World Academy of Science, Engineering and Technology
International Journal of Physical and Mathematical Sciences
Vol:18, No:10, 2024

The Problem of Now in Special Relativity Theory

Mogens Frank Mikkelsen

***Abstract*—**Special Relativity Theory (SRT) includes only one characteristic of light, the speed is equal to all observers, and by excluding other relevant characteristics of light, the common interpretation of SRT should be regarded as merely an approximative theory. By rethinking the iconic double light cones, a revised version of SRT can be developed. The revised concept of light cones acknowledges an asymmetry of past and future light cones and introduced a concept of the extended past to explain the predictions as something other than the future. Combining this with the concept of photon-paired events, led to the inference that SRT can support the existence of Now. The paper takes a critical approach to the mathematical assumption behind current interpretation of SRT.

Keywords—Relativity, light cone, Minkowski, time.

I. Introduction

TIME dilation has been an intriguing part of contemplation of time for mor than a century. Time dilation at the heart of Special Relativity Theory and was first identified by Einstein [1]. His paper inspired Minkowski [2] to develop a formalism commonly labelled Makowski spacetime diagrams. Einstein first objected to Minkowski's formalism but eventually embraced it [3]. This paper investigates where Einstein's first reaction might have been better.

The iconic double light cone, describing the past and future light cone, is one interpretation of the Relativity Theory. All measurements are based on past events, hence from a hardcore positivistic viewpoint, only time dilation in the past light cone has been verified. The future light cone is an inference. Another interpretation of the principle of relativity could be stated as follows: What humans perceive as a future is merely the past continually extending itself, and hereby providing humans with new evidence of the existence of the past. The continuity of the extending past has led humans to believe in the concept labelled 'future' – although such a phenomenon has never been directly observed.

The iconic double light cone entails intrinsic problems like the future light cone is observed by no one. The past light cone can be observed by the observer positioned in the apex where to light travels, but the future light cone sends light in all directions, where each ray of light goes into a separate past light cone of some other observer. The past light cone can be directly observed, whereas the existence of the future light cone can only be inferred based on reflections connected to past light cones. This indicates an asymmetric between past and future, that is not supported by the common interpretation of relativity theory.

Among philosophers of science, the contempt of time is an active debate on the concept of time. The main standpoints are presentism versus eternalism. There are many hybrids in-between the extremist standpoints. The debates contain treads along a mathematical approach, often involving the spacetime diagrams based on the formalism of [2] based on [1]. One example with Putnam [4] declaring that the problem of time has been solved. Hinchliff [5] counted Putnam. In response, Savitt [6] augured eternalism, which prompted a defense of presentism from Hinchliff [7]. Savitt [8] attempts to redefine the presentism/eternalism debate. But still, arguments involving words like exiting and real are difficult to use against a mathematical statement, regardless of their sharpness. Therefore, one must find a flaw in the application of mathematics to physical reality to get anywhere in the discussion.

To quote Feynman on the relation between physics and mathematics: "Physics is not mathematics, and mathematics is not physics. One helps the other. But in physics, you have to have an understanding of the connection of words with the reals word. It is necessary at the end to translate what you have figured out into English, into the world, into the blocks of copper and glass that you are going to do the experiment with. Only in that way can you find out whether the consequences are true. This is a problem which is not a problem of mathematics at all" [9].

The light cones are inherently observer centric, and its consequence is that the observer is 'stuck' in the apex of the light cone from where the universe is observed. The apex has light streaming in and out while the worldline of an observing object is passing. The complexity of this event has not been investigated enough. When the apex is related to experiments of nature, new insights can be harvested about the light cones indicating a need for revision.

II. Principle of Relativity

Based on Landau and Lifschitz [10], the following steps exhibit a version of the common interpretation of SRT (SRT).

a. We define two events: 1) start of signal, 2) end of signal. If the signal travels with the speed of light, c, the propagation of signals follows (1) presented below.
b. We define an event O as the cross point of lines obeying the equation for propagation of light.
c. The two cones, each with an apex in the event O, are labelled the future light cone and the past light cone respectively.
d. A worldline is a continuous line propagating inside the two light cones on which a clock can travel.
e. To derive the equation for time dilation (Lorentz

Mogens Frank Mikkelsen is with Technical University of Denmark, Denmark (e-mail: mogmik@dtu.dk).

transformation) the clock travels through the event O.

The equation for the propagation of light is as follows:

$$0 = (x_2-x_1)^2 + (y_2-y_1)^2 + (z_2-z_1)^2 - c^2(t_2-t_1)^2 \quad (1)$$

The proper time is defined as the time displayed on the clock. The time of the clock seen from another worldline will be distorted according to the Lorentz transformation, see (2):

$$\Delta t' = \Delta t\,(1- v^2/c^2)^{-½}, \quad (2)$$

where v is the relative velocity.

The spacetime interval is defined as (3), where $\Delta S = 0$ for light and $\Delta S < 0$ for a worldline:

$$\Delta S^2 = (x_2-x_1)^2 + (y_2-y_1)^2 + (z_2-z_1)^2 - c^2(t_2-t_1)^2 \quad (3)$$

Landau and Lifschitz [10] define $\Delta S < 0$ for worldline, whereas others, e.g. [11], define $\Delta S > 0$, but this is just a matter of conventions.

III. The Phenomena Known as Light

Besides the velocity of light (in a vacuum) being equal to all observers, other phenomena of light need to be included. Most important is that what happens between emission and absorption is an epistemological limit to our investigation of light. "The dual nature of light is evidenced by the fact that it propagates through space in a wavelike fashion and yet displays particle-like behavior during the processes of emission and absorption" [12]. These limitations are profoundly demonstrated by the many versions of Young's double-slit experiment conducted over the years.

When contemplating light, we can identify different types of world points, like event O used in the light cone interpretation of SRT. One type of world point causes light the pass freely without disturbance. Another type of world point is the photoelectric effect coursed by matter, where signals of light get absorbed. Emission is a third type of world point. Other kinds of world points could be defined based on scattering or reflection/refraction of light could be defined, but this would complicate the discussion without a benefit in sight.

To avoid overcomplicating things, the following discussion is bested on the existence of the first two types of world points mentioned above. The emission world point corresponds the event 1 and absorption corresponds to event 2 in the steps explained previously.

IV. Discussion of Light Cones

To separate the movement of objects from the effect explained by Quantum Mechanics, the concept of the Heisenberg cut is helpful. The term is wake, so the paper proposes the following definition: An object is a sample of matter that is too big to cause interference when exposed to a double-slit experiment. With this, both the Heisenberg cut and the concept of an object are defined.

As mentioned, the concept of light cones can be seen as the embodiment of the common interpretation of SRT. However, event O is ill defined according to (1). Indices 1 and 2 are deployed in point a, b, c, or d. The following will elaborate on this.

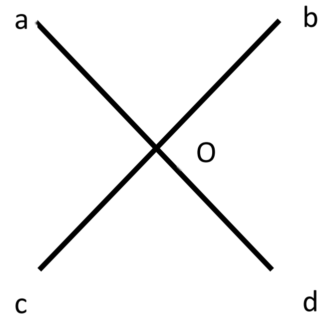

Fig. 1 Light cones

Events can be classified based on the nature of light. This classification will impact how light cones should be drawn based on (1). For the use of discussion, three world points are declared. Event type 1: emission, type 2: absorption, and type 3: no quantum effect like emission and absorption. This has implications for the construction of light cones.

I. If event O is a type 1 event (emission): Equation (1) depicts a signal from O into the future light cone.
II. If event O is a type 2 event (absorption): Equation (1) depicts a signal arriving at O from the past light cone.
III. If event O is a type 3 event (no quantum effect): There is no object on worldline passing event O, hence there is no observer in the apex of the light cones.

The borders of the light cones are defined by (1) and consist of photon-paired events of type 1 followed by type 2. The borders are defined by $S = 0$. World lines are defined as $S < 0$, hence they exist in the interior of the light cones. An observer in the universe is an object that is confined to travel on the worldline. In the apex, one can no longer separate the border from the interior of the light cone, and the three different types of events are mathematically the same, albeit different in reality.

The inference of the above is that interpretation of relativity based on event O as a single type makes an error of classification, there is not only one single type of event O in nature.

The light cones made of type 1 and type 2 is observer centric, and we can note, that an observer can only observe the past light cone, per definition, since signals are traveling away from the observing object in the future light cone. We can further argue that the future light cone cannot be observed directly by anyone. The future light cone can only be observed indirectly, e.g. via mirrors.

Next, we need to consider the special case of a photon traveling along the x-axis, getting absorbed and re-emitted, still traveling along the x-axis, based on the presumption that this is still 'the same photon'. This is equivalent to a signal first traveling vector cO and then vector Ob (or first vector dO and then vector Oa) without any delay when passing event O. We must keep in mind that a signal travels from an emission event on one worldline to an absorption event on another worldline. Therefore, there will be a delay when passing event O, since the photon energy on the second worldline cause an excitation of an atom which after a waiting can cause a new emission event. This waiting time will be discussed in Section V.

V. The Stochastic Waiting Time between Absorption and Emission

There is a waiting time in the range of 10^{-9} to 10^{-8} seconds from the excitation of an atom to the emission of a photon. The emission waiting time in a laser follows a Poisson distribution, whereas the natural chaotic light follows a Bose-Einstein distribution [12].

The waiting time itself causes a delay from the apex of the past to the apex of the future light cone when one follows the transition of energy from absorption, through excitation, to emission.

Seen from the past, the waiting time for the emission, that is about the happen, will be a stochastic variable, ΔT. Seen from the future the waiting time for a given emission is a known value, hence declared as Δt.

The difference between the same parameter defined as a stochastic variable (ΔT) and a given value (Δt) seems to be underappreciated in physics in general. There is much discussion on how to interpret the collapse of the wave function, the so-called measurement problem. With the time-bound shift from a stochastic variable to the value of the same parameter we have the mathematical foundation for a solution to the measurement problem.

In the context of relativity theory, the shift from stochastic variables to a value of the t-parameter is very helpful.

Photons on 'wings' is an expression borrowed from Optics. This is photons that have been emitted, but not absorbed. We can define three classes of photons. Photons that are absorbed, hence cause a photon-paired event. Photon on the wings, that is traveling toward unknown destinations. And photons, which have not been emitted yet, because 'their' energy is engaged otherwise in the present configuration of the universe.

The concept of stochastic waiting time for emission going forward in time, and the given value of the waiting time looking back, will from here on be referred to as the cursor of time.

A combination of the t-parameter with a cursor of time and the three classes of photons results in an interesting division of the universe into three distinct realms, often referred to as the past, present, and future. The formalism can be expressed as follows:

Defining a Clock

The special relativity theory depends on a clock to measure the time dilation. The theory revolves around the sitting where a moving clock is observed in an inertial reference frame. The proper time belongs to the selected frame, and the time dilation is measured as the temporal difference relative to the moving clock.

Defining the present moment. According to eternalism, there is no special moment. According to presentism, the present is all that exists.

The American National Institute of Standards and Technology (NIST) defines a clock as "a device that counts the oscillations and converts them to units of time interval" [13].

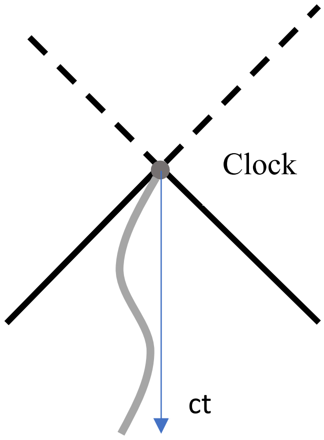

Fig. 2 Concept of a clock

The clock is a man-made device, that is definitely about the Heisenberg cut. Since time is what clocks measure, we can infer that 'time is change' in the form of the oscillation of matter. In an atomic clock, a further source is the decay of isotopes. With this epistemological approach to time, we might infer the oncological nature of time as a phenomenon streaming from emission, hence time emerges in the present, where it is streaming from matter.

When contemplating the present moment against the ticking of a clock, we can observe that the latest tick of the clock will fall behind the present, and only the tick of the clock catches up with the present moment. The tick after the latest tick of the clock is a future state that will never be realized because when the next tick is reached, this becomes the latest tick. In other words: $t_n \leq t_p < t_{n+1}$, where t_{n+1} does not exist because at the tick it will become t_n instantly. The present is 'moving' away from the latest tick of the clock towards a future tick, that will turn into the latest tick when reached.

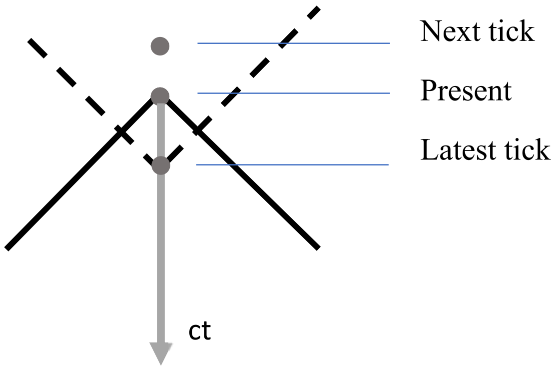

Fig. 3 Dynamic of the clock

The clock-device will absorb photons, as an object, the clock will always be present. However, the signal from the clock, the latest tick, will fall behind. Since the next tick of a clock will remain undefined, the clock can only have a past worldline. Fig.

3 exhibits a snapshot of the dynamics between the present, the latest tick, and the next tick.

To express the correlation between the latest tick and the present, we can use a floor function and state the following equation: $t_n = \Delta t \lfloor t_p/\Delta t \rfloor$, where Δt is the average time interval between ticks.

Based on the above, it can be stated that a clock cannot measure the future, only the past. The clock will exist in the present, between the latest tick and the next tick, hence the clock is ‘stuck’ in the apex of the past light cone.

Defining Past, Present, and Future

Based on the stochastic nature of the t-parameter going forward and the value nature of the t-parameter looking back, the concept of paired photons can be deployed to give a formalization of past, present, and future in a mathematical terminology. The distinction between these three domains of spacetime is based on the relation of three classes of photons to matter.

1) The past is defined by photons that have pair event on worldlings, hence have propagated according to:

$$c^2(t_a-t_e)^2 = (x_a-x_e)^2 + (y_a-y_e)^2 + (z_a-z_e)^2, \quad (4)$$

where we must recall (t_e, x_e, y_e, z_e) is an event on one atom's worldline and the event (t_a, x_a, y_a, z_a) is on the worldlines of other atoms.

2) The present is defined by still-traveling photons, which are the photons that have been emitted but not yet got absorbed by matter. The equation for the propagation can be written as a probability function for the event (T, X, Y, Z), where the variables should be calculated based on the trajectories of all the other atoms in the universe we are analyzing. The propagation equation then becomes:

$$c^2(T_a-t_e)^2 = (X_a-x_e)^2 + (Y_a-y_e)^2 + (Z_a-z_e)^2 \quad (5)$$

Given there are many atoms in the universe, this is very close to complete randomness.

3) The future is based on expectations of absorption of the traveling photons, which would change their propagation from (5) to (4). The future also includes expectations of photons to be emitted given the need for energy for the excitation of atoms will be available. The equation for this could be written like this:

$$c^2(T_a-T_e)^2 = (X_a-X_e)^2 + (Y_a-Y_e)^2 + (Z_a-Z_e)^2$$

Equation (6) is not only a mathematical description of the past, present, and future, it also provides us with a solution to the so-called measurement problem because the superposition from quantum mechanics only exists on the ‘future side of now’. When it collapses in the present, measurements exist on the ‘past side of now’.

Revisiting the Problem of Now

Based on the formalism presented in this paper concludes that all clocks exist in the vicinity of a 3D plane, we can label, Now. Clocks exist between their latest tick and the next tick. All object, that is in direct physical contact with a clock will inherit the clock’s relation to the Now plane in the universe.

If clocks can only measure the past, and time is what clocks measure, then the future is undefined. Of course, this is a conundrum, because the laws of nature provide us with predictions, some even with very tremendous accuracy.

With the past being different from the future, the double light cone should not be drawn like two similar cones. Only in the case of light without a worldline of an object passing the apex of the light cones, does the double light cones is representing nature. In the case of an object in the apex of the past light cone, the future light cone should reflect the stochastic nature of unabsorbed light. This is done in Fig. 4; a dotted line indicates the stochastic nature of the future light cone.

If the future is undefined, there is conundrum to solve. To solve this, the ‘extension of the past’ is proposed as a concept. The extension of the past is different from the future because the extended past becomes measurable with the cursor of time realized the part of the universe. Regardless of how much spacetime the cursor of time has realized, there will always exist an unmeasurable future.

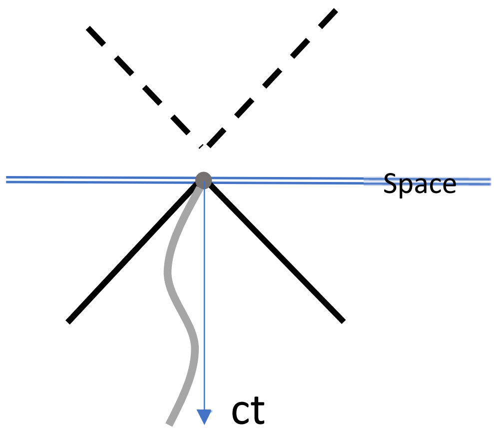

Fig. 4 The concept of time

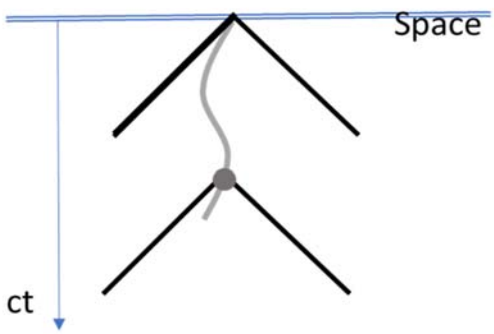

Fig. 5 The extended past (seen from the dot on the lower past light cone)

VI. Conclusion

This paper has investigated the common interpretation of the SRT, embodied in light cones in spacetime diagrams. The paper has demonstrated that the apex of the light cone, the proverbial event O, falls into different categories, each with a profound impact on the reality of the light cones. The common interpretation presumes only one type of event O,

Further, the concept of a clock was investigated. Concluding to this, a clock can only measure the past and exists between its latest and next tick. This leaves the future undefined in the temporal dimension. Combining this with the concept of photon-paired events led to the inference that SRT supports the existence of Now. The plane of Now then separates the past from the future, where the present is defined by the photons still traveling.

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