein asked: What is the velocity (W) of the man relative to the dock? According to Einstein's theorem of the addition of velocities, it is: W = v + w. But this computation was irrelevant for the purpose of Galileo's Relativity. In Galileo's Relativity equivalent uniform velocities were <u>never</u> added.



◀ Early Spacetime Diagrams ▶



Three Inertial Frames Relatively at Rest in Absolute Space and Absolute Time at the Same Position	Distance Traveled and Relative Position	Absolute Time in Each Inertial Frame	Einstein's Velocity of Each Inertial Frame
The <u>dock</u> (Earth) (x),	$x = x' + vt$	$t = t'$	$x = 0$
The <u>boat</u> at the dock (x_1),	$x'_1 = x - vt$	$t'_1 = t$	$x'_1 = v$
And the <u>man</u> on the boat (x_2).	$x'_2 = x - vt - wt$	$t'_2 = t$	$x'_2 = v+w$

Partial source: Hoffmann, 1983, p. 84