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 versus time over a 2d geometry, most likely the maximum indiscrepancy allowed. The existence of a mathematical proof of anisotropic speed of light being testable is important for relativity and more foundationally the lorentz transformation itself, while a practical test application holds the potential for answering unsolved questions regarding the nature of spacetime.

Background: The “one way speed of light” is a fundamental open problem in physics, first stated seemingly by Einstein in a letter(1). The hypothesis states that so far as measurement is concerned the one way speed of light may differ from C, 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.

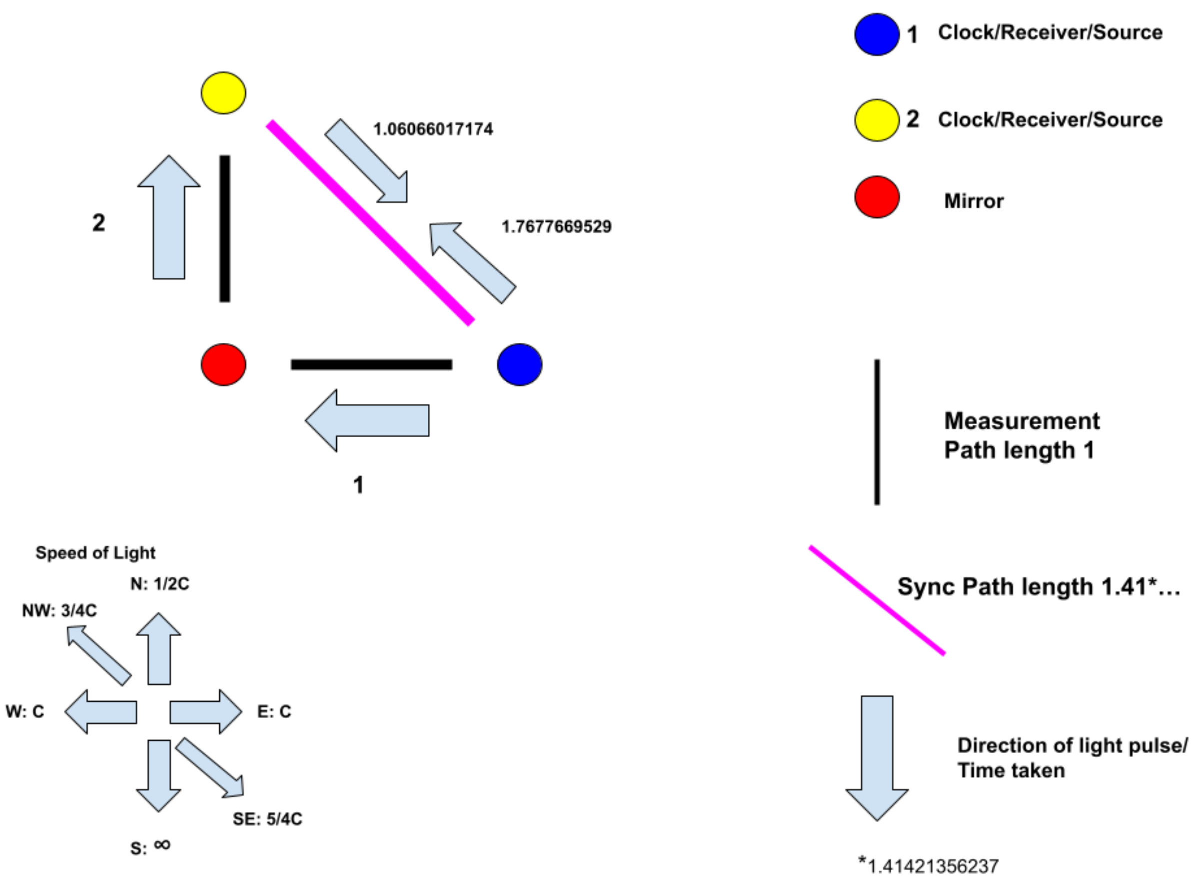
Multiple attempts to solve this measurement problem have been given over the years(2) however not a single proposal of even a hypothetical way to measure such an effect has been accepted. The primary problem extends from two seemingly inextricable problems related to the fact that you need two clocks, 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, theoretically making it and independent test and mathematical concept from 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 (C ^ 2)) and another "measurement path" with 2 length 1 paths formed at a right angle with a mirror in between to form a triangle when visualized with the sync path (pythagorean (A ^ 2) + (B ^ 2)). 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.

For the math we just take side lengths A and B to be 2 so as not to square 1, thus

$$A(2 ^ 2) + B(2 ^ 2) = C ^ 2$$
$$C = 2.82842712475$$
$$A/2 = 1, B/2 = 1, C/2 = 1.41421356237$$

In order to determine the anisotropic speed of light then all we need do in this thought experiment is take the angle compared to our north/south and east/west, where east west is C = 1, North is C = ½, and South is C = infinite, and then smoothly interpolate. Thus a 45° between N and W is C = ¾. This and the opposite direction must add up to C = 1, so the opposite direction C = 5/4.

Thus

$$SE\ C = 1.41421356237 * (5/4) = 1.7677669529$$
$$NW\ C = 1.41421356237 * (3/4) = 1.06066017174$$

Now we're going to establish "proper distance". If "proper time" is the time experienced by a clock on a worldline, proper distance is the distance in spatial dimensions regardless of an anisotropic speed of light.

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 along both the sync path and the measurement path, and then back from Clock 2 to Clock 1 along both paths. 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 (C1) at Time 1 (T1) and send a light pulse along the sync, as soon as it reaches Clock 2 (C2) then Clock 2 starts at T1, at least so far as clock 2 is concerned. Thus

T1 Clock 1= 0
T1 Clock 2 = 1.7677669529

Its here we start noticing how the setup works. Based on our proper length we can expect T2 = 1.41 (we'll shorten the decimal places for obvious reasons, the effect will still become apparent). We are then going to measure the discrepancy between expected time ET which we'd get from proper length and the actual time AT we'd get from measuring proper time.

To measure our difference we thus need to estimate when Clock 2 would receive a measurement signal, one going along the measurement path, based on proper length ET, and compare it to when it AT and proper time. First, what is the expected T1 for clock 2?

ET C2 = 1.41
AT C2 = 1.76

Note we've cut a lot of the decimal places for the sake of readability, the effect will still be apparent. Now that we have this discrepancy we're going to send a pulse along the measurement path every 5 seconds according to T1 C1. According to ET, Clock 2 should receive this pulse at T1 C2 + 5 + the proper length of the measurement path (MP) which is 2. I.E.

ET C2 = 1.41

T2 C1 = 5
ET T2 C2 = 5 - 1.41 + PL MP
PL MP = 2
5 - 1.41 = 3.79
3.79 + 2 = 5.79 = ET T2 for C2

Or rather, if Clock 2 starts at the time it receives the sync path measurement, we would expect an isotropic speed of light to have it receive the measurement pulse at T2 = 5.79. However that's not when it receives it, instead we need to take the AT measurements and the proper time measurement path PT MP which is 3.

AT C2 = 1.76
AT T2 C2 = 5 - 1.76 + PT MP
PT MP = 3
5 - 1.76 = 3.34
3.34 + 3 = 6.34 = AT T2 C2

Clock 1 Send(*T1*)	Clock 2 Recieve (*ET T1*)	Clock 2 Recieve (*AT T1*)
0 (sync path)	1.41	1.76
	Clock 2 Recieve (*ET T2*)	Clock 2 Recieve (*AT T2*)
5 (measurement path)	5.79	6.34

(Table 1.)

We thus have a discrepancy between what we would expect based on an isotropic speed of light, and what we have received based on an anisotropic speed of light. Importantly this can be repeated with multiple measurement path pulses to reduce uncertainty in a real world scenario, however for our thought experiment this serves well enough.

An additional measurement scheme of simply reversing the directions after the first measurement set, with Clock 2 being T1 0 and sending the sync/measurement pulses to Clock 1 would result in

ET C1 = 1.41
AT C1 = 1.06
ET T2 C1 = 5 - 1.41 + 2 = 5.79
AT T2 C1 = 5 - 1.06 + 1 = 5.06

I.E. By reversing directions suddenly the time differential becomes quite large in our thought experiment, even though we've done nothing to the setup. All the clocks are in the same inertial reference as before and as before are not moving with respect to each other at all, all we've done is send light in a different direction. We believe this should preclude any arguments about differing inertial reference frames for this setup.

The full implications of this will be left up to future work. However we may suggest that an initial trial for a practical setup would be simply to have clock 1 be lower than Clock 2 in earth's gravity well. An effect of apparent relative length contraction going down, or south in our thought experiment, versus an apparent length expansion going “up” or northward, would be an interesting effect to record.

References:

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