P E T E R   S T R O H M A Y E R

Lecture on the Special Theory of Relativity

1. Introduction:
Today's paper is about the *special* theory of relativity. With it, we associate the idea that time passes slowly with moving observers, and that dimensions of moving objects contract. For example, a twin who sets out on a high-speed journey is younger on his return than his brother left home. The twin also gets heavier the faster he moves. Then there is the world's most famous formula, $E=mc^2$, where you ask yourself what energy has to do with the "speed of light", and especially when squared.

General relativity, in contrast, deals with acceleration and gravity. If someone lives on the ground floor, he ages slower than his neighbor on the first floor. The clocks on the GPS satellites are faster than those on Earth and therefore always have to be readjusted. After all, as Edwin Hubble discovered, the universe continues to expand, and it expands at an ever-increasing speed. This expansion is not like that after an explosion, when chunks matter fly apart; rather, space itself expands. From this understanding, the rate of expansion has been calculated back to the Big Bang, such that we know that the universe was created approximately13.5 billion years ago and, we believe that, before that, there was neither the time nor space.

2. Philosophical Background:
To understand all this, one must leave the Newtonian laws of physics behind. Time and space are not substances or containers in which reality takes place, rather, they are relations in the sense of Leibniz.

Leibniz and Newton, the great opponents in physics and mathematics, had long been in dispute over who invented differential calculus first, when, at the beginning of the 18th century, they exchanged letters about the nature of time and space. Newton emerged victorious because Leibniz had died after Newton's 5th reply, and could not finish his arguments. Newton still thought that his powers of persuasion had broken Leibniz's heart. However, the constancy of the so-called "speed of light," as discovered in the 19th century, speaks to what Leibniz postulated.

Leibniz described his thinking in terms of relationships between time and space. In a similar way Leibniz‘s relationships begin with the constant speed of propagation of light. Then, time is the temporal relationship between two events determined by the spread of causality (the propagation of a ray of light). And, space is the spacial relationship between two events determined by the spread of causality (the propagation of a ray of light). That is, a ray of light always spreads so much through space, as time he needs for it.

According to the worldview of German idealism - I follow here Plato, Kant and Schopenhauer - we do not perceive the world as it is in itself, but per the categories that our thinking specifies - that is time, space, and causality.
In particular, causality is just a manifistation of our way of thinking. Since causality is an categorie of thinking, an effect cannot occur simultaneously with its cause. It follows, that the spread of causality is limited. The highest possible propagation of causality is the propagation of light ("speed of light").
When a ray of light leaves from one point (Event 1) and arrives at another point (Event 2), the spatiotemporal distance (see: ″so much through space, as time he needs for it") between these two events is called "light-like." Because causality can not be transmitted faster than the "speed of light", these two events are also "light-like" distant from the point of view of any other observer moving at any speed. From this principle the relational symmetry of light (the Lorentz transformation) can be deduced.

Further, the constancy of the "speed of light" has the effect that no photon (i.e., no light beam) can overtake another photon, no matter how fast the light sources move. This non-intuitive aspect of light propagation follows from the above, that time, space und causality are just manifestations of our way of thinking. In the spread of light, we encounter our own thinking.

3. <u>The Perception of Events</u>:
The universe is the epitome of all events. Science must determine where an event occurred, and when. The simplest method for determination is for an observer to set up synchronized clocks everywhere, all of whose locations are known, all running at the same speed, and all showing the same time. The synchronization is done in such a way that a uniformly moving messenger starts at one clock and, when he arrives at another clock, adds the time it took to travel. Imagine an infinite number of clocks spaced at very short distances from each other. If any event occurs at one of the clocks, then one knows by the clock‘s location and by the time it indicates where the event occurred.

4. <u>Relational Symmetry of Light</u>:
When two moving firecrackers explode, the two expanding balls of light ~~and fireworks~~ move away from their respective firecrackers.

However, if two observers move towards each other, and both simultaneously emit a spherical wave of light when they meet, then the photons emitted together at the tip of these rays of light cannot overtake each other.
Each two photons at the tip of two light beams of the both spherical waves of light spread out together forever. The photons of both emissions form a common propagation surface, but this surface does not have a defined shape. Each observer rightly asserts that he is in the center of the spherical wave he has emitted, and that the photons at the tip of his rays of light form a propagation surface in the form of a sphere. However, the two observers cannot both occupy the same center of sphere, because the observers have moved away from each other during the propagation of the light rays.

Consider this situation with this sketch:

Observers A and B move towards, then past each other with 60% of the "speed of light". At the instant of their encounter, each observer sends out a beam of light in the direction of his movement, and another beam opposite to his direction of movement, and both observers continue to move in their initial directions. (We, therefore, pick out two particularly prominent beams of light from the two spherical waves of light.).

Both of the two photons at the tips of the light beams are started simultaneously at time "0". They spread together to the left or to the right, because they can not overtake each other (they are "coordinated"). When the tips of the two light beams from Observer A reach the two event points on the two mirrors left and right with "speed of light" (c) after a time of "2", its two light beams each have a length of "2".
However, the two corresponding coordinated light rays from Observer B cannot be the same length as those of Observer A because Observer B has moved past Observer A.

According to the (separately derived) relational symmetry of light, when the light rays of Observer B (together with the light rays of Observer A) arrive at the mentioned two event points, the ray in direction of B’s motion has a length of "1", and the ray opposite to direction of motion has a length of "4". Only at this 4:1 ratio of the length of the light rays to each other (called the Lorentz transformation) do the two photons at the ray tips remain coordinated, taking into account space, time, and motion.

There is only this one solution for maintaining coordination and symmetry. It is only possible because time and space are related (they are relations in the sense of Leibniz, not substances). Further, if we assume the reverse situation of a light beam of length "2" for B, then a coordinated light beam for A would be "1" in the direction of motion and "4" in the direction of movement.

One could say: well, these rays of light have different lengths, and this should not concern us any further. But let us remember that we determined the time and place of events with synchronized clocks that we set up throughout the space surrounding all observers. Thus, with the two observers, also their respective clocks in the line fore and behind them move in a straight line past each other, whereby each clock of the line in one observer’s system sequentially encounters the clocks of the line in the other observer’s system. (This is demonstrated by the example of two listeners).
The questions are, now, what time will be displayed by two and two of the clocks, if they past each other.

It is impossible to determine these using Newtonian mechanics and the speed at which the clocks run and their respective positions. If you try, you end up in a dead end. But there is a very simple way to determine what one sees when he examines the clocks.

For example, an observer sends a beam of light along the line of his clocks. The clocks are spaced each at a distance of "1" from each other in the line. The observer is able to monitor his clocks, par example by assistants sitting each at a clock. When the photon at the tip of the mentioned light beam reaches at the first clock, that clock indicates time "1", and, when that photon reaches on the second clock, that second clock shows time "2", and so on. The synchronized clocks depict the propagation of a light beam so also the propagation of a light beam depict a clock and a yardstick (the clocks can be synchronized by such a light beam).

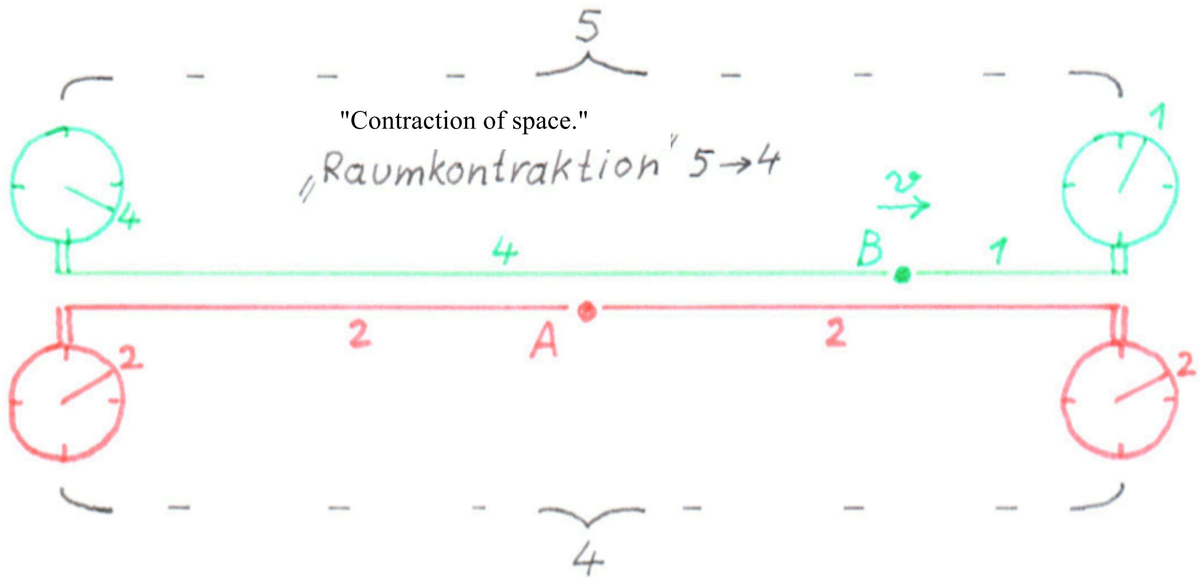
When the photons at the tips of the co-propagating beams from two observers arrive at a given event, then there are also two clocks of each observer‘s respective series of clocks at that same location. That is, at each event, the two photons meet, plus there is a clock of Observer A and a clock of Observer B.

Each clock of Observer A shows the respective elapsed-time-of-propagation of the beam from Observer A. The location of this clock from the A-series corresponds to the length of this beam, having spread along the series of clocks.

Each clock of Observer B shows the respective elapsed-time-of-propagation of the beam from Observer B. The location of this clock from the B-series corresponds to the length of this beam, having spread along the series of clocks.

But now it has to be considered that both photons at the tip of the two light beams of the two observers spread together and therefore they are always together in a place.

Let's take a look at the situation on the following sketch:



The rays of light of Observer A and of Observer B canot have the same length (relational symmetry of light). So, the time-lapse showing on the clocks that encounter cannot be the same. Intuitively, we say time passes at same rate everywhere, so all clocks should show the same time in their encounters. But this intuition is based on the Newtonian idea that time is a substance, which is not true.

The different times showing on the clocks that are located at the various clock encounters can be verified at the clock locations.

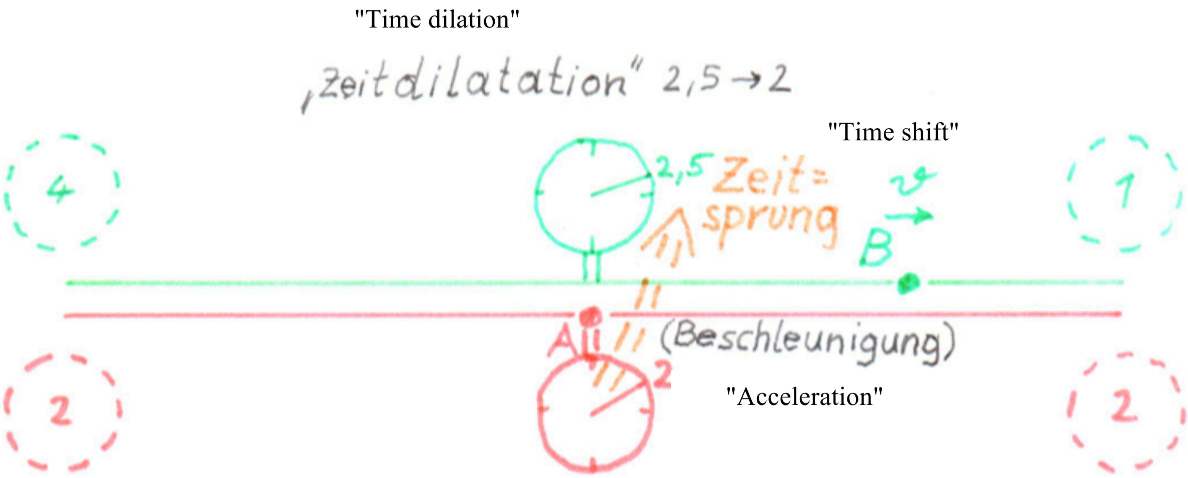
For example, in the sketch above, two assistants of Observer A, located respectively at the two remote clocks showing the time "2", would report (later) that they both met the clock of observer B at the time "2".

The two assistants of Observer B, one located at the remote clock showing the time "1" and one located at the remote clock showing the time "4" would report (later) that one met the clock of observer A at the time "1" and the other met the clock of observer A at the time "4" .

The same phenomenon applies (with respect to events occurring for observer B at time "2") to Observer B for his two clocks at a distance of "2" with the level of "2". That is, the distance between the two events is at A, a "4", and at B, a "5". This effect (symmetric for both observers) is called "space contraction".

We now ask, what occurs when a clock of observer B encounters the clock that is located at Observer A (who is in the middel of the series A), which displays "2".

Again a sketch:



The clock of Observer A encounters a clock of the series of Observer B (not the clock of observer B himself) pointer position in the middle between "1" and "4", which thus indicates "2.5". The clock of Observer A shows the elapsed time of "2", while at B the elapsed time "2.5". This effect (again symmetric for both observers) is called "time dilation".

As the clock of the observer A continue to move relative to the clocks of the series of observer B, the *actual* time delta increases. The same applies to encounters with the clock with Observer B. However, for none of the observers does the time go by faster or slower. Even moving clocks run equally fast. The effect described concerns only the relation of time and is based on the finiteness of the causal propagation.

Every observer lives in a "simultaneous" present in which, so to speak, all photons are equidistant from him at all times. But two events, which, from the point of view of one observer, take place simultaneously in his present, but do *not* take place in his present at the same time as the other observer; rather, one event takes place in an earlier present (in which all his clocks show "1"), and the other event takes place in a later present (in which all his clocks show "4"). The same applies the other way round: *what appears to occur simultaneously for the second, appears to occur one after the other for the first.* The time deltas between two observers for any events mesh like two gears. There is no contradiction. Just events cannot take place simultaneously for both observers. The present of the observers is never the same because of the relationality of time and space.

5. A true time-shift (i.e., time is no longer symmetrical for both observers) only occurs when an observer for example with a time of "2" makes a jump (many infinitesimal jumps) over to the other observer's encounter clock (i.e., into the other observer's system), and that other system has already passed a time of "2.5". The passage of the observer into the other system is connected with acceleration. For example, if one of a pair of our twins in the Introduction travels to Mars, and the other remains on Earth, the traveling twin experiences acceleration at take-off from Earth, upon landing and taking off from Mars, and upon landing back on Earth. Consequently, a time-shift will occur. A time shift occurs also in a strong gravitational field, also a phenomenon of acceleration. On first floor you stay younger than in ground floor.

6. If we regard time and space in the sense of idealism as categories of thought and understand the theory of relativity from this point of view, this has ideological and theological consequences. On the one hand, idealism opens up the freedom of the will. On the other hand, eternity does not turn out to be an infinite amount of time we spend singing the glory of God. We can talk to Pope Benedict XVI, (Encyclical "spe salvi") and introduce a moment in our lives in which we were perfectly happy. Timeless eternity will be like this fulfilled moment.

June 8, 2017

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