Some Reflections about Time, Causality and Our Life

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Causality is a principle that forms part of our conception of reality and explicitly or implicitly nobody questions the fact that an effect cannot occur before than its corresponding cause. For instance, it is not posible that the born of a boy occurs before the birth of his mother, or to receive a light signal before its emission at some place.

In Physics and at a macroscopic level of dimensions, the causality principle is associated to the postulate that it is not posible the transmission of any signal faster than light speed in vacuum. This is implicit in the Special Relativity Theory (SRT) and is valid for all observers in relative motion with constant velocity between them (inertial observers).

SRT was developed at te beginning of the twentieth century through the researchs made by Albert Einstein and other distinguished scientists, like Hendrik Lorentz, Hermann Minkowsky and Henri Poincaré, among others. Up to now this is a theory whose predictions have been confirmed by several experiments and is one of the pillars of contemporary physics. SRT has two basic postulates: 1. The laws of nature and the results of all experiments performed in a given frame of reference are independent of the translational model as a whole. 2. The speed of light is finite and independent of the motion of its source.

The mathematical formulation of SRT implies that the principle of causality is valid for all inertial reference frames if there is not any object or signal travelling with a speed greater than c (ligth speed at vacuum with a value of about 300000 km/s). For example if for an observer A two events E_1 and E_2 occur in such a way that the occurrence of E_2 is only possible if previously event E_1 has occurred, the same chronological connection of events will be seen by other observer B in relative motion with respect to A. This is shown in Figure 1 by a diagram in space time where the vertical and horizontal axes correspond to spacial position along the x axis and time, respectively. For simplicity only motion parallel to the x axis is considered. The diagonal lines crossing through the origin of this coordinate system has a slope c. Events within the blue area are causally connected and the order as they occur in time is the same for all inertial observers, independent of their relative velocities. However, an event inside this area is not causally connected with an event outside this region and for two inertial observers the corresponding sequence of events not causally connected can be different [1]. The red curved line passes through a sucession of a great number of events that for

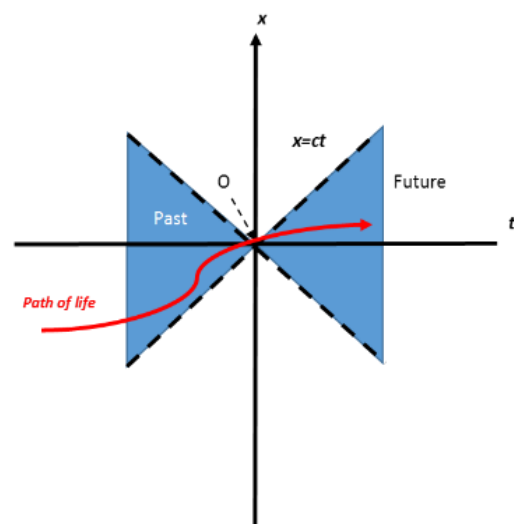example occur in the life of a person at different places and instants of time.

Figure 1: World line and the light cone.

How the principle of causality is considered in SRT and its connection with the way our life passes by time may be illustrated by the following example: Does it exist a reference frame S' for which a mother (let us call her Anne) is younger than his son (let us call him John) and if that would be possible, which should be its velocity V with respect to a reference frame S fixed to earth (where of course Anne must be born before John)? Let us also assume that Anne was born in 1950 in a city A located at 3000 Km of the city J where John was born in 1978. According to reference frame S the events are:

E_1: Anne was born in November 28, 1950 (t_1) at city A ($x_1=0$);
E_2: John was born in November 29, 1978 (t_2) at city J ($x_2=3000$ km).

Therefore according to system S: $\Delta t = t_2 - t_1 = 28\ \text{years}$; $\Delta x = x_2 - x_1 = 3000\ \text{Km}$

Using Lorentz's transformations for time we have that in system S' the time difference is

$$\Delta t' = t_2' - t_1' = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}\left(\Delta t - \frac{V}{c^2}\Delta x\right)$$

From the above equation we deduce that the required velocity V of S' with respect to S for changing the temporal order of these event (that is $t_2' < t_1'$ meaning that event E_2 occurs before event E_1) must be much greater than c by a factor $883 \cdot 10^8$. Nevertheless this calculation has not any sense since the Special Relativity Theory considers that velocities greater than c are not possible and using its equations we would get imaginary values. For instance we would obtain imaginary values for the mass of an object, a result which according to our conception of the reality does not have any physical sense.

For dealing with theoretical situations where some particles could move with velocity greater than c (as is the case of particles called tachyons whose existence up to now has not been verified experimentally), extended relativity theories have been formulated *[2-4]* where the principle of causality is shown to be valid *[5]*.

Conclusion

We can conclude from this brief analysis that it seems that light rules our existence and is closely related with the pass of our lifes through the time. Could we say that the origin of our universe coincides with the simultaneus origin of light and time?.

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