Peter Strohmayer, Relativity, June 8, 2017

1. Introduction:
Today's presentation is about the special theory of relativity. We associate it with the idea that time passes more slowly with moving observers and that moving distances contract. A twin who goes on a trip at high speed is younger when he returns than his brother who stayed at home. The twin also becomes heavier the faster he moves. Then the most famous formula of the world belongs to it, $E=mc^2$, with which one wonders what the energy has to do with the "speed of light", and still in the square.
The general theory of relativity deals with acceleration and gravitation. If someone lives on the ground floor, he ages more slowly than his neighbor on the second floor. The clocks on the GPS satellites go faster than those on Earth and therefore always have to be readjusted. Finally, as Hubble found out, the universe keeps expanding, and at an ever increasing speed. It is not like after an explosion, when chunks of matter fly apart, but the space itself expands. From this one has calculated back to the big bang and one believes to know that the world has originated thirteen and a half billion years ago and that there was neither the time nor the space before that.

2. Philosophical Background:
To understand all this, one must leave the Newtonian world view behind. Time and space are not substances or containers in which reality takes place, but they are relations in the sense of Leibniz.
Leibniz and Newton, the great opponents, had already got in each other's way during the priority dispute about the differential calculus. They had an exchange of letters at the beginning of the 18th century about the nature of time and space. Newton emerged as the winner, because Leibniz had died after Newton's 5th rebuttal and could not finish his arguments. Newton still thought that his persuasiveness had probably broken Leibniz's heart. However, the constancy of the so-called "speed of light" discovered in the 19th century speaks for the position Leibniz has represented. His relations can start at the constant propagation of the light. Time is the relation between two events, which is determined by the causality propagation (the propagation of a light ray). Space is the relation between two events determined by the causality propagation (the propagation of a light ray). A light ray always covers the space, which it needs in time for it.
According to the world view of German idealism - I follow Plato, Kant and Schopenhauer here - we do not perceive the world as it is in itself, but as the categories of our thinking - that is time, space and causality - dictate.
Especially the category of causality is our thinking. An effect cannot occur at the same time as the cause. There are limits to the causal propagation. The highest possible causal propagation is the propagation of light. If a ray of light starts at one event and arrives at another event, the temporal and at the same time spatial distance in which these events occur is called "light-like". Since causality cannot be transmitted faster than by light, these events are also "light-like" apart 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 derived.
Constancy of the "speed of light" therefore means that no photon (no light ray) can overtake another photon, no matter how fast a light source is moving.

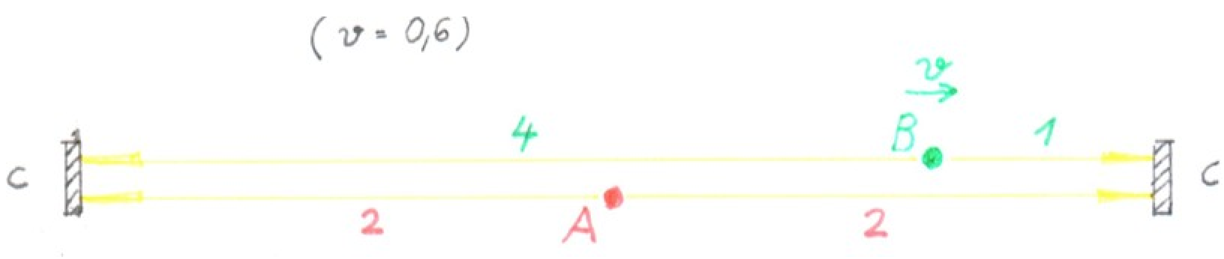
In the spreading of the light we meet our own thinking. The relations go out from our thinking.

3. <u>The perception of events</u>:
The world consists of events. Perceiving in the scientific sense is the distortion where an event has occurred and when. The simplest method is that an observer sets up synchronized clocks everywhere, whose place is known, which all go equally fast and which all indicate the same time. Synchronization proceeds in such a way that a uniformly moving messenger starts at the observer's clock and, when it arrives at another clock, adds the time that its journey took. We imagine an infinite number of clocks set up at small distances from each other. If some event occurs at one of the clocks, then we know by its location and by the time indicated by it where the event occurred and when.

4. <u>Relational symmetry of light</u>:
When two fireworks moving towards each other explode, the two expanding spheres of light together with the fireworks move away from each other.
But if two observers moving towards each other each emit a spherical wave of light at their encounter, then the photons emitted together at the tip of these light beams cannot overtake each other. They propagate together forever.
These photons form a common propagation surface which, however, has no defined shape. Each observer rightly claims that he is in the center of the spherical wave emitted by him and that the photons at the tip of his light rays form a propagation surface in the shape of a sphere. But if one observer is in the center of a spherical wave of light, the other observer cannot be there too, because he has moved away from the first observer during the propagation of the light rays.

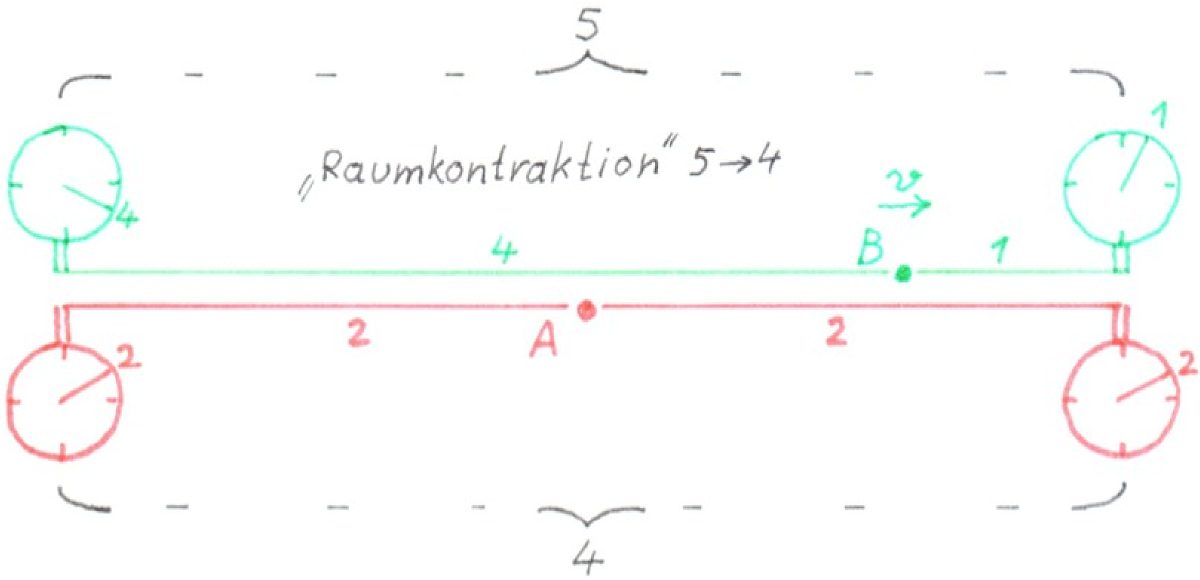
Let's consider this with the sketch:

The observers A and B move past each other with 60% of the "speed of light". At the time of their encounter, each observer emits one light ray in the direction of motion and one against the direction of motion (we thus pick out two particularly distinctive light rays from each of the two spherical waves of light).



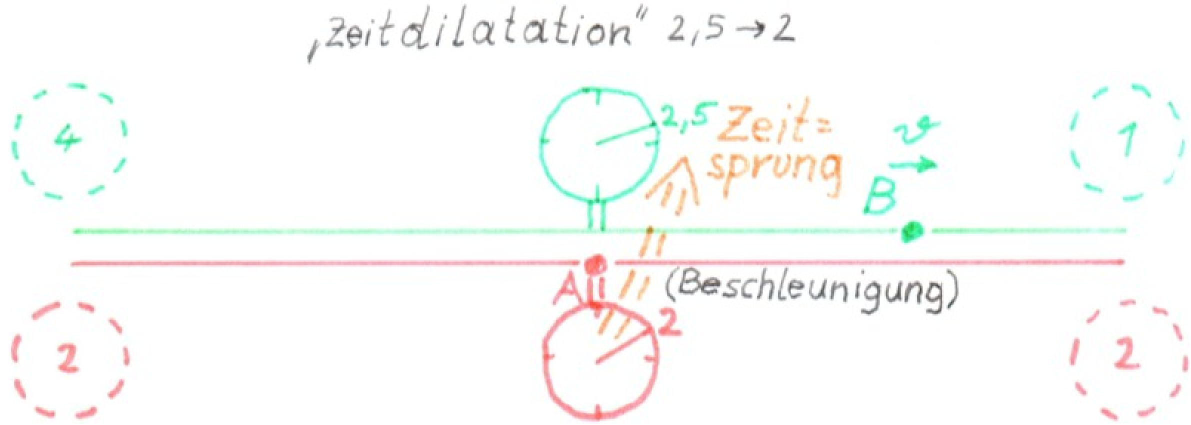
Each two photons at the tip of the light beams are started together at the time "0". They propagate together to the left and to the right, respectively, because they cannot overtake each other (they are "coordinated"). If the tips of the two light beams are each "2" away from the observer A after the time "2", his two light beams have each the length "2". Now, the two coordinated light rays at the observer B cannot also be of the same length, because B is no longer at A in the meantime. According to the (separately derived) relational symmetry of the light, the light rays of B, if they arrive at the two events, are long in his direction of motion "1" and against his direction of motion "4". Only with this relation of the length of the light rays to each other (it is called Lorentz transformation) two coordinated photons remain together considering space, time and motion. There is only this one solution. It is only possible because time and space are relations. The solution is symmetrical. Even if we assume a light beam of "2" at B, then a coordinated light beam of A would be "1" long in the direction of motion and "4" long against the direction of motion.

Now one could say: well, these light beams have different lengths. This should not touch us further. But let's remember that we have determined the time and the place of events with synchronized clocks which we had set up everywhere around the respective observer. So with the two observers also their respective series of clocks move past each other in a straight line, each clock of the one system uninterruptedly meeting some clock of the other system. (This is demonstrated by the example of two listeners).
The question is now, which clocks meet each other and which time they show. It is impossible to calculate this according to Newtonian mechanics on the basis of the speed of the clocks and their respective positions. Who tries this, lands in a dead end.
But there is a very simple way to determine the clock encounters.
If an observer sends a light beam along his clock row and we pick out the clocks, which are placed at a distance "1" from each other, then the photon at the tip of the light beam passes by the first clock, if it shows the time "1", by the second clock, if it shows the time "2", and so on. Synchronized clocks map the propagation of a light beam (they can, after all, be synchronized by such a light beam).
If the peaks of the light rays of the two observers propagating together arrive at any event, then a clock of the respective clock row is also present on the spot. At each event the two photons meet, a clock of A and a clock of B. Each clock shows just the time which corresponds to the length of the light ray which has propagated along the own clock row. Let us look at the situation on the following sketch:



If the light rays are not of the same length because of the relational symmetry of the light, then also the time indication of the clocks which meet at the event cannot be the same. Intuitively we say that time passes everywhere the same, therefore all clocks should show the same time at their encounters. But this intuition is based on the Newtonian idea that time is a substance. It is not true. The different clock positions at the various clock encounters can be verified on the spot. In the example shown in the sketch, e.g. two friends of the observer A, who are at the "2" distant clocks, would report to the observer by telephone that at the time "2" a clock of the other observer with the position "1" or with the position "4" passed by them. The reverse is also true for the other observer for his two clocks at the distance of "2" with the position of "2". The distance between the two events is "4" for A, "5" for B. This effect (again symmetrical for both observers) is called space contraction.

We now ask which clock actually encounters that clock which is located at observer A and displays "2". For this purpose again a sketch:



The clock of A encounters a clock of the observer B with a hand position in the middle between "1" and "4", which thus shows "2.5". So for A the time "2" has elapsed, for B the time

Time "2.5". This effect (again symmetrical for both observers) is called time dilation.
In the further course this time interval becomes larger and larger. The reverse is also true for the encounters with the clock at observer B. Time does not pass faster or slower at any observer. Even moving clocks run at the same speed. The described effect concerns only the relation of the 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 always equally far away from him at every time. But two events, which take place from the point of view of the one observer in his present at the same time, do not take place from the point of view of the other observer in his present at the same time, but the one event takes place in an earlier present (in which all his clocks show "1"), the other event in a later present (in which all his clocks show "4"). The same is true in reverse: what is simultaneous for the other occurs sequentially for the first. The time indications of the two observers for arbitrary events mesh like two cogwheels. There is no contradiction, only events cannot occur for both observers at the same time. The presence of the observers is never the same because of the relationality of time and space.

5. A real time shift (i.e. no longer symmetrically valid for both observers) occurs only if an observer, for whom a time of "2" has passed, makes a jump (many infinitesimal jumps) over to the clock of the other observer, for whom a time of "2.5" has already passed. The crossing of the observer into the other system is connected with an acceleration. The preserved youth of the traveling twin is based on the fact that he is accelerated at the start, at the reversal and at the return in each case, but the other one is not. The effect is also based on this that in a strong gravitational field, also a phenomenon of acceleration, a time shift occurs.

6. If we understand time and space in the sense of idealism as categories of thinking and understand the theory of relativity from this point of view, this has ideological and theological consequences. On the one hand a way is opened to affirm the freedom of the will. On the other hand, eternity does not turn out to be an infinitely long time that we spend singing about the glory of God. We can agree with Pope Benedict
XVI (encyclical "spe salvi") imagine a moment in our lives when we were perfectly happy. Timeless eternity will be like that fulfilled moment.

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