Measuring one-way speed of light – experiment and calculation

Krishan Vats
kpvats@hotmail.com

Abstract -

One-way speed of light is thought to be unknown (or impossible to measure) at this time. The reason sighted for that is problem with establishing simultaneity of the clocks at the two ends used to measure round trip speed of light. This article describes an experiment, mathematical equation and method to measure/calculate one-way speed of light.

Experiment description and calculation of one-way speed of light

If you come up with questions or doubts on this, please read the details on page2, that may address some of those.

Consider two identical and synchronized clocks C1 & C2 at a location A. Now let us move C2 from A to a new location B which is distance D from A. We are to measure speed of light in direction from A to B. C2 was moved from A to B, and thereafter C1 & C2 are in same frame of reference. i.e. the rate of passage of time in C1 & C2 is same. Though C2 can give different time reading as compared to C1 because of the time difference introduced by the displacement of C2 from location A to B. So, at any time the respective time readings T_{C1} & T_{C2} in C1 & C2 will differ by dt. Say, $T_{C1} - T_{C2} = dt$.

Suppose we had to move C2 at a constant speed for time T to reach location B, then the equation for dt is: $dt = T - \sqrt{} (T_2 - (D/V_1)^2)$

Here V_1 is speed of light in direction from location A to location B. Because V_1 is the one that we want to find, we will assume it to be c in the beginning and work it out. So, the formula is:

$$dt = T - \sqrt{} (T_2 - (D/c)^2) \quad (1)$$

Now send a light beam from location A at time T_1 in clock C1. Place value of T1 on the light beam for location B to read it. We already assumed as a start, the speed of light in this direction (Location A to Location B) is $V_1 = c$. When the light beam arrives at Location B, Location B instantaneously notes the time T_2 of the clock C2 at its location. From this trip of the beam, we get the below equation –

$$T_1 + (D/c) = T_2 + dt \quad (2)$$

By substituting the expression for dt in (2) from (1), we get

$$T_1 + (D/c) = T_2 + (T - \sqrt{} (T_2 - (D/c)^2)) \quad (3)$$

Verify that the equation holds true or not. If yes, then we know $V_1 = c$ and we are done.

If (3) is not found to be true, then let us re-write (3) as (4)

$$T_1 + (D/V_1) = T_2 + (T - \sqrt{} (T_2 - (D/V_1)^2)) \quad (4)$$

All quantities in (4) are known except V_1. We can find V_1 by tuning.

Adjust the value of V_1 up or down, re-verify the truth of eq. (4). By adjusting value of V_1 up or down, also find the direction of tuning V_1. Continue tuning the value of V_1 and verification of eq. (4) till we reach a value of V_1 that makes eq. (4) a true numerical equality. That final value of V_1 will be the one-way speed of light in direction from location A to location B.

Assumptions

1. It is assumed to be feasible to place value of T1 on the beam of light at A.
2. It is assumed to be feasible to instantaneously read the value from the beam at B

More explanation

Round trip speed of light is considered as c and this fact is used in the experiment. We fix Location A and then fix a location B at an arbitrary distance D. To find D between A & B, we send a light beam from A to B and receive back at A. This will give the distance D between A & B based upon round trip speed of light as c. Here we consider A & B are stationary with respect to each other. Even if you ask how to surely make A & B stationary with respect to each other, we can use the round-trip speed c to ensure that A & B are first made stationary w.r.t. each other. Then we send C2 from A to B and we can use round trip speed of light c, to determine the uniform speed of C2 w.r.t. A by repeatedly sending a beam from A to C2 and receiving a reflection back from C2 in the initial move of C2. Thus, by using two-way speed of light c, D can be known, and v, the constant velocity of C2 can be known and thus T (in (1)) can be known. T1 & T2 are read in real time so are both known. D is known, T is known. That means all quantities in (4) are known except V_1.

After starting $V_1 = c$, it is a matter of finding direction of tuning and then finding right value of V_1 that makes (4) a true numerical equality. To make the process efficient, a binary process can be used.

All quantities in (4) except V_1 are not only known, they are also known to be in frame of reference of position A (or C1) and position B (or C2 after C2 becomes at rest w.r.t C1).

Once one-way speed of light is established from position A to position B, we can establish the one-way speed of light from position B to position A by considering two-way speed as c. Thus, we can establish simultaneity between position A and position B.