The Speed of Light: Constant and Non-Constant

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This article examines the relativistic assumption of a constant speed of light without Einstein's postulates, building on two dissident physicists' unique theories as a possible explanation for the phenomena by which light can travel with the speed of its source and, therefore, at variable speeds.

1. Introduction

Renshaw and Calkins have proposed rather unique theories regarding the propagation of light, which are examined in Section 4. [1,2] First I consider two similar situations for non-light phenomena to extrapolate to a subsequent analogy for light to contend that the speed of light need not be constant.

2. A Special Car Ride

Riding in a car moving at constant speed v, you hold a bocce ball (hard surface) in each hand. You place the ball from your left hand on the car floor while reaching out from the car and placing the ball from your right hand on the icy shoulder of the road. Assuming negligible air resistance and friction (rolling or sliding, at least along the icy shoulder), relative to you, both balls maintain the same position, i.e., stationary. Relative to the roadway or a stationary observer on the roadway, both balls move forward (the one on the roadway sliding forward at speed v if there is negligible friction), parallel to each other and you (also moving forward at v).

If your car's floor is glass, you see the same thing relative to the roadway, i.e., both balls moving forward at v parallel to each other, but stationary relative to you. Equivalently, you could perceive the roadway as moving backward at v relative to both balls (and you). If you picked both balls up after 10 sec on your watch, Einstein would say that you would see that the observer's watch registered < 10 sec. The observer would see you picking up the balls at > 10 sec on his Einstein watch.

Relative to you, both balls traveled the same distance – zero. The observer sees the same, relative to you. Relative to the road, since you placed the balls at the same time and place and picked them up at the same time and place (forward from their release point and time), also seen by the observer, both you and the observer conclude both balls traveled the same distance – your (the car's, or the balls') speed v (relative to the roadway and observer) x observed time (10 sec on your watch, > or < 10 sec on his Einstein watch, depending upon whose perspective).

If all seconds are created equal, then for the observer to explain how you were able to pick up both balls at the same instant and location, you must have traveled faster than v [since only (> v) x 10 sec can equal v x (> 10 sec)]. But if you had traveled faster than v, you would not have been able to pick up the ball on the roadway after 10 sec on your watch, for it would have fallen behind, unless it, too, traveled faster than v. But then we are back to both balls traveling at the same speed relative to the roadway, albeit now > v.

There is no doubt that you traveled at v, either by you or the observer. Since you obviously retrieved both balls and the observer saw this, then someone's watch is wrong. According to the observer, either yours ran slow or his ran fast (or both). But you saw his watch run slower than yours, at least in Einstein's world.

Let's start again, this time you are holding a pair of tennis balls. You simultaneously bounce one vertically from your left hand in the car and one vertically from your right hand on the roadway, catching both at your hands' release points at the same time (and position, relative to you). Relative to you, both travel down and up along the same line – there is no horizontal displacement. The observer sees the same, relative to you. Relative to the roadway, both follow diagonally symmetric paths, which both you (remember your glass floor) and the observer see equally. Relative to you, the distance traveled is purely vertical and shorter than that relative to the roadway, which has horizontal displacement as well. Your watch registered 1 sec from toss to catch for each ball. The observer's Einstein watch registered something else, < 1 sec from your perspective; > 1 sec from his. Relative to you, as seen by you and the observer, both balls traveled the same vertical-only distance at the same speed. Relative to the roadway, both balls traveled the same diagonal distance (horizontal and vertical) at the same speed, again as seen by you and the observer. How can the times differ?

In this example, we examined the same action but concurrently in two reference frames. One ball was either placed or bounced vertically in the moving car, such that there was no horizontal displacement relative to that frame. The equivalent ball was either placed or bounced vertically from the moving car onto the stationary roadway, where there had to be horizontal displacement relative to that frame for you to retrieve it. Could the times for you and the two balls to accomplish the same action at the same speed over the same distance differ?

3. Now with Light

Replace the tennis balls with a pair of identical laser pens, both pointing vertically downward. Release a light pulse from each onto the mirrored floor of the car and a very reflective icy roadway. Would not the paths traced by both laser beams be analogous to those by the tennis balls? And would not the same question arise – how can the times differ? If the times are the same, then the explanation is simple. In the car, the laser beam traveled at c vertically downward then upward. On the roadway, it traveled at $(c^2 + v^2)^{0.5} > c$ along symmetrical diagonals – no difference in times, only difference in distances due to difference in speeds.

Generalize to an array of laser pens at an origin (0,0) of a stationary reference frame such that each laser pen points at each integer of 360 degrees in a circle. It is a 'no-brainer' that, if the laser array is stationary, 360 pulses emitted simultaneously will travel like an omni-directional circular light wave (spherical in three dimensions, but we will stick with two for geometrical simplicity) from a point source. This is shown by the large grey circle comprised of the small circles in Figure 1.

All observers equidistant from (0,0) will see the same light beam at the same time [e.g., at 1.0 sec if located 1.0 light-sec from (0,0) in the Figure]. Now, assume the array of lasers moves to the right (positive x direction) at 0.2c. For each of the 360 lasers, the light beam will travel at the angle θ at which the laser points (relative to the positive x axis) at a speed of $c\{[0.2 + \cos(\theta)]^2 + \sin^2(\theta)\}^{0.5} = c[1.04 + 0.4\cos(\theta)]^{0.5}$. As shown by the red circle comprised of red triangles in Figure 1, we no longer have symmetry relative to (0,0), although we still have a circle, now centered at (0.2,0). However, since the light pulses were emitted from (0,0), they no longer reach observers equidistant from that point at the same time. Instead, they now reach observers equidistant from the shifted point (0.2,0) at the same time.

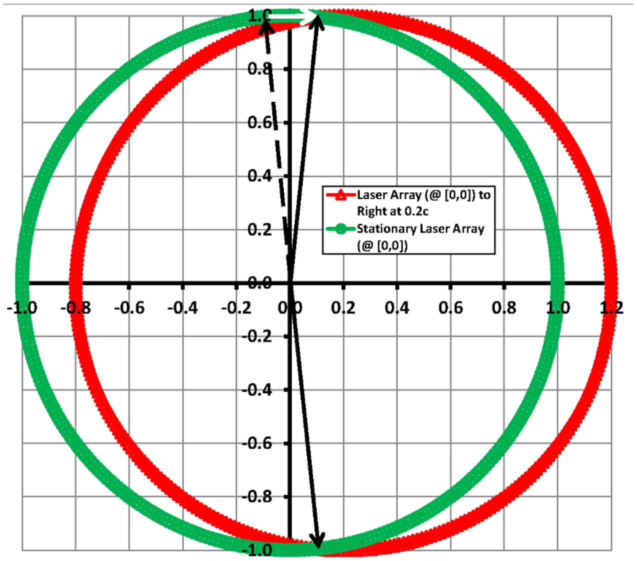

FIGURE 1. 360° Laser Array: Stationary vs. Moving at 0.2c to Right

In the Figure, the solid line(s) represents the vector sum(s) of the black dashed and solid white lines, such that this vector sum(s) = c. (The near-vertical dashed line is the light beam from the laser at speed c; the horizontal white line is the array's velocity at 0.2c.) These occur only at the following angles: $\pm[\arccos(-0.1) - \arccos(0.98)] = \pm 84.26^o$. (Recognizing that the triangle is isosceles, the law of cosines yields the following equation to be solved for α, the angle between the y axis and solid black line(s): $(0.2c)^2 = c^2 + c^2 - 2(c)(c)\cos[\arccos(\theta - \pi/2 + \alpha)]$, where $\theta - \pi/2$, the angle between the y axis and the dashed line, comes from the Pythagorean relation $c^2 = c^2\{[0.2 + \cos(\theta)]^2 + \sin^2(\theta)]\}$.) Therefore, any light beam issued from a laser pen pointing to the right of the solid black lines travels at speed > c, with the maximum (1.2c) at $\theta = 0^o$. Any light beam issued from a laser pen pointing to the left of these lines travels at speed < c, with the minimum (0.8c) at $\theta = 180^o$. Thus, only observers at $\theta = \pm 84.26^o$ and 1 light-sec from (0,0) see their respective light beams at 1.0 sec as before (when the array was stationary). An observer at x = (1,0) now sees his light beam sooner than before, at (1.0 - 0.2)/1.0 = 0.8 sec. An observer at x = (-1,0) now has to wait 1.0/0.8 = 1.25 sec before seeing his light beam. These differences have nothing to do with variation in time, only variation in light speed due to the moving source array. Note that the light beams themselves are still released relative to their lasers at constant speed c.

How could light, unlike sound or water waves, travel at different speeds in the same 'medium' (e.g., vacuum, if we can consider such as a medium) when, at least for sound or water waves, the medium itself determines the wave speed regardless of motion of the source? I speculate this is possible because light is not a 'wave' like sound or water waves, i.e., one which is actually the movement of the medium itself (either longitudinal [sound] or transverse [water]). If it has a medium (e.g., an aether, whatever that may be since it appears undetectable), then it is not the movement of the medium itself, but some other phenomenon. Since light obviously interacts with different material media (its speed slows as it passes through denser media, such as water), it cannot be the movement of the medium through which it passes. Can it even have a medium in the traditional sense?

4. Two Unique Theories for Light Propagation

I now examine two very interesting postulates about the nature of light and its propagation which, when combined, appear to offer a reasonable explanation for the nature of light and its observed properties.

4.1 Renshaw's Radiation Continuum Model

Renshaw postulates a new model of light, the Radiation Continuum Model (RCM), which I colloquially will call 'spring theory,' as it reminds me of the uncoiling of a spring fixed at one end. His detailed description follows. [1]

> Suppose we take a piece of clear elastic, very resilient and pliable, and one foot in length. We fasten one end of this elastic to a pole, and stretch the other end to a distance of one thousand miles. While it is stretched to this length, we place a faint white line every foot from the pole to the thousand-mile point. The elastic then looks like that in figure 1-1. Once we have completed marking the elastic, we allow it to return to its original one-foot length, still anchored at point *O* on the pole.
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> An important point about the way that an elastic material stretches is that any two points on the elastic always maintain the same relative separation. For example, if we place marks dividing the elastic into thirds, then as it is stretched these marks will continue to delineate three equal sections, as in figure 1-2. An implication of this is that each point on the elastic has a unique, unchanging speed as the elastic is being stretched ... These ratios of velocity and spatial separation hold for any combination of points on the elastic. In addition, for whatever speed the end of the elastic is moving forward, a unique point can be found somewhere on the elastic that is traveling at any speed we choose between zero and the speed of that end …
>
> Referring again to figure 1-1, suppose we take the loose end of the marked elastic and begin pulling it forward at a velocity of one thousand miles per hour. At the same instant, two automobiles driven by Alice and Bob pass the starting pole, traveling in the same direction as the stretching elastic. Alice, in the first auto, is traveling at twenty miles per hour, while Bob, in the second, is traveling at fifty miles per hour. Further, each automobile is carrying a camera and pointing it directly at the elastic stretching alongside. We assume a very low light level, such that a long time exposure is required to obtain any detail in a photograph taken by either camera … Each automobile begins a time lapsed photo thirty minutes after passing the starting pole, and allows the exposure to continue for thirty minutes.
>
> After the experiment is complete and the photos are developed, Alice and Bob each have a photo containing one distinct white line and nothing else. The reason for this is as follows: Given an elastic with one end stationary and one end moving forward at one-thousand miles per hour, a unique point can be found on the elastic whose velocity corresponds to any given value between zero and one-thousand miles per hour. Further, an automobile traveling at twenty miles per hour and passing the pole at the same instant the elastic commences being stretched will remain adjacent to the very point on the elastic that is also traveling at twenty miles per hour for the duration of the trip. Since there is a white line on the elastic at this

point, this line will appear to be stationary with respect to the camera in the car, and will therefore appear as a distinct white line on the photographic plate ...

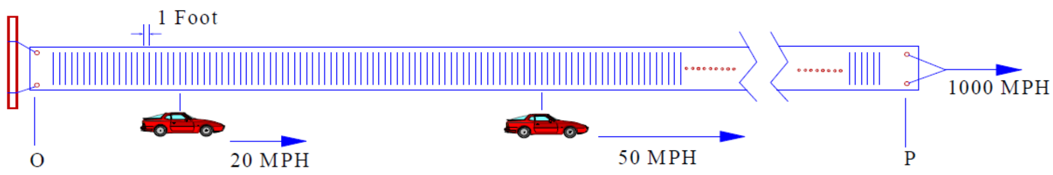
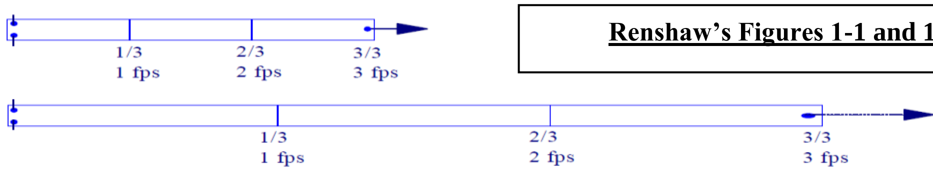


Figure 1-1 Each automobile will remain adjacent to a specific, mark on a piece of elastic stretching alongside them as long as they maintain a constant velocity



Renshaw's Figures 1-1 and 1-2.

Figure 1-2 As a piece of elastic is stretched, all points maintain their same velocities and relative separations.

When the experiment is over, Alice will conclude that the event she photographed was the release of an object with a faint white line at rest from her frame of reference (traveling at twenty miles per hour). Bob will conclude the event was the release of an object with a faint white line at rest from his frame of reference (traveling at a velocity of fifty miles per hour). If the experiment is repeated with many automobiles, all traveling at different velocities, the drivers will, after a time, conclude that the event was the release of an object with a faint white line exhibiting the unique property of appearing to be at rest from all frames of reference. In reality, the event was the release of, for all intents and purposes, an infinite stream of faint white lines, traveling at all velocities from zero to one-thousand miles per hour. The problem is that, due to the nature of the observer, only that aspect of the event remaining at rest with respect to the observer can be detected ...

A Constant Velocity for All Frames of Reference

Suppose now we repeat the above experiment with the following changes. The light requires only one second to expose the plate. Each automobile is a train, fifty feet in length. The camera is propelled from the back of the train towards the front at a velocity of ten miles per hour (Alice and Bob's trains are still assumed to be traveling at velocities of twenty and fifty miles per hour, respectively). The plate is exposed for the first second of the camera's trip down the length of the train ... This time, since the camera is moving at ten miles per hour with respect to the train, we have created a device that will record only objects that are moving at ten miles per hour with respect to the train … In this manner, each train rider knows that the apparatus will record only objects that are traveling at ten miles per hour with respect to the velocity of the moving train. Clearly, from the above arguments, Alice will conclude the event produced a glowing object traveling at ten miles per hour as observed from her frame of reference (traveling at twenty miles per hour). Bob will conclude that the event produced a glowing object traveling at ten miles per hour with respect to his frame of reference (traveling at fifty miles per hour). If the experiment is repeated with many trains, the common conclusion will be that the event was the release of an object exhibiting the unique property of an invariant velocity of ten miles per hour for all frames of reference.

Next imagine that we replace the camera in the above examples with a device that can only detect motion at the speed of light, *c*, relative to itself. The fast moving end of the elastic will need to move forward at a speed not less than *c* plus the velocity of any potential observer. For the time being, let us agree with Einstein and state that no observer will be traveling faster than *c*. This being the case, the elastic must be pulled forward with a velocity of at least two times *c* in order for all possible experimenters to record the white-line phenomena. When the experiment is performed by many people, all traveling at different speeds, they will undoubtedly come to a common conclusion — the event appears to be the release of an object that travels at the speed of light, *c*, from all frames of reference ...

The Radiation Continuum Model of Light

… Based on the analysis of the previous sections, we are ready to propose what we will call the radiation continuum model (RCM) of light. In this model, light does not radiate from its source at a constant velocity of *c*. Rather it emanates in the same manner as a piece of elastic, anchored at the source, with one end pulled forward at a constant velocity *C*, with the upper case *C* denoting a velocity that is potentially much greater than *c*, and is very probably infinite. This being the case, there will be a component of the light that is traveling at any speed we pick in the range from zero to *C*. As important a characteristic of this model of light, and of living and electro-mechanical observers, is that only that component of light that is striking the observer at a relative velocity of *c* in the observer's frame of reference will be detected … That is to say that regardless of our velocity, any light we perceive will appear to be striking us at approximately 300,000 kilometers per second (km/sec).

One of the more significant implications of the radiation continuum model of light is that it allows a more intuitive 'Galilean' structure of space and time. By Galilean, we mean that the laws of electromagnetic radiation would conform to Galilean transformations, just as Newton's laws of motion do. Under such a transformation the concepts of space and time are absolute … Now, without specifying an upper limit on the speed of light *C*, we have developed a model of light as a rubber band anchored at its source and moving forward through space at all speeds from zero to *C* [hence my term 'spring theory']. There is no obvious reason to set a bound on *C* at any value short of infinity. [Renshaw does not postulate an infinite speed, but rather a limiting speed C >> c.]

4.2 Calkins' *Relativity Revisited*

Calkins examines the nature of light from first principles, starting with the behavior of waves with which we are quite familiar – sound and water waves. [2] He postulates that the electro-magnetic 'field' of light itself comprises its propagating 'medium,' analogous to what at least is partially occurring with the more familiar, tangible media like air or water for sound and water wave propagation. To me, this suggests an interesting analogy with one of McLuhan's observations, namely that "the medium is the message" (https://en.wikipedia.org/wiki/The_ medium_is_the_ message). Calkins' detailed description follows.

> This segue through Maxwell's equations was made to develop an understanding of how the determinants of the speed of light compare with those of the speed of sound. But before we do that, it's worth noting some of the implications and interpretations about electromagnetism that have resulted from the structure of Maxwell's equations ... When the electric current is removed [from Maxwell's fourth equation], the electric field is reduced to the same dependency on the magnetic field as the magnetic field always has on the electric field. Once an electromagnetic wave leaves its source, the only electric field it contains is the kind created by a moving magnetic field. This codependency between the two fields in an electromagnetic wave is why it can be said that when a photon stops moving, it ceases to exist ...
>
> [T]he values of ε_0 and μ_0 are not coincidental. There are underlying physical phenomena that cause them to have the values that they do. By treating them as mere constants we end up with an equation for the speed of light [$c = (\varepsilon_0\, \mu_0)^{-0.5}$] that depends on no identifiable physical phenomenon … To see how this compares with the speed of sound, let's look at what is going on inside the equation for the speed of sound: $v = (B_\alpha/\rho_\alpha)^{0.5}$ … [where] B_α is the bulk modulus of air. It describes air's resistance to compression: $B_\alpha = -\Delta p/(\Delta v/v_0)$ … [T]he value of B_α is determined by the change in pressure (Δp) that is required to reduce the volume by a given amount (Δv) relative to the initial volume (v_0). (The minus sign just means that the pressure and volume change in opposite directions. When pressure is increased, volume is reduced …). The more pressure that is required to produce a given reduction in volume (i.e., the harder it is to compress the medium), the greater the value of B_α and … the faster the wave will move. ρ_α is the density of air. The greater the density, the slower the wave will move. These two characteristics of air are what determine the speed of sound. This is pretty straightforward when dealing with a stationary, physical medium such as air. It is less clear when we are dealing with light propagating through what is presumed to be the vacuum of free space …
>
> What determines the speed of sound is the amount of resistance its longitudinal wave encounters when pushing atoms of air more closely together, thereby forcing an increase in the electric and magnetic field density of their charged particles … An electric field that changes in time does not directly create an electric field that moves in space. What it does is create a magnetic field which, in turn, creates the next electric field. Ditto for the magnetic field's change in time which produces an electric field that is the source of the subsequent magnetic field … The medium of propagation of the moving electric field is the magnetic field it must push into existence as an unavoidable consequence of its movement. The magnetic field starts with zero density and moves to greater density as the moving electric field pushes it into existence. It is in the nature of the field to resist having its density increased. This is the same physical phenomenon that largely determines the bulk modulus of air [plus molecules of air bouncing off each other]. The magnetic field being pushed into existence has a field density and a bulk modulus (i.e., an innate resistance to being compressed). It is inarguable that the magnetic field is a medium of propagation since it is actively created by the moving electric field; the next electric field in the wave cannot be created without it and it is the active element in that field's creation. The same happens when the magnetic field returns the favor by pushing the next electric field into existence. The same phenomena are at work in a similar manner for the propagation of light as for the propagation of sound. They are the bulk modulus and density of their mediums of propagation. In the case of sound, the medium (air) is physical and stationary. Light, on the other hand, takes its mediums along with it. But in both cases the waves' propagation through their medium(s) is governed by the physics of electric and magnetic field compression.
>
> What we failed to realize when we accepted ε_0 and μ_0 as simple constants … is their underlying physical significance. ε_0 is not the 'permittivity of free space;' it is the ratio of the electric field's density to its bulk modulus: $\varepsilon_0 = \rho_E/B_E$ … Likewise, $\mu_0 = \rho_B/B_B$ is the ratio of the magnetic field's density to its bulk … Substituting these ratios into the equation for the speed of light gives us: $c = (\varepsilon_0\, \mu_0)^{-0.5} = (B_E\, B_B/\rho_E\, \rho_B)^{0.5}$. [Through personal conversation with Calkins, he agrees that a more dimensionally consistent representation for these would be as follows: $\varepsilon_0\, \mu_0 = \rho_{EM}/B_{EM}$, such that $c = (\varepsilon_0\, \mu_0)^{-0.5} = (B_{EM}/\rho_{EM})^{0.5}$, where 'EM' represents the 'combined' electric and magnetic (electro-magnetic) fields, which work in unison as light's propagating 'medium.' The ensuing analogy with sound and all subsequent conclusions remain the same with this slight modification.] This compares with the speed of sound: $v = (B_\alpha/\rho_\alpha)^{0.5}$ … The only difference in the structure of the two equations is that the parameters for the electric and magnetic fields are separately stated in the equation for the speed of light whereas their effects are combined in the pressure, volume and density parameters of air for the speed of sound.

4.3 Assimilation

Having provided rather lengthy (albeit somewhat compressed) discussions of these two very interesting postulates, I believe they can be combined into a reasonable description of the 'observed' constancy of the speed of light from a stationary source in any particular 'medium,' while allowing this speed to vary within the same medium with a moving source. To me, Renshaw's 'spring theory' for light is analogous to the following simple example. Consider a cannon in space (no friction, essentially no gravity), sealed at one end, open at the other, containing five cannon balls of exactly the same size and mass 'm,' each with a fixed type and amount of explosive charge between them (including one between the first ball and the sealed end of the cannon) such that, when any charge is detonated, it applies the same force 'F' linearly along the cannon tube.

If all five charges are detonated simultaneously (perhaps via some electrical means, whereby the signal to each essentially arrives simultaneously), the total force exerted on each cannon ball will be the sum of the forces from each charge lying between it and the sealed end of the cannon, i.e., 5F for the ball at the open end, 4F for the next, etc., down to F on the ball next to the sealed end. And each force will act on a total mass equal to the number of balls between it and the open end of the cannon, i.e., m for the charge between the two balls nearest the open end, 2m for the next, etc., up to 5m for the charge between the ball and the sealed end. Implicit here is an assumption that the inertia of the balls results in all forces 'pushing' off against the sealed end (via 'action-reaction' through the various balls, depending on location [which are initially stationary due to inertia when the charges detonate], before any motion takes place). Therefore, the forces as well as the masses can be combined based on the various positions of the balls and charges, with all force and any resulting motion directly solely in the direction of the open end.

Numbering the balls from n = 1 to 5, with 1 being at the sealed end and 5 at the open, the respective acceleration 'a' imparted on each is as follows: $a_n = nF/\{[5 - (n - 1)]m\} = [n/(6 - n)](F/m)$. In units of F/m, the ratio of accelerations from the ball at the sealed end to that at the open end are: 1/5 : 1/2 : 1 : 2 : 5. As the cannon is in space with essentially no gravity, once ejected, the balls will attain constant speeds 'v' determined by the time interval 'Δt' over which the explosive charges detonated via the equation $v = a\Delta t$. Since Δt was the same for all five detonations, the ratios of the five balls' velocities will be the same as those for their accelerations. The three ratios of the four distances 'Δx' between them will also remain the same even as these distances increase over time 't,' since $\Delta x = vt$, i.e., [(1 – 1/2)/(1/2 – 1/5) = 5/3] : [(2 – 1)/(1 – 1/2) = 2] : [(5 – 2)/(2 – 1) = 3].

For this to be analogous to Renshaw's 'spring theory,' which sees the 'elastic' ever expanding with widening differences between the procession of points at increasing but constant speeds, each cannon ball must continue at a differing but constant speed according to these ratios. If we view these cannon balls as 'points' along a light beam (the choice of the word 'points' does not necessarily imply any particle-like nature to the light beam, such as discrete photons -- it merely corresponds to locations along the beam), then for the beam to be analogous to Renshaw's elastic AND Calkins' wave, it requires a medium to limit it to a constant speed (actually a range of constant speeds, strewn along the beam, since the 'fastest' end of Renshaw's elastic or beam proceeds at some maximum, constant speed $\geq 2c$).

Now we take advantage of Calkins' "medium is the message" approach, which provides us with a medium for light, other than the traditional aether or the non-existent medium of a vacuum, i.e., the electromagnetic field itself. As with other media (albeit non-material), it still provides a means by which to limit the light wave to a constant speed, namely c when in a vacuum from a stationary source. In summary, combining the two postulates of Renshaw and Calkins, one seemingly reasonable model for light is Renshaw's RCM that allows light to travel over a wide range of speeds, but due to Calkins' electromagnetic medium (which provides 'resistance'), limited to being observed at constant speed in a particular medium when emitted from a stationary source.

5. Conclusion

If light travels at a constant speed in a given medium when emitted from a stationary source, and if it is analogous to sound or water waves, then it would not exhibit different speeds when emitted from a moving source within the same medium, only the traditional Doppler Shift, i.e., change in frequency and wavelength, but not speed. However, I have already postulated that light behaves 'Galileanly' by acquiring the velocity vector of a moving source, allowing for speeds different from c. [3] Renshaw supports this by assuming the source motion 'moves' the observer to a different point on the elastic, or light beam where, while a constant speed is still observed, the 'true' speed differs from c. But this does not align with Calkins' analogy of light with sound and water waves, where the wave speed is invariant due to the resistance of the medium, regardless of the source's motion. However, if one considers light to be a different type of wave from sound or water, at least partially, perhaps these can be rectified.

In air or water, or any other material medium, Calkins acknowledges the role of the medium itself to providing resistance to the wave in addition to that inherently provided by the compression of any electromagnetic fields already present due to the atoms comprising the medium. Thus, a moving source in such a medium has its speed limited by the resistance from that medium itself. However, if the material medium itself were also moving in its entirety, say along with the source, then the net result would be a wave propagating at the constant speed in the medium itself PLUS that speed of the moving medium (summed vectorially), at least to an outside observer (i.e., one not moving with the moving medium). Light has no material medium in the sense of that for sound or water waves – only the electromagnetic field itself. Therefore, when the source (of light) moves, the electromagnetic field (the medium) moves along with it, since the medium is generated from the source. Could not this be the analogy that allows for Galilean addition of the $\underline{c}$ and $\underline{v}$ vectors for a moving source of light? And from Renshaw's RCM approach, could not this speed of light different from c correspond to being able to observe the true speed from a different point along the elastic beam?

6.0 References

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2nd Annual John Chappell Natural Philosophy Society Conference

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SPECIAL CAR RIDE (BOCCE BALLS)

- Riding in a car moving a constant speed v, you hold a bocce ball (hard surface) in each hand. You place the ball from your left hand on the car floor while reaching out from the car and placing the ball from your right hand on the icy shoulder of the road.
  - Relative to you, both balls maintain a stationary position.
  - Relative to the roadway or an observer on the roadway, both balls move forward parallel to each other and you.
  - If you picked both balls up after 10 sec on your watch, Einstein would say that you would see that the observer's watch registered < 10 sec. The observer would see you picking up the balls at > 10 sec on his Einstein watch.

SPECIAL CAR RIDE (BOCCE BALLS)

- If all seconds are created equal, then for the observer to explain how you were able to pick up both balls at the same instant and location, you must have traveled faster than v [since only (> v) x 10 sec can equal v x (> 10 sec)].
  - But if you had traveled faster than v, you would not have been able to pick up the ball on the roadway after 10 sec on your watch, for it would have fallen behind, unless it, too, traveled faster than v. But then we are back to both balls traveling at the same speed relative to the roadway, albeit now > v.
  - Since you obviously retrieved both balls and the observer saw this, then someone's watch is wrong.

SPECIAL CAR RIDE (TENNIS BALLS)

- Now you are holding a pair of tennis balls, one which you simultaneously bounce vertically from your left hand in the car and one vertically from your right hand on the roadway, catching both at your hands' release points at the same time (and position, relative to you).
  - Relative to you, both travel down and up along the same line – there is no horizontal displacement. The observer sees the same, relative to you.
  - Relative to the roadway, both follow diagonally symmetric paths, which both you (remember your glass floor) and the observer see equally. Relative to you, the distance traveled is purely vertical and shorter than that relative to the roadway, which has horizontal displacement as well.

SPECIAL CAR RIDE (TENNIS BALLS)

- Your watch registered 1 sec from toss to catch for each ball. The observer's Einstein watch registered something else, < 1 sec from your perspective; > 1 sec from his.
  - Relative to you, as seen by you and the observer, both balls traveled the same vertical-only distance at the same speed.
  - Relative to the roadway, both balls traveled the same diagonal distance (horizontal and vertical) at the same speed, again as seen by you and the observer.
  - How can the times differ?

SPECIAL CAR RIDE (LASER PENS)

- Replace the tennis balls with a pair of identical laser pens, both pointing vertically downward. Release a light pulse from each onto the mirrored floor of the car and a very reflective icy roadway. Would not the paths traced by both laser beams be analogous to those by the tennis balls? And would not the same question arise – how can the times differ?
  - If the times are the same, then the explanation is simple. In the car, the laser beam traveled at c vertically downward then upward. On the roadway, it traveled at $(c^2 + v^2)^{0.5} > c$ along symmetrical diagonals – no difference in times, only difference in distances due to difference in speeds.

SPECIAL CAR RIDE (LASER PEN ARRAY)

- Generalize to an array of laser pens at an origin (0,0) of a stationary reference frame such that each laser pen points at each integer of 360 degrees in a circle.
  - It is a 'no-brainer' that, if the laser array is stationary, 360 pulses emitted simultaneously will travel like an omni-directional circular light wave (spherical in three dimensions, but we will stick with two for geometrical simplicity) from a point source.

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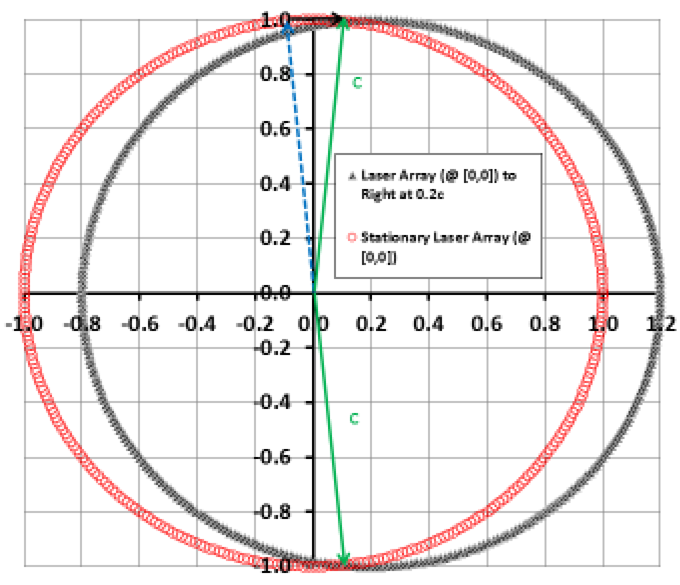

The green line(s) represents the vector sum(s) of the blue dashed (light beam from the laser at speed c) and **black** lines (array's velocity at 0.2c) such that this vector sum(s) = c. Recognizing that the triangle is isosceles, the law of cosines indicates that these occur only at the following angles: $\pm$[arcos(-0.1) – arcos(0.98)] = $\pm$**84.26º**. Therefore, any light beam issued from a laser pen pointing to the **right of the green lines travels at speed > c**, with the maximum (1.2c) at θ = 0º. Any light beam issued from a laser pen pointing to **the left of these lines travels at speed < c**, with the minimum (0.8c) at θ = 180º.

Only observers at θ = ±84.26º and 1 light-sec from (0,0) see their respective light beams at 1.0 sec as before (when the array was stationary).

An observer at x = (1,0) now sees his light beam sooner than before, at (1.0 - 0.2)/1.0 = 0.8 sec.

An observer at x = (-1,0) now has to wait 1.0/0.8 = 1.25 sec before seeing his light beam.

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SPECIAL CAR RIDE (LASER PEN ARRAY)

- These differences have nothing to do with variation in time, only variation in light speed due to the moving source array. (Note that the light beams themselves are still released relative to their lasers at constant speed c.)
- How could light, unlike sound or water waves, travel at different speeds in the same 'medium' (e.g., vacuum, if we can consider such as a medium) when, at least for sound or water waves, the medium itself determines the wave speed <u>regardless of motion of the source</u>?

WHAT IS THE NATURE OF LIGHT?

- I speculate that light is not a 'wave' like sound or water waves, i.e., one which is actually the movement of the medium itself (either longitudinal [sound] or transverse [water]).
  - If light has a medium (e.g., an aether, albeit to date undetectable), then it is not the movement of the medium itself, but some other phenomenon.
  - Since light obviously interacts with different material media (e.g., speed slows as it passes through denser media), it cannot be the movement of the medium through which it passes.
  - Can it even have a medium in the traditional sense?

TWO UNIQUE THEORIES FOR LIGHT

- Renshaw (*Restoration of Space & Time: Galilean-Newtonian Relativity in the 21st Century*, http://renshaw.teleinc.com/Book/Chapter%201%20-20A%20 Model%20of%20Light.pdf)
  - Radiation Continuum Model (RCM)
- Calkins (*Relativity Revisited*, http://www.calkinspublishing.com/)
  - Light as its Own Medium

RENSHAW'S 'SPRING THEORY'

Figure 1-1 Each automobile will remain adjacent to a specific, mark on a piece of elastic stretching alongside them as long as they maintain a constant velocity

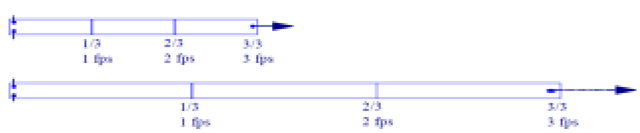


Figure 1-2 As a piece of elastic is stretched, all points maintain their same velocities and relative separations.

http://renshaw.teleinc.com/Book/Chapter%201%20-20A%20 Model%20of%20Light.pdf

RENSHAW'S RCM

- In this model, light does not radiate from its source at a constant velocity of c, but in the same manner as a piece of elastic, anchored at the source, with one end pulled forward at a constant velocity C (upper case C potentially >> c).
  - A component of light travels at any speed in the range from zero to C with the key characteristic of this model of light, and of living and electro-mechanical observers, that only that component of light that strikes the observer at a relative velocity of c in the observer's frame of reference will be detected.
  - <u>Regardless of our velocity, any light we perceive will appear to strike us at ~ 300,000 km/sec</u>.

RENSHAW'S RCM

- RCM allows a more intuitive 'Galilean' structure of space and time, where the laws of electromagnetic radiation conform to Galilean transformations as do Newton's laws of motion.
  - The concepts of space and time are absolute.
  - Without specifying an upper limit on the speed of light C (upper case), Renshaw developed a model of light as a rubber band anchored at its source and moving forward through space at all speeds from zero to C.

CALKINS' 'LIGHT AS ITS OWN MEDIUM'

- Calkins examines the nature of light from first principles, starting with the behavior of familiar sound and water waves.
  - He postulates that the electro-magnetic 'field' of light itself comprises its propagating 'medium,' analogous to what at least is partially occurring with the more familiar, tangible media like air or water for sound and water wave propagation.
    - This suggests an interesting analogy with one of McLuhan's observations, namely that "the medium is the message"
      - This codependency, characterized by ε_0 (free space permittivity) and μ_0 (free space permeability), is not coincidental.

CALKINS' "MEDIUM IS THE MESSAGE"

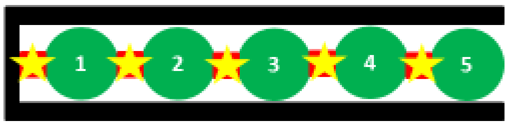
- For the speed of sound: v(elocity) = $(B_\alpha/\rho_\alpha)^{0.5}$, where B_α = bulk modulus of air, describing air's resistance to compression: $B_\alpha = -\Delta p/(\Delta V/V_0)$, where Δp = change in pressure needed to reduce the volume by a given amount (ΔV) relative to the initial volume (V_0). These two characteristics of air determine the speed of sound.
  - The same phenomena are at work for the propagation of light as for the propagation of sound. They are the bulk modulus and density of their mediums of propagation.

CALKINS' "MEDIUM IS THE MESSAGE"

- The underlying physical significance of ε_0 and μ_0 are as follows:
  - ε_0 is not only the 'permittivity of free space,' but also the ratio of the electric field's density to its bulk modulus: $\varepsilon_0 = \rho_E/B_E$. $\mu_0 = \rho_B/B_B$ is not only the 'permeability of free space,' but also the ratio of the magnetic field's density to its bulk.
    - Substituting these ratios into the equation for the speed of light gives us: $c = (\varepsilon_0\ \mu_0)^{-0.5} = (B_{EM}/\rho_{EM})^{0.5}$, where 'EM' represents the 'combined' electric and magnetic (electro-magnetic) fields, which work in unison as light's propagating 'medium.' This compares with the speed of sound: $v = (B_\alpha/\rho_\alpha)^{0.5}$
    - The only difference in the two equations is that the electric and magnetic field parameters are separately stated in the equation for the speed of light, whereas their effects are combined in the air pressure, volume and density parameters for the speed of sound.

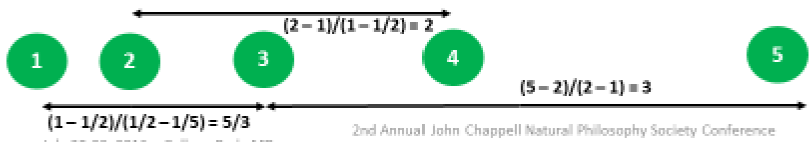
ASSIMILATING THE TWO THEORIES

- I now attempt to combine Renshaw's and Calkins' theories into a reasonable description of the 'observed' constancy of the speed of light from a stationary source in any particular 'medium,' while allowing this speed to vary within the same medium with a moving source.
  - Assume Renshaw's 'spring theory' for light is analogous to a cannon in space (no friction, essentially no gravity), sealed at one end, open at the other, containing five cannon balls of exactly the same size and mass 'm,' each with a fixed type and amount of explosive charge between them (including one between the first ball and the sealed end of the cannon) such that, when any charge is detonated, it applies the same force 'F' linearly along the cannon tube.



Space cannon with balls (green) and charges (red).

With all five charges detonated simultaneously, the respective acceleration 'a' imparted on each ball is as follows: $a_n = nF/\{[5 - (n - 1)]m\} = [n/(6 - n)](F/m)$.
In units of F/m, the ratio of accelerations from the ball at the sealed end to that at the open end are: 1/5 : 1/2 : 1 : 2 : 5.
As the cannon is in space with essentially no gravity, once ejected, the balls will attain constant speeds 'v' determined by the time interval 'Δt' over which the explosive charges detonated via the equation $v = a\Delta t$. Since Δt was the same for all five detonations, the ratios of the five balls velocities will be the same as those for their accelerations. The three ratios of the four distances 'Δx' between them will also remain the same even as these distances increase over time 't,' since $\Delta x = vt$, i.e., [(1 – 1/2)/(1/2 – 1/5) = 5/3] : [(2 – 1)/(1 – 1/2) = 2] : [(5 – 2)/(2 – 1) = 3].



ASSIMILATION

- For this to be analogous to Renshaw's 'spring theory,' which sees the 'elastic' ever expanding with widening differences between the procession of points at increasing but constant speeds, each cannon ball must continue at a differing but constant speed according to these ratios.
  - If we view these cannon balls as 'points' along a light beam, then for the beam to be analogous to Renshaw's elastic AND Calkins' wave, it requires a medium to limit it to a constant speed (actually a range of constant speeds, strewn along the beam).

ASSIMILATION

- Now take advantage of Calkins' "medium is the message" approach, which provides a medium for light, other than the traditional aether or the non-existent medium of a vacuum, i.e., the electromagnetic field itself.
  – As with other media (albeit non-material), it still provides a means by which to limit the light wave to a constant speed, namely c when in a vacuum from a stationary source.

SUMMARY

- Combining the two postulates of Renshaw and Calkins, one seemingly reasonable model for light is Renshaw's RCM that allows light to travel over a wide range of speeds, but due to Calkins' electromagnetic medium (which provides 'resistance'), limited to being observed at constant speed in a particular medium when emitted from a stationary source.

CONCLUSION

- I postulate that light behaves 'Galileanly' by acquiring the velocity vector of a moving source, allowing for speeds different from c.
  - Renshaw's 'spring theory' supports this by assuming the source motion 'moves' the observer to a different point on the elastic, or light beam where, while a constant speed is still observed, the 'true' speed differs from c.
  - In a material medium, Calkins acknowledges that the medium itself provides resistance to the wave in addition to that inherently provided by the compression of any electromagnetic fields due to the atoms of the medium.
  - A moving source in such a medium has its speed limited by the resistance from that medium itself.

QUESTIONS

- Light has no material medium – only the electromagnetic field itself. Therefore, when the source (of light) moves, the electromagnetic field (the medium) moves along with it, since the medium is generated from the source.
  - Could not this allow for Galilean addition of the $\underline{c}$ and $\underline{v}$ vectors for a moving source of light?
  - From Renshaw's RCM approach, could not this speed of light different from c correspond to being able to observe the true speed from a different point along the elastic beam?