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Revisiting the Michelson-Morley experiment: Source Velocity might be imposing on light velocity

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Abstract:
According to the perceptions of common man, if speed of light is finite then it must be relative. It should depend upon relative motion between source and observer. On this view, starlight aberration and inverse of it too is discussed. Further, the effect of motion of source on light velocity is analyzed when their velocities are perpendicular and parallel to each other. It is found that the velocity of source is being imposed on velocity of light.

1. Introduction

‘*Velocity of light in vacuum is constant. It does not depend on the state of motion of source or observer.*’

This conclusion, drawn from Michelson-Morley experiment, is beyond the perception of common man.

Common man thinks that, is the velocity of light in vacuum finite? Yes.

Then the velocity of light with respect to a man moving with velocity *v* along the direction of motion of the light should be *c*-*v*.

If it is *c* again, then it is a magic.

Science does not believe in magic.

Here these things are reinvestigated using common man perception.

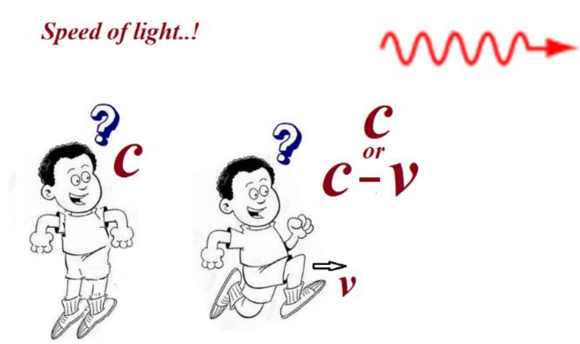

Figure 1. Two common guys thinking about speed of light.

2. Michelson-Morley experiment

Michelson and Morley designed an apparatus, in order to find out the velocity of earth in the ether, which is a hypothetical medium responsible for propagation of light. They carried series of observations in the year 1887 and afterwards [1].

Aim: To determine velocity of earth with respect to ether with assuming that velocity of light is constant with respect to ether. Earth travels in ether and after 6 month it travels in opposite direction, therefore, velocity of light recorded at these two events would be different giving the velocity of earth with respect to the stationary ether.
Findings: No changes in the velocity of light at these two events.

Conclusion: No ether is required for propagation of light. Light travels in vacuum with constant velocity independent of state of motion of source.

Discrepancy in the conclusions and the results of Michelson-Morley experiment: Michelson-Morley experiment was designed to measure the difference in velocities of light when apparatus moves in ether in two opposite directions, with assuming that speed of light would be constant with respect to the stationary ether. The apparatus was not designed to measure the speed of light directly when the light source is in motion with respect to the apparatus. Therefore, one cannot conclude from the results of Michelson-Morley experiment that the speed of light is constant and is independent on the state of motion of source or observer.

Appropriate conclusion from Michelson-Morley experiment: The results do not confirm ether. If ether exists then it does not maintain speed of light constant with respect to itself.

Purpose of this presentation is to find out which property of the ether, if exists, or of vacuum too is responsible to produce null results in the Michelson-Morley experiment.

3. Starlight aberration

Aberration is a phenomenon which produces an apparent position of a celestial object from its true position. It is due to the relative velocity of the observer with respect to the celestial object which can be explained using figure 2(a).

Earth is moving with a velocity $v = 3 \times 10^4\ m/s$ around the sun. An observer, if wants to locate a star above his head, let at position A by a telescope T, then he will not be able to locate its correct position. If he directs the telescope towards the correct position of the star, the light coming from the star when enters the telescope through point *a* and while going toward the point *b*, the telescope has been shifted towards the right side because of which the light will not reach to the point *b* of the telescope and hence the observer will not be able to see the star. If he tilts the telescope in the direction of motion, as shown in figure 2(b), such that the light entered at position *a* will manage to reach at position *b* without any obstacle while travelling the telescope towards the right then he will be able to see the star. But now the observed position of the star will be at position A_2 instead of A_1 which is its correct position and A_2 is its apparent position. This phenomena is confirmed experimentally and is called starlight aberration. Reverse of this event must happen [2] is discussed next which carries more importance.

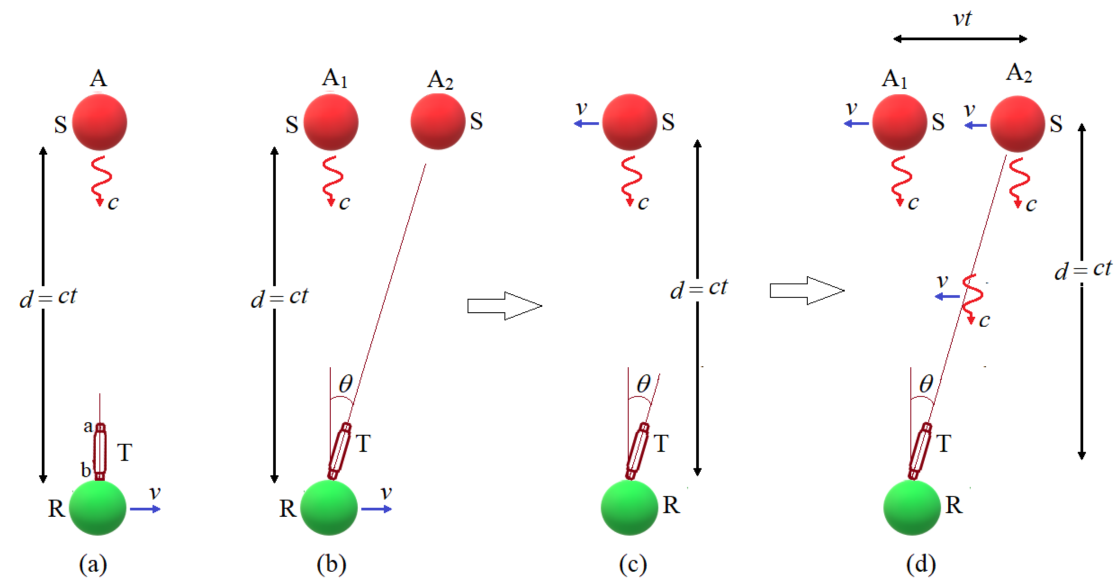

Figure 2. Starlight aberration, (a) and (b) observer in motion, (c) and (d) source in motion. A_1 and A_2 are true and apparent positions of source respectively.

3.1 Starlight aberration in reverse

Velocity is relative. If an object A is moving with uniform velocity $\boldsymbol{v}$ relative to another object B in space means it is the rate of change of position of the object A with respect to object B or vice versa. It is impossible to predict that which object is rest and which is moving. It gives freedom to make choice of frame of reference in which either object A is rest or object B is rest. Therefore, starlight aberration should also occur when source is in motion and observer is rest as shown by figure 2(c). Only relative motion between them is needed. In this case also the observer will have to tilt the telescope in appropriate direction to locate the position of the light source or star as shown in figure 2(d). The light entering into the telescope now has two velocities, c and v, where c is the velocity of light and v is the velocity of the source. Thus the velocity of the source is found to be imposed on the velocity of light. Without use of starlight aberration one can also prove this effect using the general motion of objects in space.

4. Effect of source velocity on light velocity: source moving perpendicular to light propagation

Consider figure 3(a) where a light source and a receiver are separated by a distance d. Source emits light pulse which receives by the receiver in time t, therefore, $d = ct$. An observer O, which is at rest, observers this event. Suppose there is another observer O' with respect to him the source S, the receiver R and first observer O are all moving with uniform velocity v to the right as shown in figure 2(b). The observer O' also observes the same event and finds that the receiver R receives the light at the same time *t.* But as the source and the receiver are in motion, therefore, he finds changes in positions while at the time of receiving the light. He notices that at time $t=0$, the source was at A_1 receiver was at B_1 and the light was emitted. In time *t*, the source has moved to position A_2 and receiver at position B_2 where the light is received. Thus the light has travelled along the diagonal with velocity *v* to the right and with velocity *c* in downward direction. Thus he finds that the velocity of the source is imposed on the velocity of light. It is expressed in terms of figure 3(c). One may think that how the observer O' have detected all the positions. For that one can use other technique to note this event. Suppose four observers having clocks synchronized are placed at positions A_1, A_2, B_1, and B_2 and note the event and then conclude together. They will conclude the same.

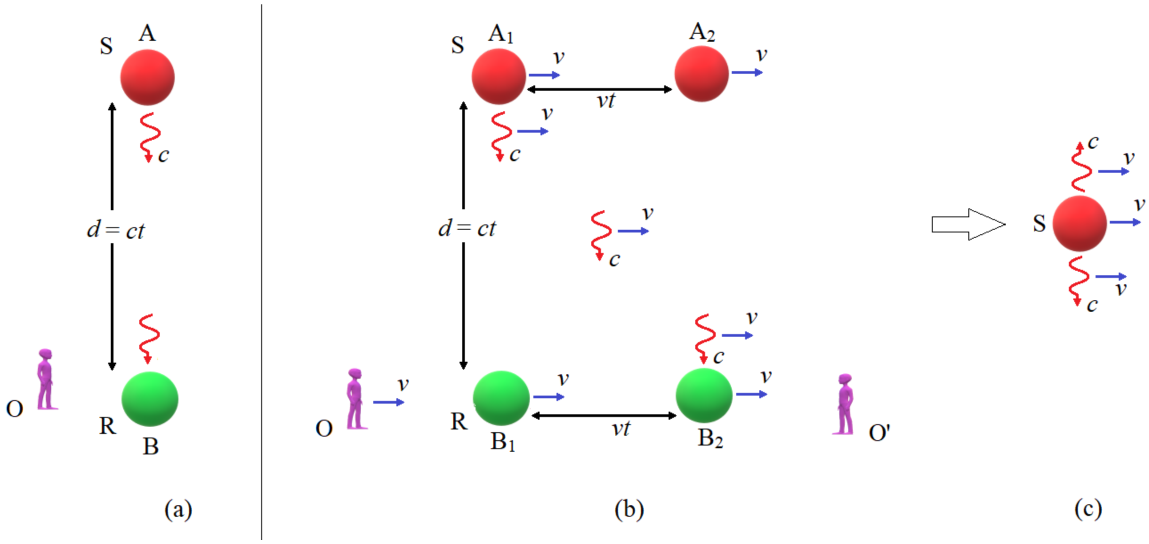

Figure 3. (a) Source, receiver and observer are at rest. (b) Source and receiver are moving with uniform velocity *v* to the right of the observer O'. (c) Velocity of source is imposed on velocity of light.

4.1 Experience in daily life

At first one may surprise that how it is possible. Consider another example of solid objects such as a canon fires a ball with velocity *w* to hit a target T as shown in figure 4(a). If observer is at rest with respect to the canon observes this event then his observations will be similar to that of in figure 3(a). Now suppose the canon and the target are moving to right with velocity *v* with respect to another observer O' then his observations will be similar to that of observations made in a figure 3(b). He concludes that the ball fired by the canon has a two velocities *w* and *v*, where *w* is the velocity of the ball due to firing of canon and *v* is the velocity of the canon. This types of events we observe in daily life. Surprisingly this is also happening for light.

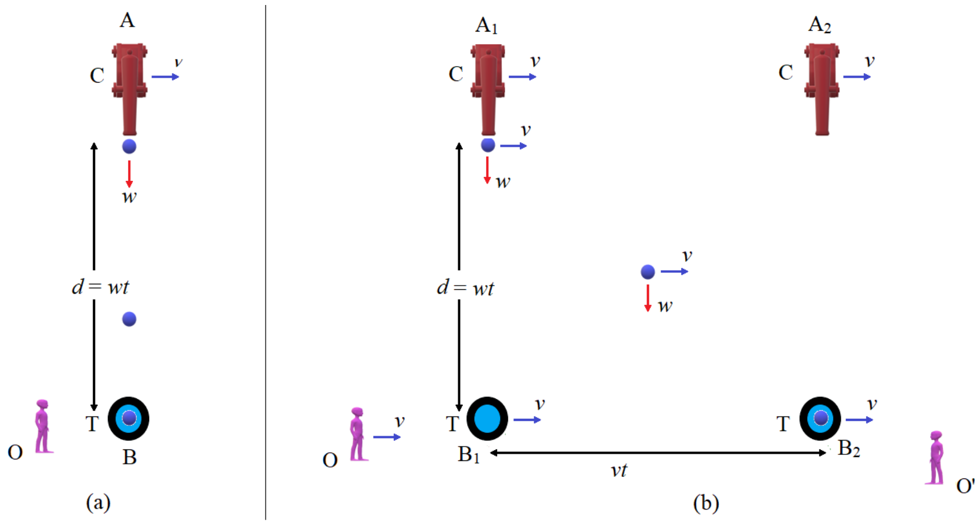

Figure 4. (a) Canon, target and observer are at rest. (b) Canon and target are moving with uniform velocity v to the right of the observer O'.

4.2 Experimental verification of light aberration when source in motion

In starlight aberration, observer on earth surface moves with orbital velocity 30 km/s around the sun and observes the aberration of light. Such types of aberration should also be observed if the light source is in motion instead of the observer. For that the source emitting light is to be moved with high velocity to get significant result. Fortunately, laser sources are available for production of sharp beam of light but to move them in high velocity may become a grueling task.

Let us put a laser source on a rotating arm. The arm may be rotated with required speed to get high tangential velocity where the laser beam emerges in perpendicular to it. The expected aberration in laser beam may be observed at suitable distance from the source. Such type of designing is illustrated in figure 5 which consists of a portable laser source producing sharp beam of light fixed on one end of the arm. The screen is fixed at distance d and a slit in front of the laser source. At first, keeping the laser source S at rest, spot x_1 is marked on the screen where the laser light falls on screen. Further, rotate the arm with suitable rpm w and mark point x_2 on the screen of the laser light. Now it may be difficult to locate exact laser point on the screen due to the diffracted and scattered laser light from the edges of the screen. A telescope may be used for observations. Due to the rotational velocity of the shaft, tangential velocity attained by the laser source would be $2\pi Rw$, where R is radius of the arm. For instance, R = 3m, w = 3000rpm, the tangential velocity comes to, v = 942m/s. As, c = 2.99792×10^8m/s, it gives c/v = 318250.5 indicating to get 1cm displacement of the laser spot on the screen, for this rpm, the screen should be placed at distance 3.182505 km from the source. This distance appears to be large, but the results obtained will have exalted importance. Instead of setting the screen up to such large distance, one may take multiple reflections of the due beam in two parallel plane mirrors separated by a fixed distance and obtain suitable traveled path before examination. Such types of alternatives may be used, on demand of situations, at the time of performance of the experiments. Results of this experiment will confirm that the velocity of laser source is imposed on velocity of laser light when both velocities are perpendicular to each other.

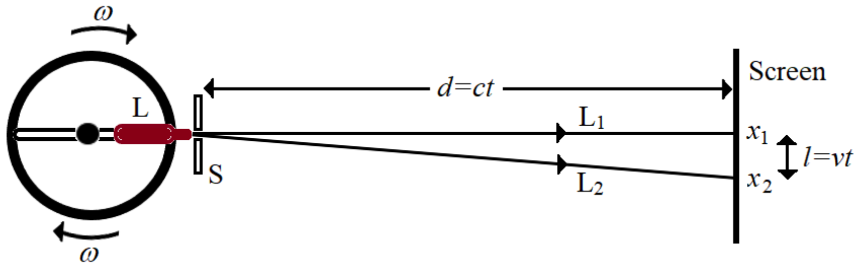

Figure 5. Laser light aberration experiment confirming velocity of laser source is imposed on velocity of laser light.

5. Effect of source velocity on light velocity: source velocity and light velocity are parallel

Now we investigate what effect could be produced on velocity of light when the source moves parallel to propagation of light. For that we consider figure 6 in which a source of light S placed at position A emits a light pulse in the direction of a receiver R placed at B which receives the light pulse. A rest observer observes this occurrence and confirms that the source emits light pulse at time zero and receives the receiver at time *t* with concluding distance between them is *ct*.

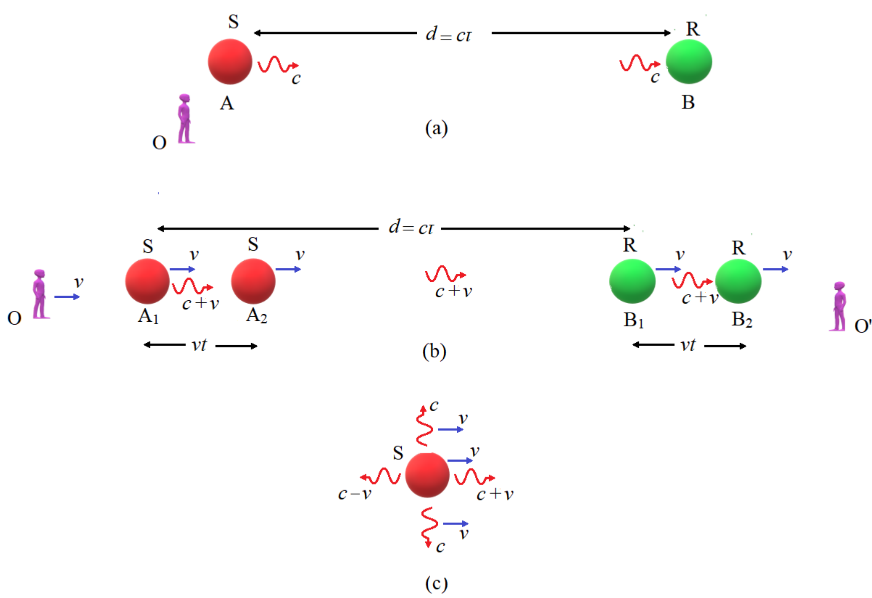

Figure 6. (a) Source, receiver and observer are at rest. (b) Source and receiver are moving with uniform velocity *v* to the right of the observer O'. (c) Velocity of source is imposed on velocity of light.

Further, suppose the source S and the receiver R and the observer O too all are moving with uniform velocity *v* to the right side of the observer O' along a straight line, as illustrated in figure 6(b). Now source S emits a light pulse at time zero in the direction of the receiver R. As the source and observer are relatively rest with respect to each other, the receiver receives the pulse in time t as the distance between them is not altered. This phenomenon is now observed by the observer O' which is at rest and concludes that the light pulse is emitted by the source at position A_1 in the direction of receiver at time zero. Meanwhile the receiver moved a distance vt to the right where it received the pulse at position B_2 at time t. Thus the observer O' concludes that the total distance traveled by the light pulse in time t is $ct + vt$ with velocity $c + v$. Similarly, if the light is emitted in opposite direction of the source velocity by the source then the velocity of the light pulse counted by the rest observer O' would be $c - v$. Thus velocity of source is imposed on velocity of light when both are moving along same direction. It is illustrated by figure 6(c) including effect of figure 3(c).

5.1 Experience in daily life

Such events occur frequently in daily life of common man which could be understood using canon ball firing as illustrated in figure 7. A canon fires a ball with velocity w to hit a target T placed at distance d at rest. An observer O which at rest observes this event such as the canon fires a ball at time zero which hits the target at time t with velocity w such that $d = wt$. Suppose the canon and the target both moves with uniform velocity v to right of another observer O' as shown in figure 7(b). This observer also observers the same event and concludes that, at time zero the canon is at position A_1 and fires the ball which hits the target at time t. But meanwhile the target moved to distance B_2 where the ball hits it. Thus the observer O' concludes that the total distance traveled by the ball in time t is $wt + vt$ with velocity $w + v$. If the canon moves in opposite direction of the target, the velocity of the ball observed by the observer would be $w - v$. Thus the velocity of the canon is imposed on the velocity of the ball which a general experience of common man. This is also happening for light.

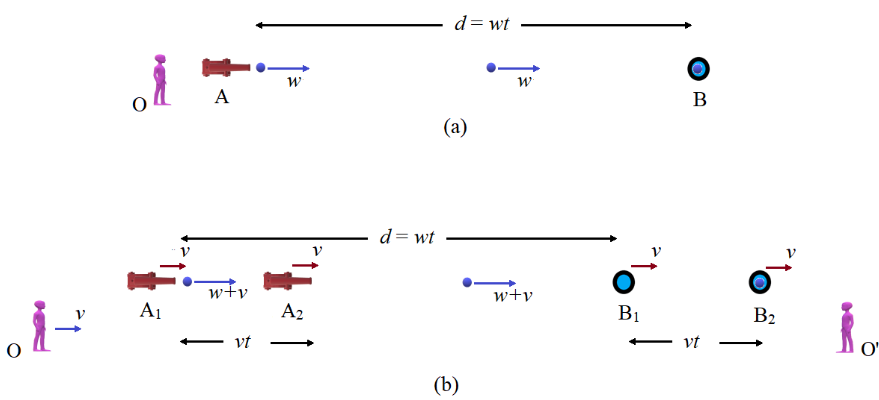

Figure 7. (a) Canon, target and observer are at rest. (b) Canon and target are moving with uniform velocity v to the right of the observer O'.

5.2 Experimental verification of velocity of source imposed on velocity of EM waves

Consider a system producing continuous electromagnetic wave of wavelength 0.1m. Surely, the wavelength measured by an observer, when both source and the observer are at rest or both are in uniform motion in space moving with same speed in same direction, is constant and is evidently 0.2m. If the source is made to move with velocity 3600km/h towards the observer, the changed wavelength observed by the observer using Doppler Effect equation $\lambda_o = \lambda_s\sqrt{\frac{1-v/c}{1+v/c}}$ should be 0.199999333m. This wavelength is shorter than the previous wavelength. Now such two waves, of wavelength 0.2m and of 0.199999333m, are made to travel along same direction simultaneously. If these waves, at any instant, are in phase at point A then, because of the wavelength difference, they will be out of phase at distance nearby 30km, say at point B, from the initial point A. For further travel of 30km they will be again in phase.

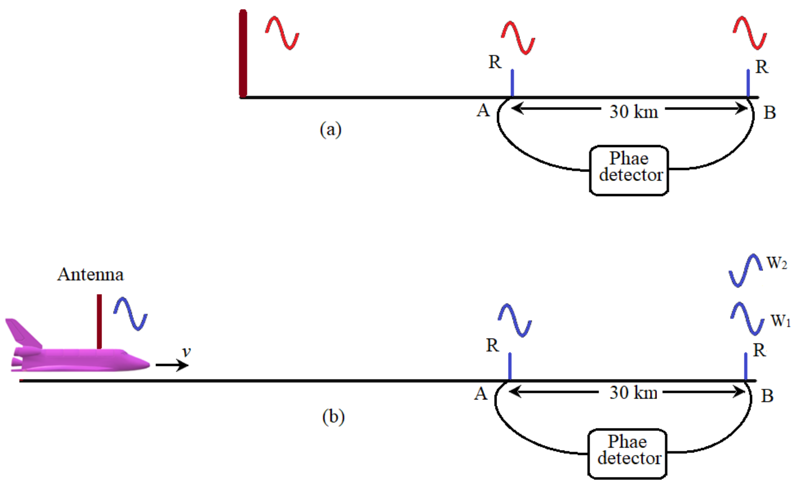

Figure 8. (a) Radiating antenna is at rest. The EM wave at positions A and B is in phase. (b) Radiating antenna moving with velocity 3600km/h towards the receivers where the EM wave at positions A and B should be either in phase (W_1) or out of phase (W_2).

For experimental verification, we set an antenna producing such continuous wave on ground surface. First we mark a point A on the ground and draw a line passing through the antenna. We mark another point B on the line at distance 30km from point A and place two receivers at these two points to receive signal produced by the antenna. The received signals are fed to a phase detector to detect the phase difference between these two signal received at these two points as shown in figure 8(a). Now we allow the antenna to produce the EM waves of 0.2m wavelengths and adjust position of any one of the receiver to get the phase difference zero between the signals received by the receivers.

Now we make the antenna to travel along the line towards the receivers with velocity 3600km/h and check the phase difference between the signals received by them as shown in figure 8(b).

1. If the phase difference is of 180 degree, then the velocity of the wave is constant and frequency and wavelength is changed according to the Doppler Effect. It means velocity of the source is not imposed on the velocity of wave.
2. If phase difference is zero then wavelength is not changed but velocity and frequency is changed. It means velocity of the source is imposed on the velocity of wave.

What does common man expect?

The presence of wave at point A or B means it produces electric field and magnetic field at these points. Production of fields means polarization of the vacuum. It will not depend on who is observing, whether the observer is at rest or in motion. In figure 7(a), suppose another receivers A' and B', separated by the same distance that of between A and B, are moving towards the antenna and observe the phase difference at the time when they coincides on A and B. The phase difference observed by both systems should be same as the field properties produced there should not depend on the state of observer. Since the receivers A and B are at rest and observe zero phase difference. But according to the Doppler Effect the phase difference observed by the receivers A' and B' should be of 180 degree as they are moving towards the antenna with velocity 3600km/h because of which the wavelength observed is shortened. Common man expects that there should not be change in wavelength consequently velocity and frequency should be changed implying that the velocity of the antenna should be imposed on the velocity of wave. Since velocity is relative and no one can decide whether antenna is moving or the receivers are.

6. Conclusions

Following conclusions may be drawn from the above discussions.

1. The ether, if exists, allows to continue uniform motion of any object without any restriction.
2. The source of light consists of charged particles and fields. Thus, along with the source, the fields associated with the charged particles also have uniform motion in ether without any restriction.
3. The fields of charged particles in atoms of the source are responsible to produce light which also consists of fields. Therefore, the velocity of the charged particles is imposed on velocity of fields in the light. In other words, velocity of source is always imposed on velocity of light.
4. If ether could restrict uniform motion of objects in it and tries to bring them at rest then the velocity of light with respect to ether would be constant.
5. If ether does not exist, then vacuum is doing the same.

References

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