Chapter 7

EARLY ATTEMPTS TO UNDERSTAND THE VELOCITY OF LIGHT

Nineteenth century scientists wondered whether the transmission velocity of light varies depending upon: 1) the motion of light's emitting body, 2) the motion of light's medium, and 3) the linear motions of matter to which light relates. Several early experiments seemed to give answers, but their results were often distorted by the imaginary concept of stationary ether. By 1880 there was more confusion and there were more false assumptions than there were real answers.

A. Three questions that need to be answered.

It can be a daunting task to attempt to sort out and explain, let alone understand, the labyrinth of false assumptions, invalid theories, irrelevant equations, false conjectures, paradoxes, and misinterpreted experiments that (during the last two centuries) have confused and distorted physics in general, and Maxwell's concept of the constant transmission velocity of light at *c* in particular. Most prominently included within this labyrinth are the arbitrary concepts of stationary ether as an absolute reference frame; Newton's absolute space and absolute time; the theories of 'ether drag' and 'partial ether drag;' the Michelson & Morley null results; Fitzgerald's, Lorentz's and Einstein's contraction of matter theories; the misapplication of Galileo's Relativity to light; the Lorentz transformation equations; and above all Einstein's theories of relativity.

Since a basic understanding of each of the above is necessary to an appreciation of the current untenable situation and to its ultimate solutions, we will do our best, in this and later chapters, to state and explain such confusion and distortions in as straightforward, simple and understandable terms as possible. We will thereafter set forth and explain the real facts and the real solutions for the false assumptions, paradoxes and other problems that have been created and still exist.

As previously stated, because Maxwell's equations (which contained the constant transmission velocity of a light ray at *c*) were written with respect to the theoretical material medium of stationary ether at rest in absolute space, it was asserted by 19th century scientists and others that such equations were only valid for that absolute stationary reference frame. (see Resnick, 1968, pp. 16 - 17) Assuming that this incorrect assertion was true, it was then asked by the same scientists: What is the transmission velocity of a light ray with respect to material bodies which are in linear motion relative to the stationary ether reference frame and relative to such transmitting light ray?

If such 19th century scientists had realized that the concept of stationary ether was just a fictitious myth (like phlogiston and caloric), and that a stationary ether reference frame does not and could not exist, then they probably never would have made such assertions or asked such questions because they would obviously have been meaningless. Likewise, all of the experiments and theories that were later concocted in order to attempt to answer such meaningless questions probably never would have occurred. Thus, Maxwell's constant transmission velocity of light at *c* in the abstract or relative to the medium through which it propagates might never have been misunderstood nor distorted to the degree that it is today.

Nevertheless, such 19th century scientists did not realize that the stationary ether reference frame was only a myth, so all of such meaningless questions were asked and answered in *ad hoc*, absurd and invalid ways. As a consequence, Maxwell's concept of the constant transmission velocity of light at *c* relative to its real medium of empty space (a vacuum) was totally misunderstood by everyone, and especially Einstein who invented Special Relativity in a misguided and futile effort to unravel the confusion. Special

Relativity has, in turn, distorted all of physics and science in general.

The valid questions that should have been asked and answered by such 19th century scientists have nothing to do with the false concept of stationary ether. They include the following: Does the constant transmission velocity of light at *c* vary depending upon: 1) the motion of a light ray's emitting body; 2) the motion of the medium through which such light ray propagates; or 3) the linear motions of material bodies toward or away from such propagating light ray.

In order to answer these three valid and relevant questions, let us first consider the concepts of linear motions (velocities) of material bodies relative to each other. Where a train is being propelled at a constant velocity of 60 km/h relative to the rails (v_1), and a man walks through the train at the constant velocity of 3 km/h in the direction of the train's motion (v_2), the total speed of the man will be 63 km/h relative to the rails.[1] (Figure 7.1A) This result represents the simple law of the 'computation of relative speeds' for material objects, which Einstein characterized as the 'classical addition of velocities.' (see Einstein, *Relativity*, pp. 19 – 20)

Likewise, where a material object, such as a bullet, is fired from the speeding train and accelerates away from the train in the direction of the train's motion, the velocity (v_1) of the train is added to the muzzle velocity (v_5) of the bullet in order to determine the total velocity (v_6) of the bullet relative to the rails ($v_1 + v_5 = v_6$).[2] (see Figure 7.1C) Similar computations apply to other trains and bullets being propelled in the same and opposite directions. (see Figures 7.1D, E, F, G and H)

[1] But the velocity of the train will only be 57 km/h relative to the walking man. (Figure 7.1B) Strangely enough, this second computation which results in a relative velocity is more important for the purposes of this treatise than the first computation. We will discover why in Chapters 19 and 21.
[2] The muzzle velocity of a bullet relative to the gun is similar in concept to the transmission velocity of light at *c* relative to its point of emission in space. (Chapter 22)

Very importantly for our later discussions, in Figure 7.1 the propelled velocity of the walking man, each moving train and the muzzle velocity of the bullet also exhibit relative velocities of approach or separation with respect to each other.[3]

Within the context of the above examples and analogies, let us now precisely restate the questions that were facing such 19th century scientists. Do Maxwell's theories of light and his electromagnetic wave equations mean exactly what they specifically state or imply: that a ray of light transmits in all possible directions over vast distances of empty space at the constant transmission velocity of c (300,000 km/s) in the abstract or relative to the medium of ether or a vacuum at the instant that such light ray comes into existence, and regardless of the linear motion of its emitting body or the linear velocity of any material body with respect to which such light ray may propagate? Or does the transmission velocity of a light ray vary in every possible direction because of the linear motion of the light ray's emitting body, because of the motion of its medium, or because of the linear velocity of any material body relative to which such light ray propagates?

Before we proceed, it should be noted that throughout this treatise we will refer to the vacuum or void of empty space through which light transmits at velocity c as a 'medium,' even though that term is usually reserved for a material medium such as air or the hypothetical ether. The rationale for this somewhat unorthodox definition and generalization of the meaning of 'medium' is as follows. First of all, Maxwell himself specifically referred to light constantly propagating throughout a vacuum at velocity c.

[3] The reason why these simple concepts are so important is that Einstein substituted a light ray propagating at velocity c for the walking man, which resulted in relative velocities for the light ray of c – v and c + v depending upon the direction of the linearly motions of such material objects. (see Chapters 19 and 21) However, he incorrectly claimed that such relative linear velocities changed the constant transmission velocity of the light ray at c (to $c \pm$ v). (see Einstein, *Relativity*, pp. 22 –23) This monumental mistake will be further discussed and explained in Chapters 19, 20F, 21 and 22. Incomprehensible as it may seem, Special Relativity is really nothing more than Einstein's elaborate attempt to reverse such monumental mistake.

(see Maxwell's Papers, Vol. 1, p. 580) Secondly, if Maxwell's theories of light and his equations were valid through the mythical material medium of ether, but ether does not exist, they should be equally valid through what remains…the vacuum of empty space, and what remains (the vacuum of empty space) should continue to be equally as valid as ether as a medium (material or otherwise). What else is light transmitting through at velocity *c* from a distant star to the Earth, other than the vacuum of empty space? How and what else was light actually transmitting through at velocity *c* during the 19th century? It was always the same medium: the almost perfect vacuum of empty space.

B. The Motion of Light's Source Body

First, let us examine the question: Does the transmission velocity of a light ray at velocity *c* relative to the medium of empty space vary depending upon the speed and direction of motion of the source body from which such light ray is emitted? For the answer, we will defer to Willem de Sitter's empirical binary star theory which asserts that the orbital velocity (v) of a light emitting binary star must not be added to (*c* + v) or subtracted from (*c* – v) the velocity *c* of the light which the star emits, because this would necessarily result in 'ghost star' images in a binary star system,[4] which images have never been observed. (see Figure 7.2; Bergmann, p. 19; Dingle, 1972, pp. 205 – 207; Einstein, *Relativity*, p. 21) Based on De Sitter's binary star observations and his resulting empirical theory, Einstein postulated:

> "that light is always propagated in empty space with a definite velocity *c* which is independent of the state of motion of the emitting body."[5] (Einstein, 1905d [Dover, 1952, p. 38])

[4] A 'binary star system' exists where two stars orbit around their common center of gravity.
[5] Based on his own theory of the 'Relativity of Direction' (Einstein, *Princeton*, 1922, pp. 24 – 25), which he borrowed from Poincaré, Einstein postulated that this velocity of light at velocity *c* is also independent of the direction of motion of the emitting body. (Einstein, *Relativity*, p. 21)

De Sitter's theory and the underlined part of Einstein's postulate are compatible with Maxwell's equations based on the wave theory of light (Bergmann, p. 19), with the 1851 interference experiment of Fizeau (see Section C of this chapter),[6] with the null result of the Michelson & Morley experiment (Chapter 9),[7] and with empirical measurements of the speed of sound waves.[8] Measurements of the velocity of starlight received on Earth from stars with different relative speeds also appear to confirm these conclusions.[9] Therefore, let us accept De Sitter's theory and the (underlined) second part of Einstein's above postulate as valid.[10]

C. The Motion of the Medium

Next, let us examine the second question: Does the transmission velocity of light at velocity *c* vary depending upon the motion of the material medium through which it propagates? With respect to the vacuum of empty space the answer is obviously no, because the vacuum of empty space (by definition) is not a material medium and how can the 'nothing' of a vacuum (vis. empty space) move? Therefore, let us confine the remainder of our discussion to material mediums that do move.

As we discovered in Chapter 6, when a light ray propagates through a stationary material medium (i.e. water), it does not transmit relative to that medium at velocity *c*,

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[6] The results of Fizeau's 1851 interference experiment are also empirical confirmation of De Sitter's theory. (see Section 7C)
[7] The M & M null results (and similar results of other experiments) are also empirical confirmation of De Sitter's theory.
[8] "The speed of sound waves being likewise independent of the motion of the source." (Feynman, 1963, p. 15-2) Also see Chapter 8.
[9] Why? Because light rays received on Earth from stars and other luminous celestial bodies with different relative velocities do not have different measured transmission velocities when received on Earth. (see *the* 'aberration of starlight' in Chapter 7D)
[10] Very importantly, in Chapters 21 & 22, we will discuss and explain why the (not underlined) first part of Einstein's above postulate is not valid and why it was a major false premise for his entire Special Theory.

but rather at a different velocity that is less than *c*. (Figure 6.8) Now the question becomes: Does the linear motion of such material medium (i.e. water) cause a light ray to transmit at a different velocity relative to such moving medium than when such medium was not moving (i.e. stationary water)?

Where sound is emitted in the direction of a terrestrial wind, the speed v_1 of the wind (the moving medium) is added to (or subtracted from) the transmission speed of sound v_2 in order to determine the total speed v_3 of the sound relative to the surface of the Earth ($v_1 \pm v_2 = v_3$). (Gamow, 1961, p. 162; also see Chapter 8) Do material 'combinations of speeds' also occur with non-material light in the moving medium of water?

By 1851, technology had progressed to the point where French scientist Armond Fizeau (1819 – 1896) was able to test the effect of a moving medium (vis. pure water) on the velocity of light that passed through such moving medium. In Fizeau's interference of light experiment (see Figure 7.3), a ray of in-phase monochromatic light (see Figure 7.4A) was emitted from a terrestrial light source and propagated toward a partially reflective glass plate called a 'beam splitter.' The beam splitter had a thin layer of silver on it just thick enough to reflect one half of the light ray (pencil A) in a perpendicular direction toward mirror M_1. The other half of the light ray (pencil B) passed through the partially reflective glass plate toward mirror M_3. The two pencils of light traveled along two opposing light paths that were slightly different in length, one clockwise and the other counter clockwise.[11] When the two pencils of light met again at the eye of Fizeau, their slightly out-of-phase waves 'interfered' with each other (see Figure 7.4B) and

[11] This slight difference in length caused the wave phases of the two light pencils to be slightly out-of-phase. (Figure 7.4B)

established an interference pattern of dark and light rings (called "interference fringes") when viewed through a small telescope.[12] (see Figure 7.4C) When the water in the tubes was at rest relative to the tubes this interference fringe pattern remained constant. (Figure 7.4D1)

Based on the known length of each monochromatic light wave and the known velocity of light through the medium of water at rest (w) (approx. 226,000 km/s), Fizeau calculated that the speed of water flowing through the tubes must be 7 m/s (v) in order to change the relative phase of the light waves propagating through the moving water by about one half of a wave length (see Figure 7.4D2) over the 150 cm length of the tube. (Goldberg, p. 440; Gamow, 1961, pp. 162 – 163) Sure enough, when the water was allowed to flow through the tube at 7 m/s from the water tank four stories above the experiment, Fizeau observed through the telescope that the interference fringe pattern shifted about 44% of a wavelength. (see Figure 7.4D2)

This shift in the pattern of interference fringes implied to Fizeau that the flow of the water (v) caused a difference in the time interval for the light pencils to travel their courses, and that this time interval difference was manifested by such fringe shift. He concluded that about 44% of the speed of the water (v) is added to or subtracted from to the velocity of the light (w) propagating (through the ether) in the moving water, depending upon the direction of the flow.[13] (Gamow, 1961, p. 163) In effect, Fizeau (reasoning on the basis of the ether theory) conjectured that "the motion of the water only

[12] Newton discovered this pattern of rings, but he did not know its cause. (Gamow, 1961, pp. 75 – 79)

[13] Fizeau measured the velocity of light in both directions of the water's flow (v). It was w + 44% of v with the flow, and w – 44% of v (Figure 7.4D3) against the flow when BS and M_1 exchanged positions and the alternate light source was used. (see Figure 7.3; Bergmann, p. 21) Did the velocity v of the water change the inherent property of the transmission velocity of light in stationary water at w to w + 44%v or w – 44%v; or did it merely drag or carry the waves of light at w along with the ether in the water in a piggyback fashion?

partially drags the ether," and hence also the light embedded in the ether in the water.[14] (Goldberg, p. 443) Fresnel's algebraic equation which described these empirical results was $W = w + v(1 - 1/n^2)$.[15] (see Einstein, *Relativity*, p. 46, F.N.)

When one ignores the mythical concepts of ether and ether drag, the empirical results of the 'Experiment of Fizeau' become much clearer. They suggest that the transmission velocity of light in stationary water w is totally independent of the velocity of the source of the radiation (vis. the solar orbital velocity of the Earth)[16] and that it is partially independent of the motion of the transmitting medium (water). The 'Experiment of Fizeau' paradoxically appeared to contradict the material theorem of the 'computation of relative velocities,'[17] which asserts that 100% of the speed of the water (v) should have been added to or subtracted from the velocity of the light in the moving water (w).[18] (Figure 7.1) What was the answer to this paradox? To this date there is no accepted explanation.[19]

Why did the motion of the water v only result in a change of the velocity of the light in the moving water equal to 44% of v? Why did this magnitude occur in two

[14] Fizeau's explanation was the piggyback scenario. A much more logical modern explanation is hereinafter described by the author. It concludes that the inherent transmission velocity of the light's photons changed (relative to the medium of moving water). (see infra this Section)
[15] Where W is the velocity of the light relative to the tube, v is the speed of the water relative to the tube, n is the index of refraction of the medium *c*/w, *c* is the velocity of light through empty space, and w is the velocity of light through stationary water. (see Einstein, *Relativity*, pp. 45 – 46, and F.N.)
[16] The velocity of light in stationary water (w) was independent of the motion of the Earth through space, because the results of Fizeau's experiment did not depend on the Earth's motion or its direction of motion. There was no fringe shift caused by the solar orbital motion of the Earth in any different direction, or otherwise, when the water was stationary in the tube. This was a further confirmation of De Sitter's above theory. There also was no correlation between the experimental results in opposite directions of the water's flow and in the assumed opposite direction of the Earth's solar orbital motion.
[17] Einstein always referred to this computation as the 'classical addition of velocities.'
[18] The results of Fizeau's 1851 experiment also demonstrated that Fresnel's above equation (then called his 'ether drag coefficient,' and now called the 'coefficient of refraction') appears to describe something that it was not intended to describe…the percentage or fraction (f) of the speed of a moving liquid medium which is added to or subtracted from the velocity of the light propagating through it.
[19] Einstein's relativistic and algebraic description of Fizeau's results is not an explanation. (see Einstein, *Relativity*, pp. 43 – 46)

opposite directions? We will now suggest a possible answer.

Remember from Chapter 6 that water is much more densely packed with atomic particles (i.e. electrons) than air. Therefore it takes more time for each photon of light to be absorbed by a greater quantity of densely packed atomic particles (electrons) of water and then reemitted. (see Halliday, p. 893) Again, this should be the reason that wave trains of photons empirically propagate slower in stationary water (226,000 km/s) than in less dense stationary air (299,800 km/s).

With regard to the 1851 experiment of Fizeau, it is suggested by the author that the rapid motion of water causes a photon to encounter a fewer number of water particles (electrons) during a given time interval when it propagates with the water's flow, because the water particles (electrons) are moving away from each propagating photon. (see Figure 7.5A) Each photon thus takes less time being absorbed and re-emitted by fewer encountered particles. Therefore, the velocity of each photon in the direction of the flow should be slightly greater than 226,000 km/s. By way of extrapolation, if the water was flowing at 1% of the velocity of *c*, then each photon would catch up to and encounter even fewer numbers of rapidly moving particles during a given time interval. In this event, each photon should propagate through the super fast water much faster than 226,000 km/s + 7 m/s.[20]

On the other hand, when a photon propagates against the water's flow, it should encounter a greater number of water particles (electrons) during a given time interval, because the water particles (electrons) are moving toward the photon. Thus, the velocity of the photon in this direction should be less than 226,000 km/s., because it would take

[20] Theoretically, if the water was moving at 50% of *c*, then the velocity of each photon through such super duper fast water would be vastly greater than 226,000 km/s, for the same reasons as previously described.

more time being absorbed and re-emitted by a greater number of water particles. (see Figure 7.5B)

In Fizeau's 1851 experiment, it is suggested that these scenarios empirically caused the total process of absorption and reemission of the photons to be somewhat speeded up with the flow and somewhat slowed down against the flow, by a magnitude equal to 44% of the speed of the water (7 m/s) in each direction. *A priori*, the motion of the water does not partially transfer the speed of the water to the velocity of the light; nor does it drag or carry the photon along (piggyback style) at an increased or decreased velocity relative to the tube, as hypothesized by Fizeau, Einstein and others.[21] Rather, the motion of the water merely makes it possible for the photon to encounter more or less atomic particles (electrons) during a given time interval, to incur more or fewer processes of absorption and re-emission, and thus to inherently transmit faster or slower through the moving medium of water. (Figure 7.5)

The 1851 experiment of Fizeau did not demonstrate the existence or non-existence of the assumed ether itself. Nor did the results of Fizeau's experiment detect any absolute motion of the Earth through or relative to the stationary ether. Nor did it show that the Earth partially dragged the ether along with it, as was theorized by Fizeau, Fresnel and others. Why? Because a few decades later it was demonstrated by Michelson, Einstein and others that there was no ether. It was a myth. Therefore, the concept of ether was superfluous or irrelevant to the results of Fizeau's experiment.

If ether did not exist and therefore was irrelevant to Fizeau's experiment, it must also be irrelevant to Maxwell's equations. If there is no ether in space, then all of space

[21] Einstein's relativistic formula for the composition of two velocities is very similar to Fresnel's partial drag co-efficient, and Einstein incorrectly claimed that Fizeau's 1851 experiment was an experimental confirmation of his relativistic formula. (see Chapter 29)

must be empty and Maxwell's equations must be valid for the vacuum of empty space. Since *a priori* empty space itself is nothing, and nothing cannot move, therefore the constant transmission velocity of light at velocity *c* cannot vary because of the motion of the medium (empty space) through which it propagates.[22] The 19th century scientists apparently did not realize any of these facts. Neither did Einstein and most of the 20th century scientists realize many of these facts.

Except for the above discussion, the main relevance of the 1851 experiment of Fizeau to this treatise is twofold: 1) it can be used as an empirical analogy to help explain the paradox of the Michelson and Morley experiment (see Chapters 9, 10, 11 and 12); and 2) Einstein claimed that Fresnel's empirical formula which described the results of Fizeau's experiment, $v' = v(1 - 1/n^2)$, and thus the paradoxical result of Fizeau's experiment itself, are best described by his Special Theory of Relativity. Later, Einstein and his followers even claimed that Einstein's relativistic equation which describes Fizeau's paradoxical experiment was an exceedingly important experimental confirmation of the validity of Special Relativity. (Einstein, *Relativity*, pp. 43 – 46 Resnick, 1968, p. 37)

However, on the contrary, we have just suggested a quantum physical process that can (not only describe but) fully explain the paradoxical results of Fizeau's experiment (whereas Einstein, Fresnel and Fizeau merely mathematically described such paradoxical results). In Chapter 29 we will refute and mathematically disprove Einstein's claim that Fizeau's 1851 experiment was an experimental confirmation of his relativistic

[22] It makes no difference whether Maxwell's equations were written with reference to the imaginary substance of ether, or with reference to the non-substance of a vacuum or empty space. The constant transmission velocity of light through or relative to either medium, real or imagined, is still empirically measured as velocity *c*.

composition of velocities formula or his Special Theory.

D. The Linear Motions of Other Material Bodies

Finally, let us turn to the third and most important question presented in this chapter: Does the constant transmission velocity of a light ray at velocity *c* relative to the medium of empty space vary, depending upon the linear motions of the bodies toward which such light ray propagates?[23] The first experiment that deals with this question was conducted around 1728, the year after Newton's death. British astronomer James Bradley (1693 – 1762) devised an optical experiment designed to measure the magnitude of observed stellar parallaxes.[24] (see Figure 7.6A) But in the process Bradley discovered that he had to tilt the telescope slightly in the direction of the Earth's motion around the Sun in order to keep the viewed star in the center of the telescope's field of view.[25] (Figure 7.6B)

This tilting requirement, which Bradley had discovered by accident, was later called the "aberration of starlight." (Goldberg, pp. 429-432) The angle that the telescope must tilt in order to keep the viewed star in the center of the field of view is called the "angle of aberration."[26] (*Id*., p. 431) Since Bradley already knew the Earth's approximate solar orbital distance, he also knew the approximate orbital speed v of the

[23] This is the primary question that Einstein was grappling with in 1905, and was attempting to answer with his Special Theory. (see Einstein, *Relativity*, pp. 21 – 23)
[24] A "stellar parallax" is the "apparent shift in position of a star as a result of being viewed from slightly different perspectives as the earth moves around the sun." (Goldberg, p. 429) The astronomer sees "a change in the orientation of the [viewed] star relative to the other [surrounding] stars." (*Id*., p. 430; Figure 7.6A)
[25] When viewing stellar parallaxes, "the stars appear to move in [tiny] circles" relative to the astronomer on Earth (Resnick, 1968, pp. 28, 29), which in effect results in a miniature depiction of the Earth's solar orbit. (Hoffmann, 1983, p. 49)
[26] Bergman described the angle of aberration as follows: "when a light ray enters the telescope, let us say from straight above, the telescope must be inclined in the indicated manner, so that the lower end will have arrived straight below the former position of the upper end by the time that the light ray has arrived at the lower end." (Bergmann, p. 21)

Earth (30 km/s). He computed the distance which he had to tilt the upper end of the telescope (in order to compensate for the orbital speed v of the Earth) compared to the distance light had to travel from the upper end of the telescope to his eye (at the velocity of light). This ratio v/*c* was approximately 1:10,000. [27] (Bergmann, pp. 21 – 23) From this ratio Bradley also computed the approximate finite transmission velocity of light to be 303,000 km/s.[28] (Hoffmann, 1983, p. 49)

Among other things, the aberration of starlight also demonstrated that the velocity of starlight does not depend on the state of motion of the medium of transmission (vis. ether or air). Why? Because if it did, starlight that entered the Earth's atmosphere would be swept along by the moving air (or the ether with the embedded light in it would be dragged along by the Earth moving through the ether) and the aberration effect would not exist or would vary in certain directions. (Bergmann, pp. 21 – 22)

The aberration of starlight also implied that light had a constant transmission velocity relative to the medium of empty space, regardless of the relative linear speed of its source body (the star). Why? Because the angle of aberration (the ratio 1:10,000) was always the same for every star, regardless of the star's speed or direction of motion relative to the Earth. (*Id*., pp. 21 - 23)

In addition, and very importantly, the aberration of light implied that the relative speed or direction of motion of the body (i.e. the Earth) toward which such starlight propagates did not alter the transmission velocity of the starlight, again because the angle of aberration (the ratio 1:10,000) was always the same for every star, regardless of the

[27] With trigonometry, Bradley was able to calculate the angle of aberration: tan a = v Δ t / *c* Δ t = v/*c*; or 1:10,000. (Resnick, 1968, p.28)
[28] Thus, the aberration of starlight confirmed Römer's theory that the transmission velocity of light was finite. But Newton never knew of this experimental confirmation.

relative linear speed of the Earth in two opposite directions during its solar orbital motion. Thus, the aberration of starlight also gave a definite answer to our third question: the transmission velocity of light at velocity *c* does not vary depending upon the linear motion of bodies toward which it propagates. Bradley's experiment constitutes an empirical confirmation of this fact.

Nevertheless, Bradley's experiment resulted in a baffling paradox. How could the velocity of light retain the same value in a terrestrial experiment, regardless of the Earth's relative velocity of 30 km/s in two opposite linear directions? [29]

In 1905 and again in 1916, Einstein challenged Bradley's aberration of light phenomenon[30] and his above empirical confirmation, in an attempt to answer the above paradox and to remain consistent with the basic false premise for his Special Theory. (Einstein, *Relativity*, pp. 21 – 23) Einstein then applied his Lorentz transformation equations to Bradley's empirical and mathematical result, which distorted such result so that it remained consistent with Special Relativity. (see Chapter 31) In effect, the Lorentz transformations mathematically made the velocity of starlight an absolute and invariant velocity of *c*, regardless of the Earth's relative orbital velocity of 30 km/s either toward or away from such starlight. Then, with classical circular reasoning, Einstein and his followers claimed that this distortion of Bradley's experiment was an experimental confirmation of Einstein's Special Theory, because it mathematically did away with the paradox. [31] (see Resnick, 1968, p. 37; and Chapter 36)

What could happen if Bradley's telescope was filled with a different medium than

[29] The detailed answers to the paradox of why this result occurs are found in Chapters 21D and 22E.
[30] Einstein actually described stellar parallax but he labeled it 'aberration.' (Einstein, *Relativity*, p. 55)
[31] Einstein not only claimed that his mathematically distorted phenomenon of the aberration of starlight supported his Special Theory of Relativity, but also that his Special Theory predicted such distorted effect. (see Chapter 31)

air: vis., water? In 1871, British astronomer George Airy (1801 – 1892) performed a modification of Bradley's earlier aberration experiment. In Airy's experiment the medium of air in the telescope was replaced with the medium of water. (see Figure 7.7) Paradoxically, this time the starlight appeared to arrive at point E rather than at point D as it did in Bradley's experiment. [32] In spite of these differences, Airy discovered that the angle of aberration of the telescope was exactly the same as when Bradley conducted the experiment with air in the telescope. What was the answer to this paradox? (see Figure 7.7; Goldberg, pp. 444 – 445)

In 1810, French scientist Francois Arago (1786 – 1853) also conducted an experiment, which coincidentally was also an attempt to answer our third question. Arago focused his telescope on a nearby star that was low on the horizon, and periodically observed it over the course of a year. (Goldberg, p. 89; Figure 7.8) He assumed that the solar orbital speed of the Earth toward or away from the star would change the transmission velocity of the starlight received through his telescope; just like the accelerated muzzle velocity of a bullet fired toward a linearly moving carriage will increase or decrease the bullet's relative speed depending upon the linear direction of the carriage's motion. [33] (see Figures7.1G and 7.1H)

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[32] The explanation for this paradoxical result, according to the ether theory and Fresnel's ether drag coefficient, was that the orbiting Earth partially dragged the ether in the water (with the light embedded in it) along with the Earth, and this is the reason that it arrived at point E rather than point D. (Goldberg, p. 447) The real reasons, which Airy apparently did not realize, were that light only propagates through water at three-fourths of the transmission velocity that it propagates through air at *c*. (Figure 6.8) This slower transmitting velocity of light takes a longer interval of time to descend through the telescope filled with water than through air. During this longer time interval the Earth moves further transversely to the vertical path of the starlight, than it did when Bradley's telescope was filled with air. (see Figure 7.7) Because nineteenth century scientists did not know about these concepts and were confused by the ether theory, they were forced to dream up arbitrary reasons for mysterious results, such as 'ether drag.'

[33] In the bullet/carriage analogy (Figure 7.1), the transmission speed of the bullet remains approximately 2060 km/h relative to the surface of the Earth during its flight toward train II. But with respect to train II moving relatively toward train I at 50 km/h, the approaching bullet has a relative speed of approach equal to 2,000 + 60 + 50 = 2110 km/h. Similarly, the bullet's approach speed relative to train III is 2,020 km/h.

The focus of a telescope's glass lens (a prism) depends upon the bending or refraction of light through the medium of the shaped glass prism toward a focus point. In turn, the magnitude of the bending of light depends upon the transmission velocity of the light through a given glass lens; the faster the transmission velocity of the light through such lens, the less the angle of refraction (bending), and *vice-versa*.[34] (Hoffmann, 1983, pp. 60 – 61; Born, pp. 132 – 133; Figure 6.7D)

Arago also assumed that the above theoretical change in the transmission velocity of light (faster or slower) through the lens would alter the focus of his telescope. (*Id*.; Goldberg, pp. 89, 438) But paradoxically, the focus of Arago's telescope remained constant. "The refraction of starlight through glass appeared to take place just as though the earth were at rest in the ether." (French, p. 45) In other words, the Earth's orbital speed (v) relative to the velocity of the starlight did not increase or decrease the transmission velocity of light through the glass lens. Arago was mystified by this apparent paradox, and the scientific community still appears to be equally mystified. (see Coleman, pp. 20 – 22)

The reason that there was no change in the focus was, of course, because the constant <u>transmission velocity</u> of light at *c* relative to its medium of empty space (a vacuum) does not change when the light ray approaches an object (i.e. Earth) that is moving linearly in either direction. Only the <u>relative time interval</u> of approach ($ct - vt$ or $ct + vt$) and the <u>distance/time interval of propagation</u> of the transmitting light ray from its light source (the star) to the observer (Arago) changes, depending upon the different linear speeds of the material bodies and the distances involved. When the light ray

[34] Again, as shown in Chart 6.7B, this ratio of the transmission velocity of starlight through the vacuum of empty space at velocity *c* relative to the transmission velocity of the starlight through the material medium of a specific glass lens (v), is called the index of refraction (n) of the lens: $n = c/v$.

finally reached the lens of the telescope, its velocity of transmission relative to the medium of air (just prior to entering the lens) remained approximately *c* and constant.[35] The light ray did not enter the lens with a changed transmission velocity of $c - v$ or $c + v$ as Arago assumed that it would.[36]

Properly analyzed, Arago's experiment really demonstrated that a light ray transmitting through empty space at *c* has two separate and different velocities: 1) the constant velocity of transmission (300,000 km/s) in the abstract or relative to the medium of the vacuum of empty space (which is an inherent property of such light ray), regardless of the relative linear motions of the material objects toward which it propagates; and 2) a relative velocity or changing time interval of approach over varying distances toward all linearly moving material objects.[37] (see Figure 21.1) As Figure 7.1 demonstrates, material terrestrial objects with a constant uniform motion also have the same two velocities: 1) a constant velocity of propelled or forced motion with regard to the relatively stationary air and the Earth's surface, and 2) varied velocities of approach or separation relative to every other linearly moving terrestrial object.[38] (see Figure 21.6)

When Arago's colleague, French scientist Augustin Fresnel (1788 – 1827), was later informed of Arago's puzzling result, he took it upon himself to attempt to construct a quantitative description of the empirical paradox. Fresnel theorized that in Arago's

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[35] The instant before the ray of starlight entered the prism it was still the phenomenon of light with a constant transmission velocity of approximately *c* relative to the medium of the air, regardless of the relative velocity and relative time interval of approach it might have had during its journey from the star. Thus the velocities of its component colors should act as they normally do through a prism. (see Figure 6.7D)

[36] For a more detailed answer to the above paradox, see Chapter 22E.

[37] These conclusions are compatible with the absence of ether, the wave theory of light, and with Maxwell's equations. (Bergmann, p. 19) The 'aberration of starlight' also confirmed these conclusions, but the scientific community was not ready for them.

[38] All of these conclusions will become critical to our later discussions of Special Relativity and Einstein's incorrect assumptions. They are also experimental confirmations of our discussions in Chapters 21 and 22.

experiment, the ether must have been partially dragged along by the motion of the Earth, and that the magnitude of such "ether drag" depends upon a mathematical equation or coefficient. Goldberg explains Fresnel's reasoning:

> "Rather than the relative speed between the earth and the ether being v, Fresnel thought that the relative speed is $v(1 + 1/n^2)$, where n is the index of refraction. The function $1 + 1/n^2$ became known as 'the Fresnel dragging coefficient' and [it] affects the velocity of light in transparent materials such as lens and prisms[39] to compensate exactly for the changes being sought to determine the motion of the earth through the ether."[40] (Goldberg, pp. 89, 90)

In 1818, Fresnel published his empirical formula for the velocity of the moving Earth v' in the partially dragged along ether: $v' = v(1 – 1/n^2)$.[41] (Born, p. 136; see Einstein, *Relativity*, p. 46, F.N.)

Fresnel's formula does describe the changed transmission velocity of light propagating through a specific moving transparent medium, which depends upon its index of refraction and its relative velocity; but the theoretical motion between the Earth and the mythical ether had nothing to do with it. In effect, when Fresnel backed into his formula, he coincidentally described the correct empirical result, but for the wrong reason. This wrong reason, 'ether drag' or something like it, would haunt and distort science for many decades to come, and it still does.

All of the previously described optical experiments are very insightful as to the transmission velocity of light in various contexts, especially if one ignores the false concepts of ether and ether drag. But none of such optical experiments give any

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39 These algebraic formulae of Fresnel describes the empirical results, but for the wrong reasons.

40 In the above formula, n is the index of refraction (*c*/v) of the medium, *c* is the velocity of light in the vacuum of empty space, and v is the velocity of light in the medium. (Goldberg, p. 88) The reasons for Fresnel's coefficient are completely explained by the above discussion of Arago's experiment, by the prior discussions of Chapters 6 and 7, and by Chapter 22E.

41 "Fresnel established that to explain Arago's observation and all other effects of the first order it was sufficient to assume that the ether is only partly carried along by matter." (Born, p. 133) This, of course, was a completely invalid reason.

indication as to the assumed absolute velocity of the Earth through the stationary ether. All of them, except the 1851 experiment of Fizeau, were designed to demonstrate 'first-order effects'…the ratio of v/*c* (1:10,000), rather than the much more precise 'second-order effect' of v^2/c^2 (1:100,000,000).

E. The Sagnac Effect

In 1913, French scientist Georges Sagnac published the mysterious results of an interference of light experiment which he had conducted.[42] (see Kelly, pp. 34 – 39) Sagnac placed four mirrors on a disc, one of which was a half-silvered beam splitter. (see Figure 7.9) A light source on the disc at L sent a beam of monochromatic light to the beam splitter at A. Light pencil 1 propagated straight through the beam splitter A; it was then reflected from mirror B to mirror C and to mirror D. From mirror D, light pencil 1 again propagated straight through the beam splitter and was viewed through a telescope T by a camera at position E on the disc. On the other hand, light pencil 2 was reflected by the beam splitter to mirror D, then to mirror C and B, and finally it propagated through the beam splitter and the telescope to the camera at position E. Focusing mirror B was then adjusted so that the two light pencils were slightly out of phase, and an interference fringe resulted.

The disc with all of the above apparatus on it was then rotated in a clockwise direction at velocity w. As measured by fringe shifts on the rotating disc, it took a longer period of time for light pencil 1 to complete one circuit from A to B to C to D to A in the direction of such rotation, than it took for light pencil 2 to complete one circuit from A to

[42] Sagnac actually published numerous other papers on this subject from 1897 to 1914. (Kelly, p. 35)

D to C to B to A in the opposite direction.[43] When Sagnac reversed the spin of the disc, he obtained the opposite result.[44] Thus there was a "difference in time (dt) for the light to traverse the [same] path in opposite directions…" (*Id*., p. 35) The results of Sagnac's experiments imply that the velocity of light is not always the same in every direction, and that this contradicts Maxwell's theory of light, Maxwell's equations, and Einstein's second postulate concerning the constancy of velocity *c*.

What is the explanation for these paradoxical Sagnac Effects? The relativists claim that the Sagnac Effect has nothing to do with Special Relativity because it involves rotation (acceleration) rather than inertial motion (see D'Abro, 1950, p. 154), or in the alternative they claim that it is an example of the Relativity of Simultaneity or the Dilation of Time.[45] (see Kelly, p. 45; Henderson, pp. 113 – 121) Some claim that it can only be explained by General Relativity or by the existence of ether. There are at least 10 other proposed explanations for the above Sagnac Effects, none of which is persuasive. (see Kelly, p. 61)

The author suggests that such Sagnac Effects can be explained in a similar manner to his explanation for the 1851 Fizeau experiment. (see Chapter 7D) The Sagnac experiments are substantially the reverse of the Fizeau Experiment: the light ray is moving but the material medium (air) is substantially stationary. Because of such motion of the light ray toward the air particles more photons interact with more electrons (of air) in the direction of rotation during a given time interval than in the opposite direction

[43] The Sagnac Effect is only evident for motion with or against the direction of motion of the disc. [There is] no effect for directions that are towards or away from the center of rotation. (Kelly, p. 48)
[44] It is also known that light emitted on the surface of the Earth takes a longer period of time to propagate in the easterly direction of the Earth's rotation on its axis (i.e. in the direction of such rotation relative to the Sun) than in the westerly direction against such rotation. (see Kelly, p. 39)
[45] The Sagnac Effect has also been claimed to be a contradiction to Einstein's two fundamental postulates, because the velocity of light varies from *c* in two different directions. Probably for this reason it is almost never mentioned in articles that favor Special Relativity.

where the light ray and its photons are moving relatively away from such electrons. Thus there is more absorption and re-emission of photons in the direction of such motion and therefore a slightly longer time interval for light to propagate in that direction, and a slightly shorter time interval for light to propagate in the direction opposite to such motion.

For the above reasons, the Sagnac Effects (like the Fizeau Effects) are purely physical and empirical effects. They have nothing to do with Special Relativity, and they certainly are not examples of the Relativity of Simultaneity nor the Dilation of Time. Nor can they be considered to be an experimental confirmation of Special Relativity.

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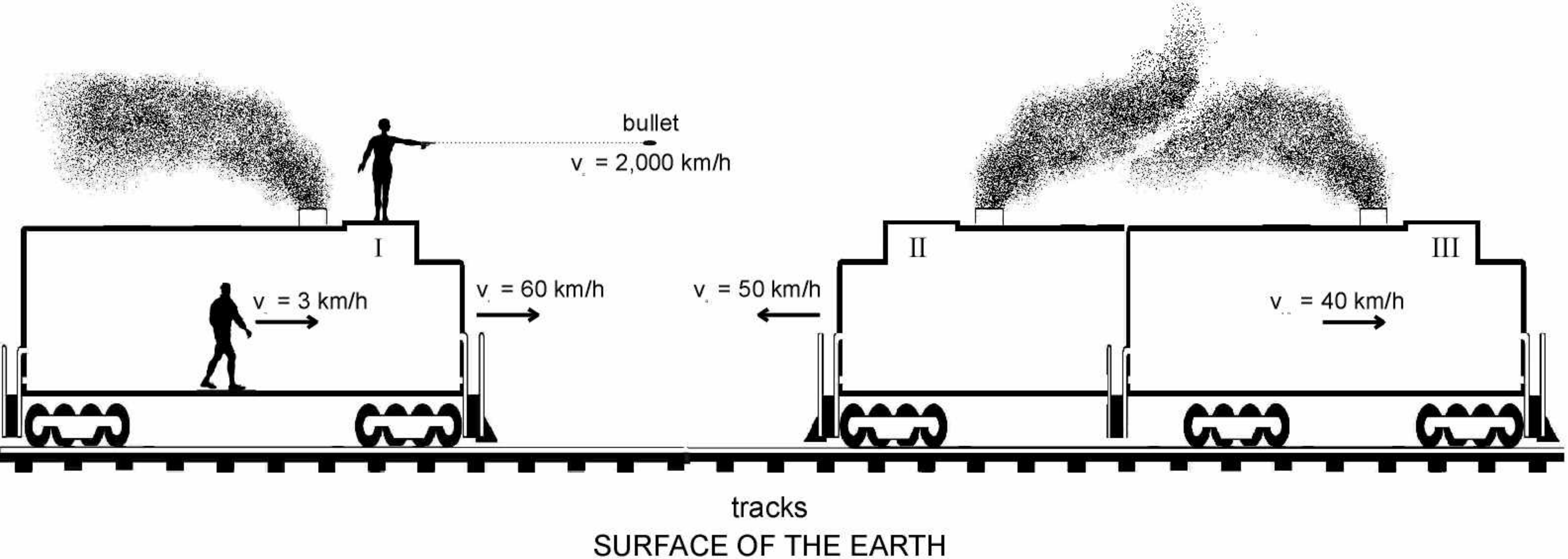
In Chapter 9 we will examine the ‘second-order’ Michelson and Morley experiments which were conducted in the 1880’s in an attempt to detect and measure the absolute velocity of the Earth through the stationary ether. But first let us analyze one more set of 19th century experiments which have relevance to our future discussions. These are the Doppler effects of sound and light, which we shall briefly discuss in the next chapter.



A. Speed (v_2) of walking man relative to the rails is

$v_1 + v_2 = v_3$

60 + 3 = 63 km/h

B. Speed (v_4) of train relative to the walking man is

$v_1 - v_2 = v_4$

60 - 3 = 57 km/h

C. Speed (v_6) of the bullet relative to the rails is

$v_1 + v_5 = v_6$

60 + 2,000 = 2,060 km/h

D. Speed (v_7) of the bullet relative to train I is

$v_5 - v_1 = v_7$

2,000 - 60 = 1,940 km/h

E. Speed (v_8) of train I relative to train II is

$v_1 + v_9 = v_8$

60 + 50 = 110 km/h

F. Speed (v_{11}) of train I relative to train III is

$v_1 - v_{10} = v_{11}$

60 - 40 = 20 km/h

G. Speed (v_{12}) of the bullet relative to train II is

$v_5 + v_1 + v_9 = v_{12}$

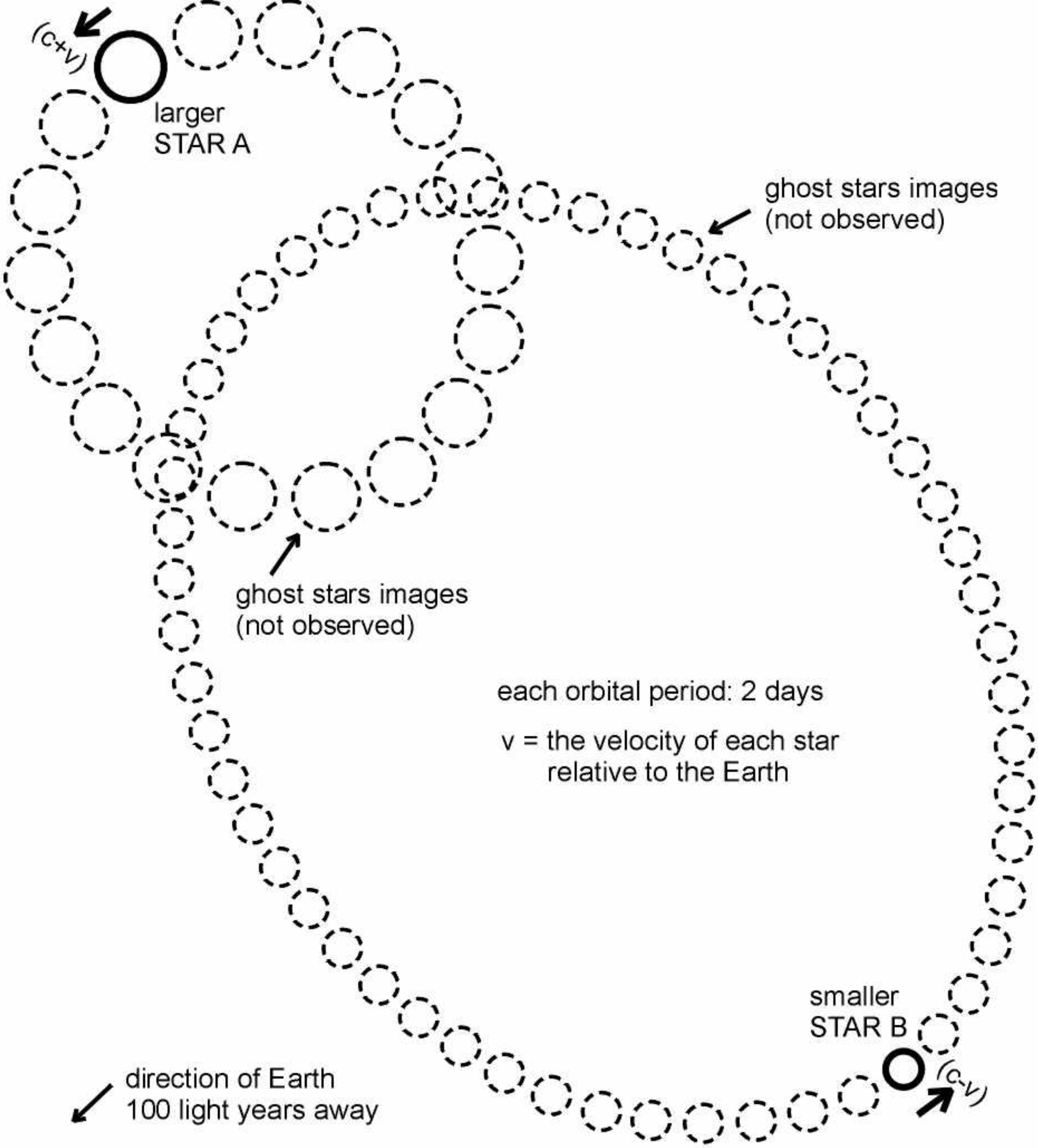
2,000 + 60 + 50 = 2,110 km/h

H. Speed (v_{13}) of the bullet relative to train III is

$v_5 + v_1 - v_{10} = v_{13}$

2,000 + 60 - 40 = 2,020 km/h

Figure 7.1 The 'Computation Of Relative Speeds' For Material Objects



Professor Dingle described De Sitter's binary star theory as follows: If the binary star system was 100 light years from Earth, then the light component coming from star B at *c* - v (299,700 km/s) would take about 70 days longer to reach the Earth than the light component coming from star A at *c* + v (300,300 km/s). Because of their orbital motion, these components would be reversed with every orbit (i.e. every 2 days).

> "An Earthbound observer would therefore see a hopeless confusion of light from the two components, bearing no resemblance at all to the orderly revolution that would actually be taking place. In fact, however, he does see such an orderly revolution. The conclusion drawn from this is that light must actually travel at the same speed *c* from both components at all times, as Einstein's postulate requires." (Dingle, 1972, p. 206)

Figure 7.2 DeSitter's Binary Star Theory

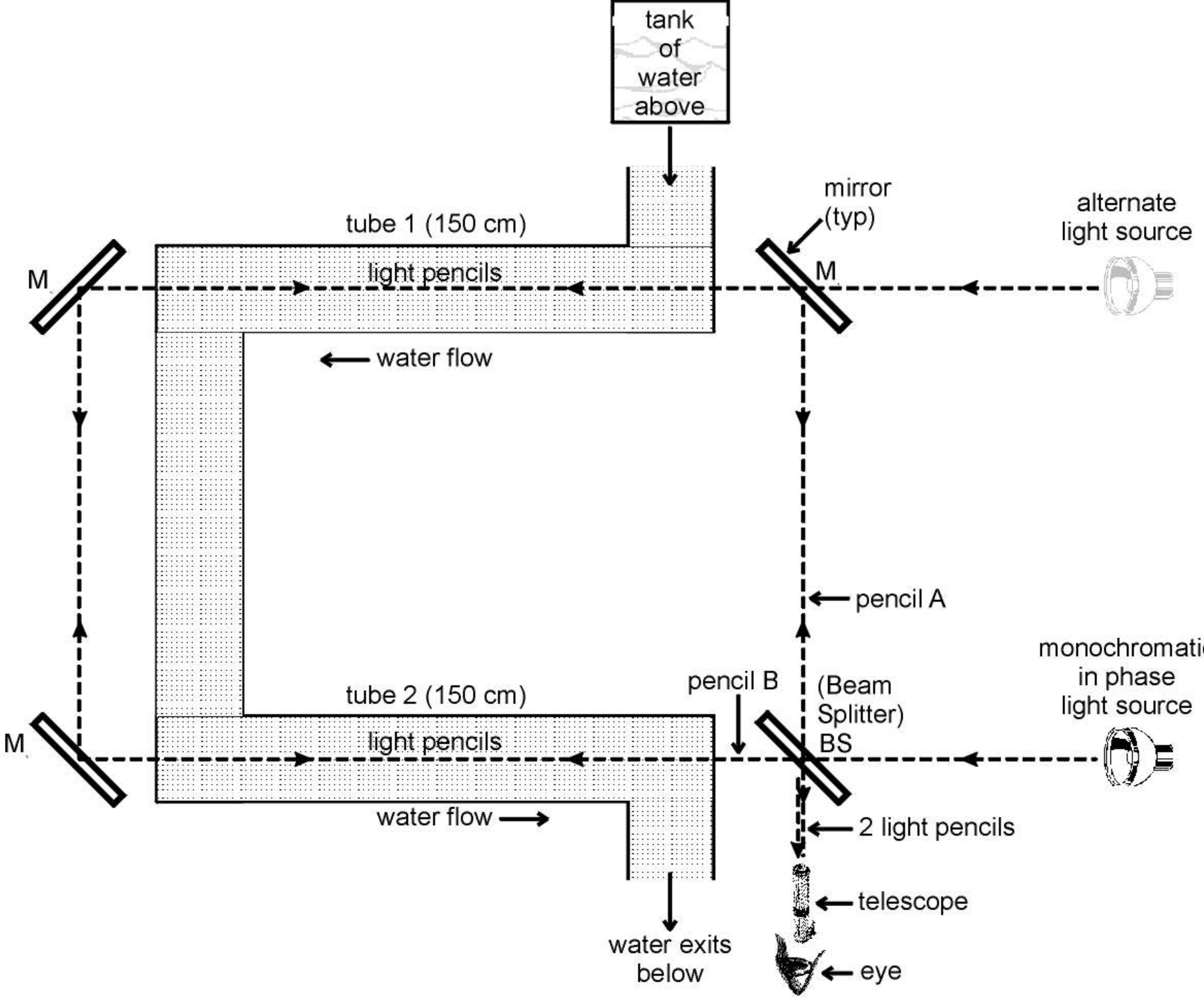


Figure 7.3 The So-Called Ether Drag' Experiment Of Fizeau Which Paradoxically Determined The Velocity Of Light In A Moving Medium (Water)

Source: See Born, p. 139

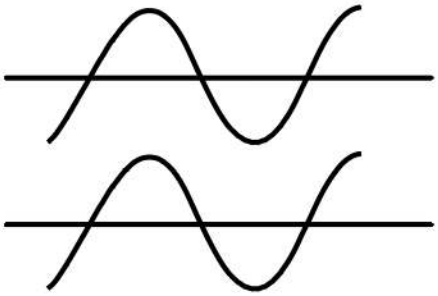


Figure 7.4A With light waves "in phase," no interference fringe is produced.

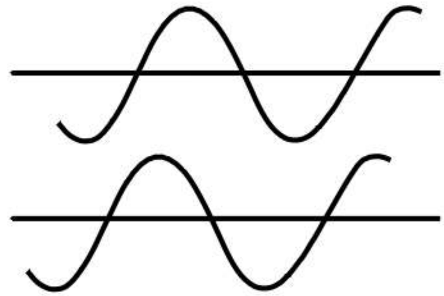


Figure 7.4B Light waves slightly "out of phase" interfere with each other and can produce an interference fringe.

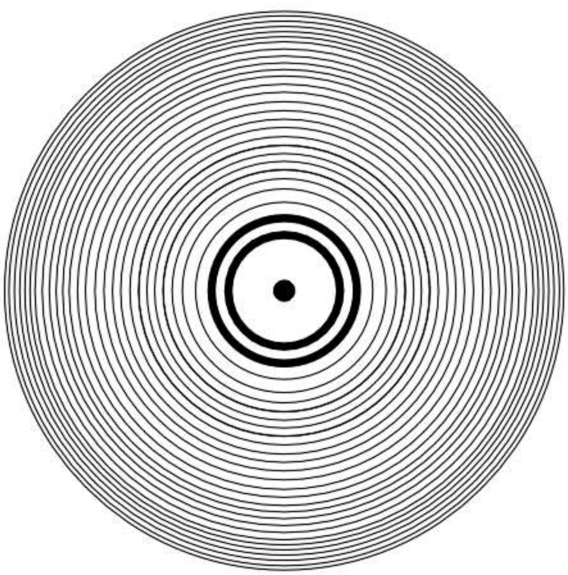


Figure 7.4C Circular interference rings or fringes (sometimes called Newton rings) produced by out of phase light waves.

Source: Halliday, 1992, p. 958

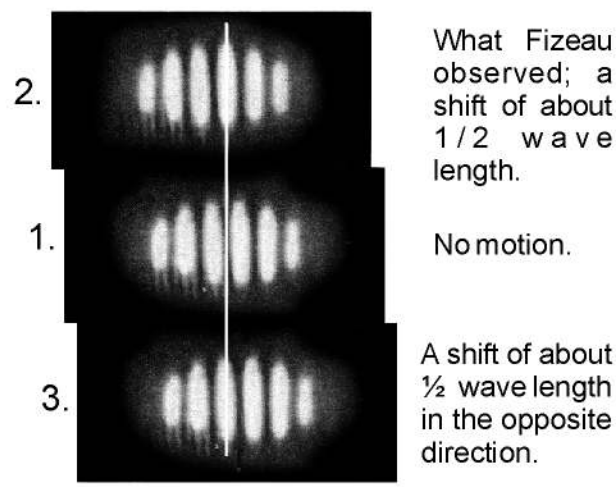
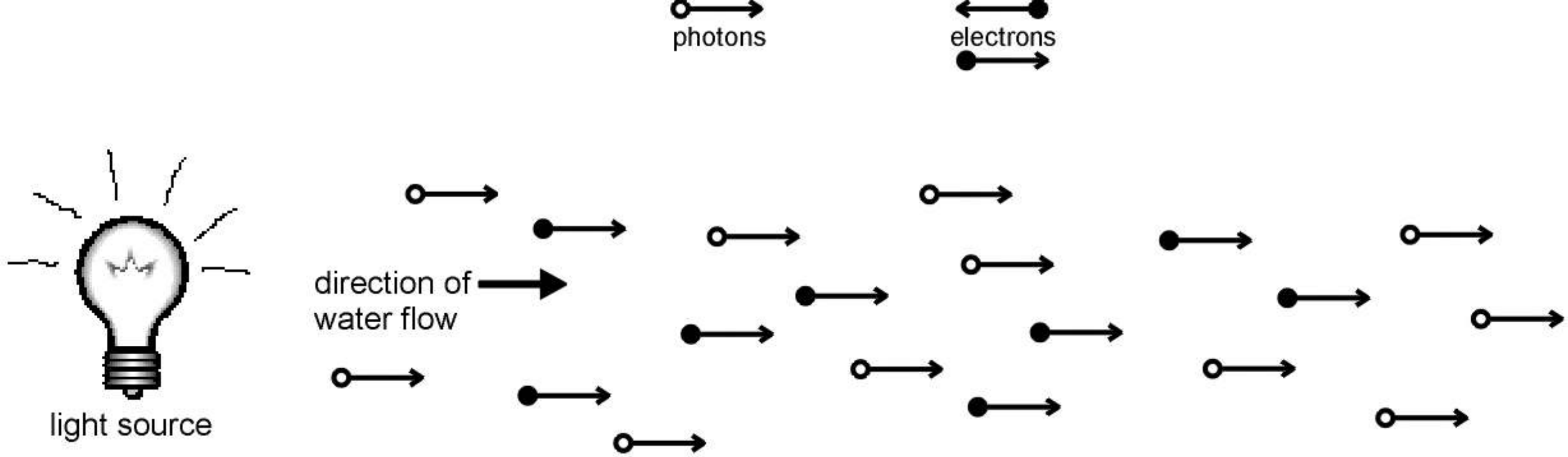
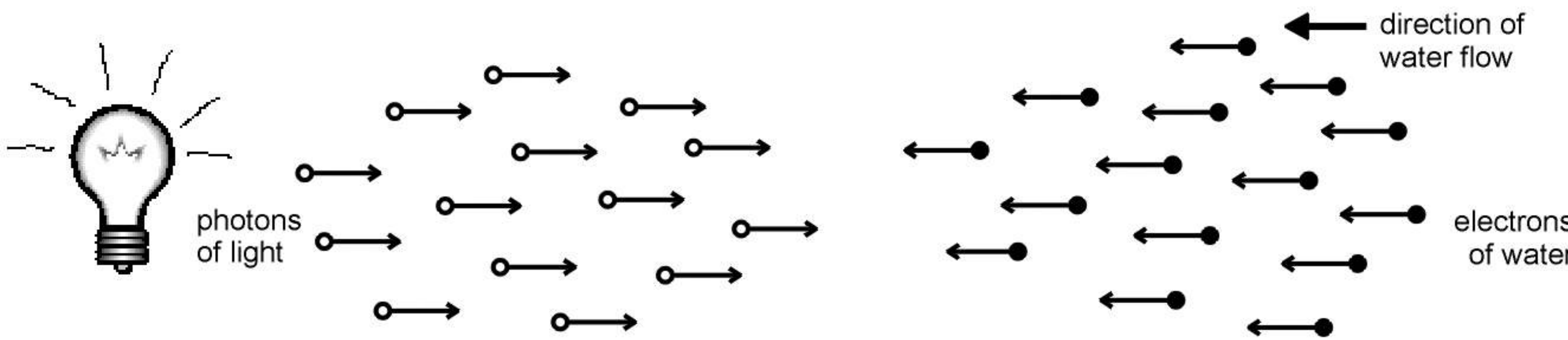


Figure 7.4D Fringe shifts produced by motion of the medium, motion of the light source, or motion of the focusing mirror.

Figure 7.4 Out Of Phase Light Waves Create Interference Fringes And Relative Motion Creates Fringe Shifts



A. Photons of light propagating with the flow of water electrons. Less chance of contact, absorption and re-emission = faster velocity of light.



B. Photons of light propagating against the flow of water electrons. Greater chance of contact, absorption and re-emission = slower velocity of light.

Figure 7.5 A New Explanation Of Fizeau's 1851 Experiment

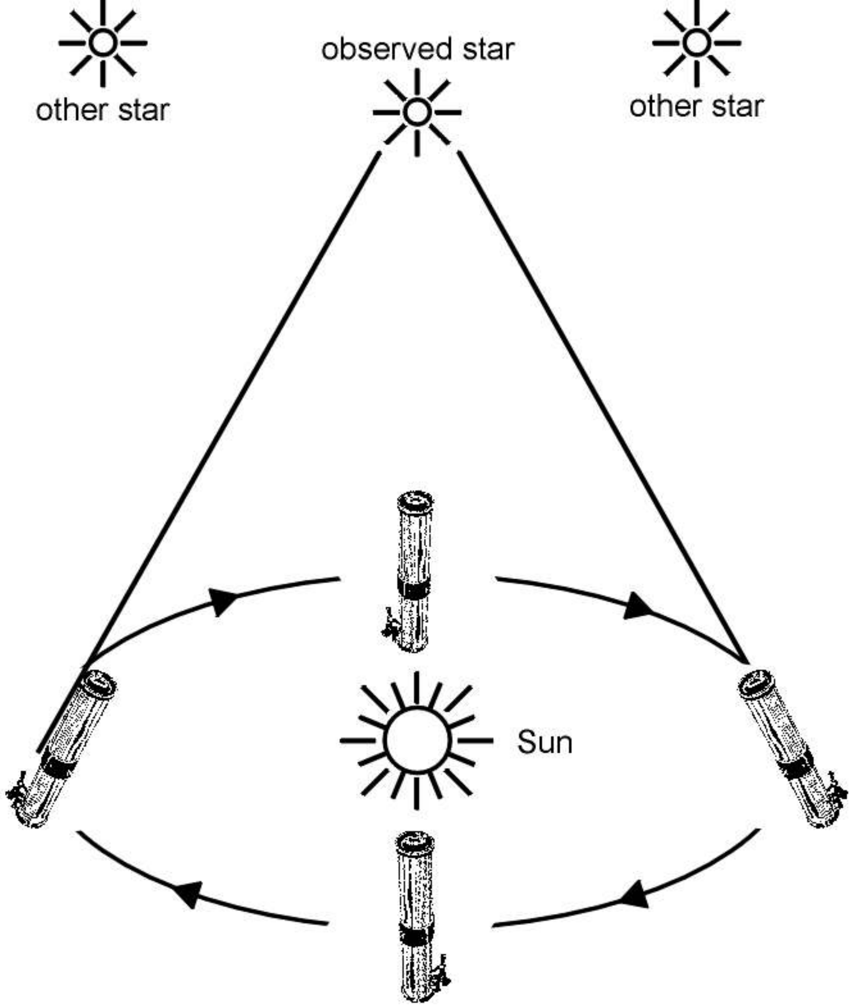


Figure 7.6A Stellar Parallax
As a telescope on the Earth orbits the Sun, its angle of orientation relative to an observed star changes with respect to other stars.

[Note: If the velocity of light was instantaneous, or if the Earth was at rest relative to the viewed star, then the aberration of starlight would not occur.]

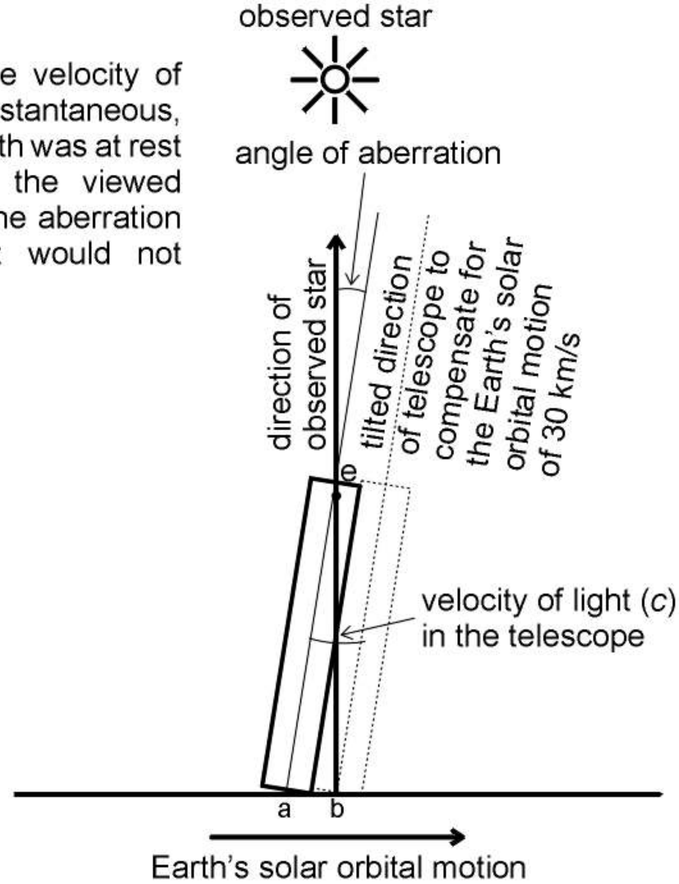
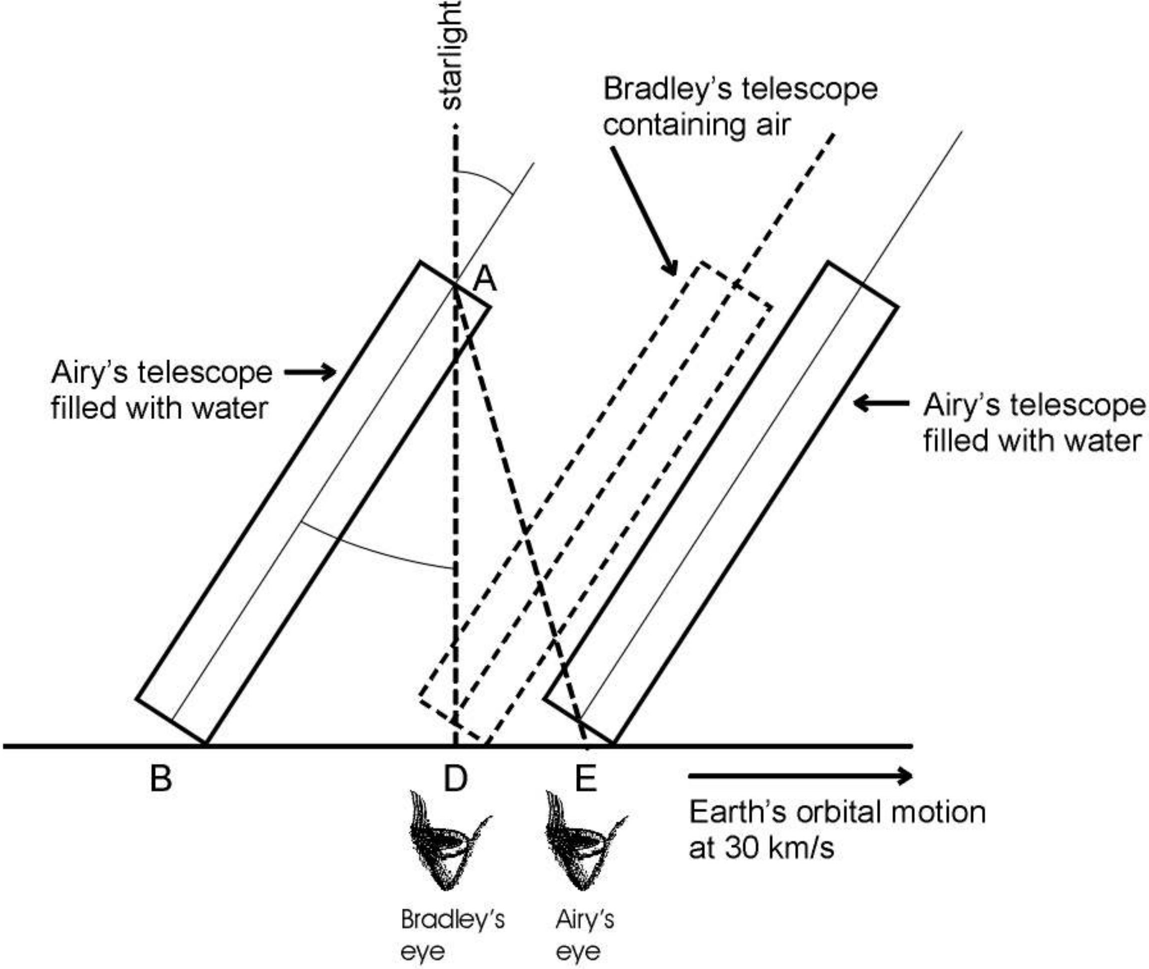


Figure 7.6B Aberration of Starlight
Had the telescope been vertical and the light entered the center of the tube at e, the light would have no longer been at the center of the tube when it arrived at b, because of the solar orbital motion of the Earth. (Goldberg, p. 431) In order to keep the observed star in the center of the field of view, the telescope must be tilted a slight distance (ab/eb or v/c = 1/10,000) in the direction of its solar orbital motion.

Figure 7.6 Stellar Parallax And The Aberration Of Starlight

(Not to Scale)

Sources: Goldberg, pp. 429 - 432; Born, pp. 93 - 95



The starlight enters the A end of the telescope at velocity *c* (300,000 km/s), but must pass through water to reach the B end. The water slows the starlight down to 226,000 km/s so it takes longer to reach the B end. During such propagation through water, the Earth moves further to the right than with Bradley's telescope which was filled with air. So instead of seeing the starlight at D (as Bradley did), Airy sees the slower propagating starlight at E. The difference is a result of the greater index of refraction of the more dense medium of water. In other words, the photons of light encounter a greater number of atomic particles (electrons) in the water than in the less dense air, and the resulting absorption and re-emission of more photons by more electrons results in a greater interval of time for starlight to propagate through the tube of Airy's telescope.

Figure 7.7 The Airy Experiment

(not to scale)

Source: Goldberg, p. 445

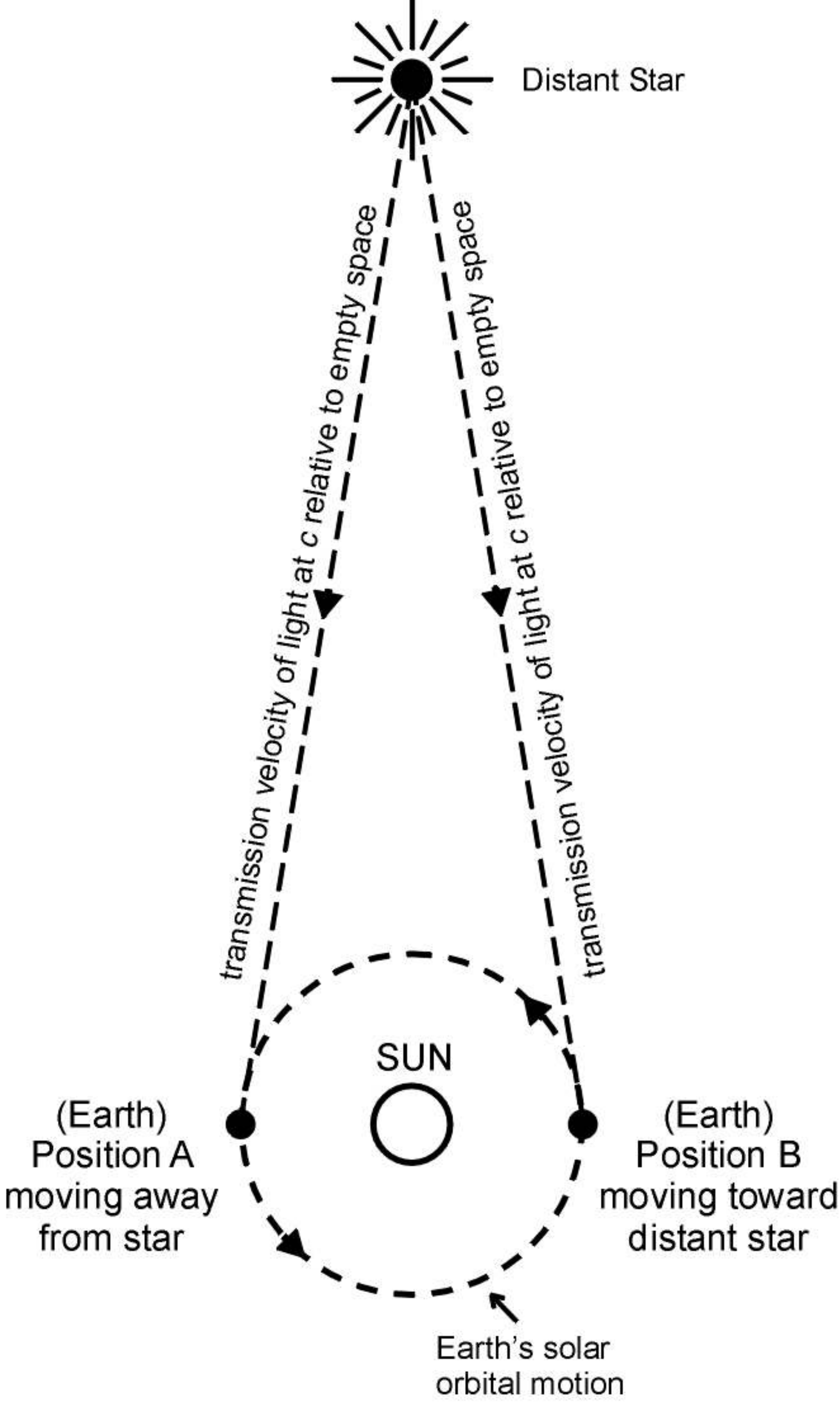


Figure 7.8 The Experiment Of Arago

Arago assumed that the transmission velocity of starlight would decrease through his telescope as the Earth moved away from the star at position A, and that such transmission velocity would increase through his telescope as the Earth moved toward such star at position B. He also assumed that the focus of his telescope would change, because of such varying transmission velocity of starlight .

Sources: Born, pp. 132 - 133; Goldberg, pp. 88 - 89, 438

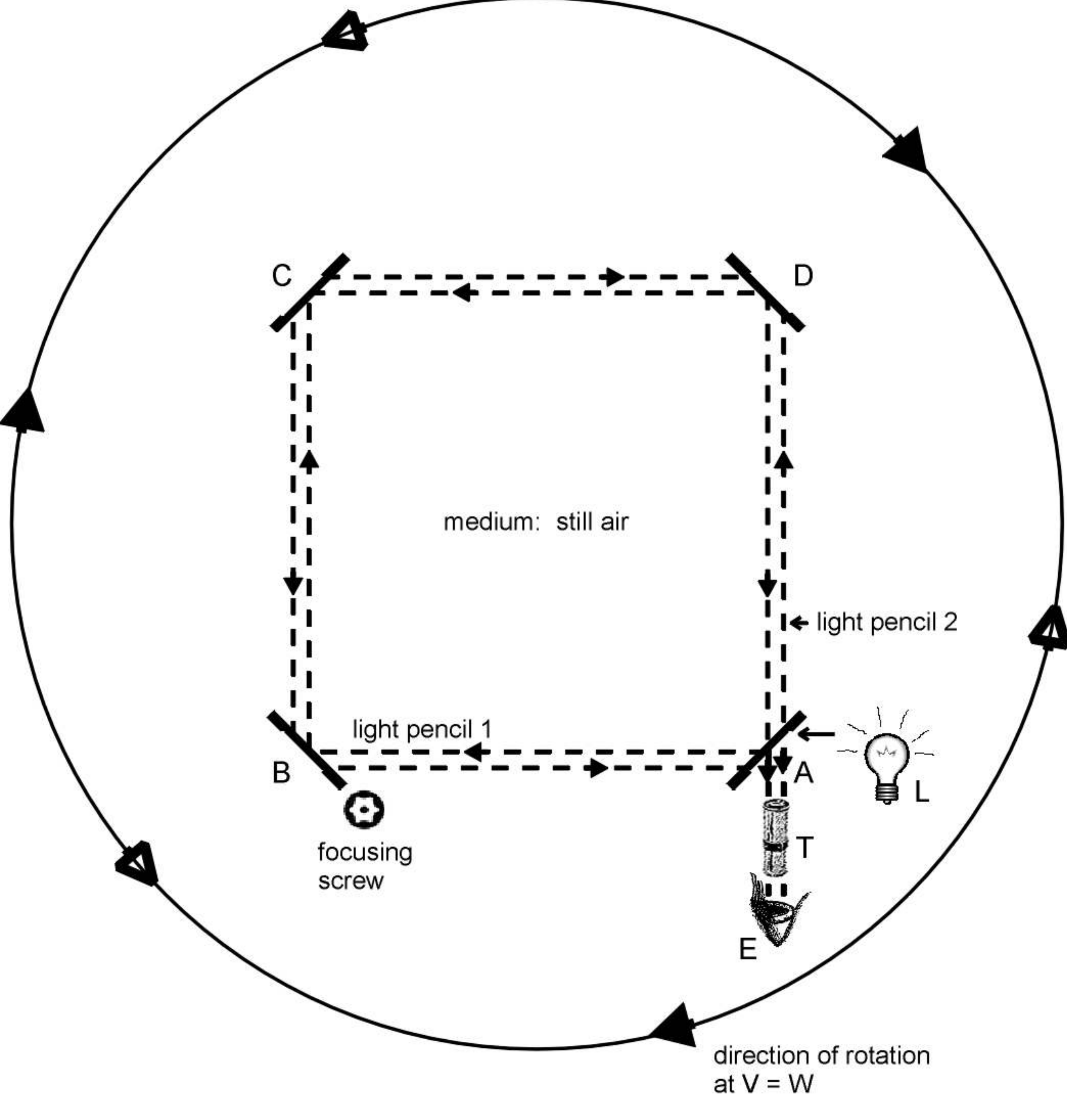


Figure 7.9 The Paradoxical Sagnac Effect

Source: Kelly, pp. 34 - 39