The One Way Light Fantastic

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Abstract: We propose a setup allowing the physical testing of a “one way” or rather anisotropic/directionally dependent speed of light. A foundational yet unsolved measurement problem proposed to be impossible, we demonstrate the basis for a setup that is immediately practicable. Our insight is simply that the pythagoerean theorem allows for a tiny geometric indiscrepancy in path length over a 2d geometry, most likely the maximum indiscrepancy geometrically allowed. With this in hand new test of relativity never before possible can be achieved.

Background: The “one way speed of light” is a fundamental open problem in physics, first stated seemingly by Einstein in a letter(1). The theory states that as far as known physics is concerned the speed of light may differ from C in a given direction of spacetime, so long as it travels the reciprocal speed in the opposite direction such that the two cancel out to C. The problem then is how to measure such a directionally differential speed of light.

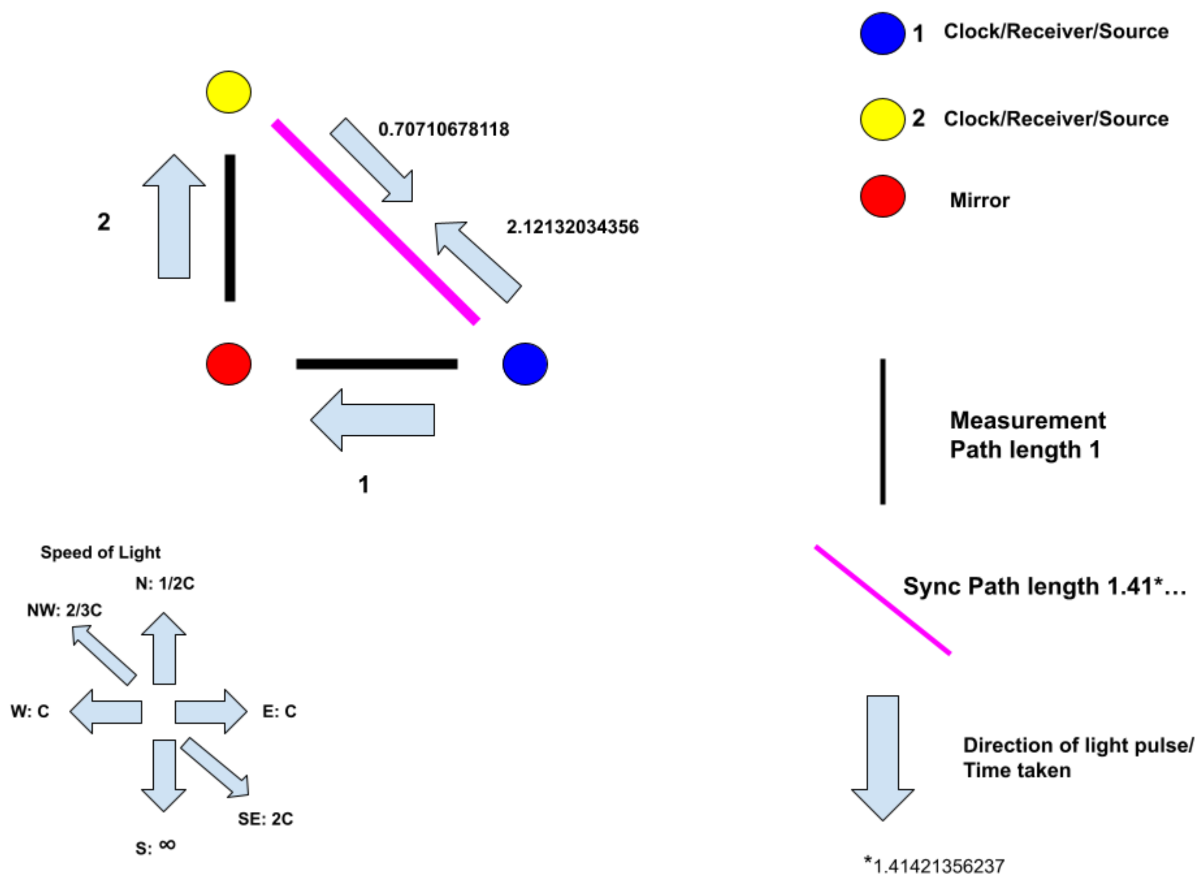
Multiple attempts to solve this measurement problem have been given over the years(2) however not a single proposal of even a hypothetical way to measure such an effect has been accepted. The primary problem extends from two seemingly inextricable problems related to the fact that you need two clocks, and the two must be synced to measure the time it takes to get from one to the other.

The first problem, as stated in (1), is if the two clocks are distant and you send a light signal for sync you must already know the speed of light between them to have their times match up. The second problem is known as the “slow moving clocks” problem as described in (3). It shows if clocks are synchronized locally, the relativistic effects of then moving the clocks away from each other have to be taken into account. As the relativistic effects can be dependent on an anisotropic speed of light(4), again you’d need to know the value you are measuring before taking the measurement. This being the case though we can see that this provides a new and invaluable measurement tool.

Here we show the principle of the problem is simple to solve, and leave any future practical setups to use our proposal as basis. Our principle makes no assumptions about the value of the measurement prior to making it, thus our solution is unique and unrelated to any previous work other than directly solving the problem itself. Our solution makes use of no unidirectional path, and so does not encounter any problems associated with such solutions. Our solution does not involve any reference frames moving relative to one another, and so does not require any lorentz transformations. As this is a foundational problem upon which all theory rests, testing both it and related measurements would prove applicable to all areas of physics.

Description of Experiment:

Our proposed setup is simple. We have 2 sites that can act as clocks and source/measurement for photons. These are static in relation to one another. A direct "sync path" between can be taken as of length 1.41… (pythagorean theorem) and another "measurement path" with 2 length 1 paths formed at a right angle with a mirror in between form a triangle when visualized with the sync path. See Fig 1 for a visualization.



(Fig 1.)

We assume a smoothly varying anisotropic speed of light with the maximum possible differential; one direction going infinitely fast and the opposite going half of C. Please note this is arbitrary and our setup can measure any difference, but for illustration purposes the above is useful.

To establish the "proper distance" between Clock 1 and Clock 2 we use a light pulse to measure the speed of light along each path symmetrically. This is to say, we send a pulse of light from Clock 1 to Clock 2, then back from Clock 2 to Clock 1. We get the round trip time and divide that by 2, giving us the "length" of each path as experienced by light itself, or "proper length". This, regardless of anisotropy, confirms our path lengths of 1.41 for the sync path, and 2 for the measurement path.

The second step is to start both our clocks and match them up. We start Clock 1 and send a light pulse along the sync, as soon as it reaches Clock 2 then Clock 2 starts. Given the above example Clock 1 starts at T = 0, Clock 2 starts at T = 2.12(...), we'll shorten this to T2 And T1. Then we begin sending light pulses along the measurement paths at regular intervals of 5 seconds according to T1. Based on our proper length results we'd expect a lightpulse from Clock 1 at T1 = 5 to be received at Clock 2 at T2 = 5.59 (Expected Time/*ET*). The actual time (*AT*) that Clock 2 would receive the light pulse is T2 = 5.88. These results can be seen in Fig 1. Showing multiple runs.

Clock 1 Send(*T1*)	Clock 2 Recieve (*ET T1*)	Clock 2 Recieve (*AT T1*)
0 (sync path)	1.41	2.12
	Clock 2 Recieve (*ET T2*)	Clock 2 Recieve (*AT T2*)
5 (measurement path)	5.59	5.88
10	10.59	10.88
15	15.59	15.88

(Table 1.)

How do we end up with these results, why does this happen?
Step 1: Begin Clock 1 at T = 0 and send a light pulse to Clock 2.
Step 2: Light pulse arrives at Clock 2, begin Clock 2/T2. This happens at T = 2.12 according to our anisotropy of light. Thus T2 = T1 - 2.12. However, our expected T2 would be T1 - our proper length, of 1.41, which is based on our round trip time.
Step 3: Light pulse from Clock 1 at T1 = 5.
Step 4: Light pulse from Step 3 arrives at Clock 2 at T1 = 8, Thus T2 = 5.88. However, based on an isotropic speed of light the pulse should have arrived at T1 = 7; or more importantly T2 = 5.59. (T1 - 1.41). The expected T2 and actual T2 arrival times are different shows us an anisotropy in the speed of light.

We have thus measured any anisotropic speed of light. We have done so in a manner that allows us to repeat multiple parts of the experiment so as to gradually reduce uncertainty from any stochastic effects such as light emission. And we have done so in a manner that should prove eminently practical to realize as a physical test.

Or consider this another way: Take the setup and sync pulse from above, and then for step 2 reverse the clocks. Now Clock 2 sends the sync pulse to Clock 1 and then the measurement pulse. Using the above numbers we can calculate that according to Clock 1's sync time is now 0.70 behind Clock 2 and travel time is 1. Thus Clock 1 receives a travel time pulse at our scheduled interval + 0.30 time according to Clock 1. In reverse the travel time pulse was received at scheduled interval + 0.88. Thus, again, we show how to measure the time differential, this time with the exact same clock setup and simply reversing directions.

This ability to reverse the direction and still get a signal also presents a counterargument to any concerns about inertial reference frames. Any reference frame effect would be reversed, but thanks to measuring the difference between geometric paths and clock times the effect should remain.

This change between the actual time received and expected time will be relatively small herein, the difference present thanks to the difference between expected and measured times. But this setup will allow us to measure any anisotropic in perhaps the simplest way possible. To highlight our contribution: We take the measurement of the difference between directions to determine anisotropy, without any assumptions about the speed of light, without any reference frames moving relative to each other, and with a fully invertible experiment that will give us

Lastly we remind our readers that this is useful for other measurement types, such as measuring the anisotropic expansion/contraction of spacetime. This could prove an incredibly useful test of many theories involved with cosmology and dark energy. Now this is an idealized scenario, however practical measures should be able to overcome physical limitations versus a perfect scenario such as this. Thus we have shown that measuring the "one way" speed of light is both straightforward from a theoretical perspective, and given direction for a practical measurement of such in the future.

References:

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