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

The role of action propagation in special relativity theory.

To determine the velocity of a point of matter as a ratio of distance to time, a stationary observer measures the distance covered and the time required for this. With continuing acceleration, the distance covered by the matter point in a certain time would have to become longer and longer (or the time required for covering a certain distance would have to become shorter and shorter). Thus also infinitely high velocities appear conceivable. In addition, synchronized clocks would have to indicate always the same, absolutely passing time independently of their movement.

2 Doubts about these views appeared towards the end of the 19th century. With the addition of high velocities it had come to strange results. In an experiment carried out by Michelson and Morley it had turned out that the "velocity of light" in vacuum is always the same for all observers - independent of their movements to each other. A photon overtakes every observer with "speed of light", no matter how fast he moves with respect to the light source.

All attempts to explain the constancy and unsurpassability of the "speed of light" on the ground of the conventional conceptions of time and space (e.g. ether theories) have failed in the consequence. As a reason for this failure, the incorrectness of the conventional conceptions about time and space was finally recognized.

3. one must not start from the preconceived notions of time and space to explain the phenomenon of the constant "speed of light" (and fail), but one must start from the phenomenon of the "speed of light" to get clarity about the notions of time and space.

But it is not the light as a physical phenomenon of the propagation of electromagnetic fields (according to Maxwell's equations) which has such a far-reaching meaning. Rather the propagation of light (as well as e.g. the propagation of gravitational waves) is representative for a fundamental principle of being: the finiteness and constancy of the propagation of effects (causal propagation). A cause can never instantaneously trigger an effect. Between cause and effect there is always a gap. If there would be no such "separateness", at any rate with a first cause its effects would have to occur instantaneously and with these in turn also all subsequent effects. The world would have to be finished with its beginning.

It would be wrong to say that the effect propagation would bridge the gap between cause and effect with a certain "speed", because the effect propagation (light propagation) has no "speed". It has no sense to ask how much space ("meter") a light pulse covers in a time ("second"). It behaves the other way round: Space, time and speed are defined only by the effect propagation.

We gain a scale for the space and for the time which is equal from the point of view of every unaccelerated coordinate system by taking as a basis a reproducible process occurring in the nature as a "material constant", e.g. the decay of an atom in an atomic clock which is resting from the point of view of a coordinate system. This natural process marks two events, which take place from the view of this coordinate system at the same place one after the other. It would take place in the same way in each of the coordinate systems moved to each other. No system is distinguished before the others (principle of relativity).

A light pulse which propagates during the process determined by the two events, covers a reproducible portion of "space" in a reproducible portion of "time" from the point of view of the coordinate system concerned on the basis of the chosen "material constant". The spatial "length of the propagation of the light pulse" during the process reaches from the point of its emission to the point of its arrival from the point of view of the coordinate system concerned. The temporal "length of the propagation of the light pulse" during the process reaches from the point of time of its emission to the point of time of its arrival from the point of view of the respective coordinate system.

Since both "lengths of the propagation of the light pulse" are based on the same effect propagation, the spatial "length of the propagation of a light pulse" is the same size as the temporal "length of the propagation of a light pulse" from the view of the coordinate system concerned. It has no sense with the effect propagation to distinguish between the size of the portion of space which it covers and the size of the portion of time which it covers.

A signal font of the light always covers that in space what it needs in time for it. Space and time form with regard to their common foundation, the effect propagation, a unit, the "space-time". The gap, which lies from the view of a coordinate system between the beginning and the end of an effect propagation (between two events), is both the "time" and the "space". Both are a mental construct won from the relations of the effect propagation.

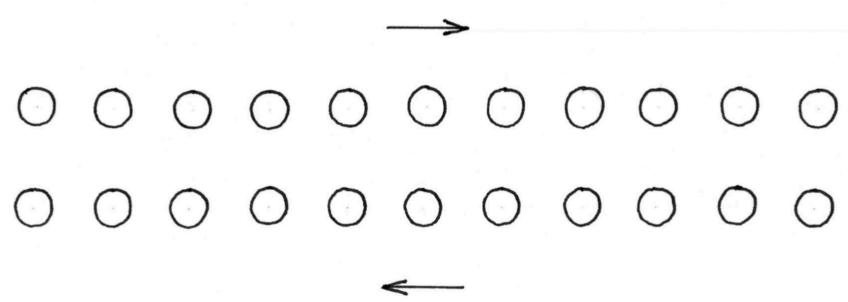
The "length of the propagation of the light pulse in the coordinate system in question" (the effective propagation) defines two equal units of measurement: a spatial distance as a unit of measurement for space and a temporal distance as a unit of measurement for time. The portion of space traversed by light during the chosen process is the unit of measurement for a spatial distance ("light second"). The portion of time taken by the selected process is the unit of measurement for the distance in time (also "light second"). The "speed of light" is the ratio of the portion of space covered to the portion of time covered of the same size, i.e. dimensionless "1".

The "velocity" is the ratio of the way covered by the matter point to the time needed for it determined from the view of the respective reference system. Both the way of the matter point and the time needed for the covering is measured in light seconds (the unit of measurement of the effect propagation), with it the time always turns out longer than the mastered way. In the time of "1" (in a temporal light second) a matter point can cover at most a way of approximately "1" (approximately a spatial light second). As ratio of way to time, the speed is therefore a fraction or a percentage of the "speed of light" of "1".

The (coordinate) velocity can already from its own concept - and not because of any mysterious physical barriers - never become as great as the "velocity of light". The velocity of a point of matter defined in this way is not approached by the propagation of effect with any step, no matter how high or long the acceleration is. Every light pulse, which is emitted by the matter point or passes it, overtakes the matter point with "speed of light" under all circumstances (see above).

5.1 According to the conventional view, resting (unaccelerated) clocks, which have been synchronized once, always show the same time among themselves. This shall not change. The further view, based on the idea of an absolute time, that such clocks would always show the same time even in direct comparison with clocks moving past, however, turns out to be wrong on closer examination. Only clocks, which are in rest to each other, show the same, continuously passing time after their synchronization among each other.

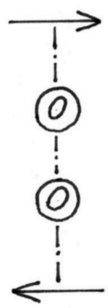
But let's imagine, for example, observers moving past each other in two rows - like cars in oncoming traffic. Each observer carries a clock with him.



All watches have the same design and go at the same speed.

Let us assume that the relative velocity (v) of the observers is 60% of the "speed of light" (c). So, from the point of view of one observer, the other observer moves past him with v = 0.6c.

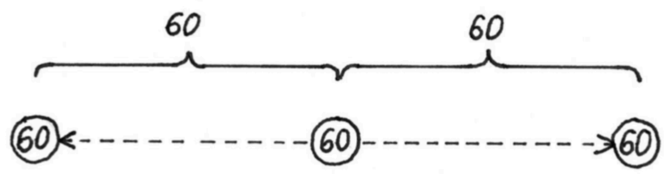
We now pick out two observers, e.g. the two observers in the middle of their row. At the moment when these observers pass each other, they set the hands of their clocks to "zero" (for the other clocks of the respective clock row see below). This forms the starting point for the comparison, whether synchronized clocks, which are in a relative movement to each other, still show the same time at their meeting or not.



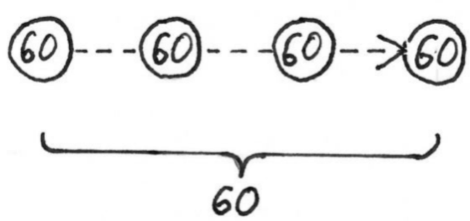
To bring all other clocks of the respective clock row to the same state as the middle clock, all clocks of a row must be synchronized. For this purpose, the respective observer in the middle of his clock row must send a light pulse to the clocks resting in front of and behind him from his point of view (but any other uniformly moving signal of known speed would also suffice for this purpose). The light covers from the respective view of the observers that at space, which it needs at time for it. If the light pulse needs e.g. 60 seconds up to the next clock, then this clock is temporally 60 light seconds and spatially 60 light seconds away from the first clock.

The time span needed by the light pulse to reach the next clock is ideally measured with a "light clock", which are two parallel mirrors at a certain spatial distance, between which the signal front of a light pulse performs countable pendulum movements. Each observer can determine the length of the propagation of his light pulse up to the event of passing by the next clock according to the principle of the equally divided "half-time reflection" of light pulses, without having to go to the other end of the distance to be measured. He only has to halve the time for the outward and return run of the light pulse reflected at the event in question (cf. *W. Stegmüller,* Erfahrung, Festsetzung, Hypothese und Einfachheit in der wissenschaftlichen Begriffs- und Theoriebildung, Berlin u.a., Springer (1970), p 79 and 146f).

If, at the moment when the light pulses arrive at the clocks set up 60 light seconds away, these are set to "60 seconds", all three clocks of this clock row will from then on continuously show the same time.



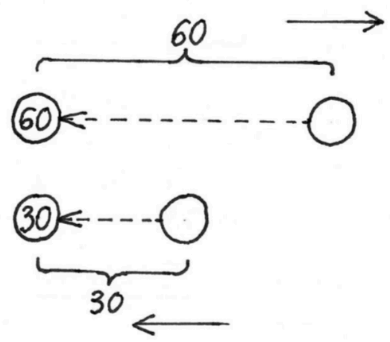
The connection existing between space and time becomes visible when a light pulse propagates along such a synchronized clock row. The clock of the clock row, at which the photon at the tip of the light pulse just passes, always shows exactly the time, which corresponds to its spatial distance from the initial clock.



5.2 Now, two observers moving towards each other in the middle of their respective clock rows each emit a light pulse in the same direction along their axis of motion (along their clock rows) when they meet. The signal fronts of the two light pulses cannot overtake each other because of the constancy and uncrossability of the effect propagation.

Wherever the signal fronts pass during their <u>common</u> propagation, there are also two certain clocks of the clock series of the two observers, which just pass each other and whose indications can be compared directly with each other. These clocks show in each case the time corresponding to the length of the propagation of the respective light pulse.

While the two photons at the tip of the two light pulses (the signal fronts) propagate together and thus are always at the same place, the two observers (the light sources) have moved away from each other due to their relative velocity since the emission of their light pulses. The lengths of the propagation of their light pulses up to the mentioned event of the passing of the two clocks are therefore different from the view of the respective observers. Thus also the times differ, which are indicated by the meeting clocks of the respective clock row, at which the two photons at the top of these light pulses of different propagation length just arrive. This means the end of Newtonian physics.



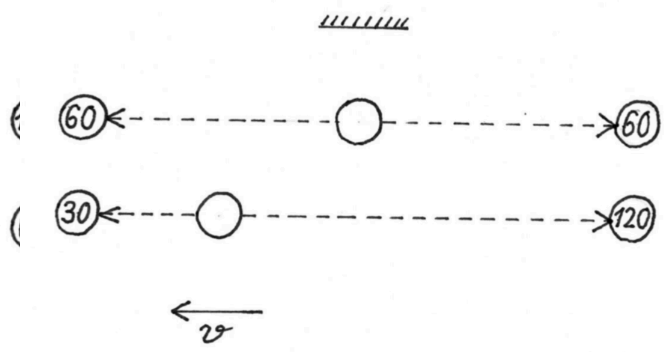
Synchronized clocks of the clock series moving past each other can not show the same time at their meeting for this reason. The effect propagation, the "speed of light", the course of time etc. are the same in all inertial systems. All clocks tick equally fast in all uniformly moving systems. But the temporal and the spatial distance between (distant) events are not equal from the view of different systems.

5.3 In order to capture the symmetry of the event, two observers moving towards each other shall emit a light pulse each not only in one but in both directions along their axis of motion at their encounter. Since no photon can overtake another, on each side two photons propagate coordinated and always arrive together at any event.

Now the one observer 1 claims related to his "present" (after the time span which has elapsed from his point of view since the encounter), the propagations of his two light pulses are of the same length and would arrive from his point of view at two simultaneous events which are equally distant from him. He is right, because he is exactly in the middle between these two events.

But what should now the other observer 2 say to these two concrete events which have been determined by observer 1 and described as "simultaneous"? The propagations of his two light pulses (whose photons at the top have propagated together with those of the observer 1) cannot also be of the same length with respect to these events because he has already moved away from the other observer and therefore he cannot also be in the middle between these two events. Considering the different lengths of the propagation of the light pulses emitted by him, he comes to the conclusion that these two concretely determined events did not take place simultaneously in his "presence". The one event, where his light pulse with the shorter propagation arrived, occurred earlier for him, while the other event, where his light pulse with the longer propagation arrived, occurred later for him.

Conversely, events described as simultaneous by observer 2 do not occur



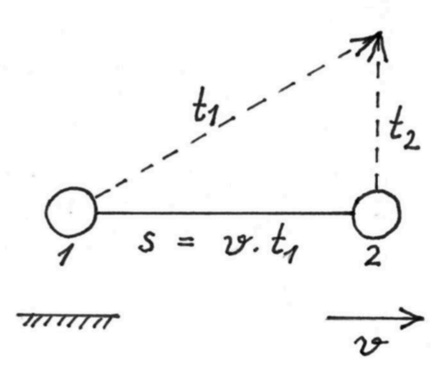
simultaneously for observer 1.

Never the observers moving to each other could determine distant events (outside of the "relativistic center") which take place simultaneously from the point of view of one observer as well as from the point of view of the other observer. In this sense one speaks of the relativity of simultaneity. It does not contradict the intuitive certainty that the propagation of effects (the passing of time in each of the observers as a category of thought) occurs in absolute synchronism.

6. if the observers emit not only single light pulses but two spherical waves of light (light pulses in all directions) at their encounter, the two signal fronts, formed by all photons at the tip of all light pulses, can also not overtake each other in their effect propagation. All photons at the tip of the single light pulses of the one system propagate together in pairs with the photons at the tip of the single light pulses of the other system in a shell surface (which has no "objective" geometrical form independent of a reference system).

The two light pulses, whose photons at their tips propagate together in pairs from the event of the meeting of the observers (or the emission), never have the same direction - apart from the case of the emission along the axis of motion described above. To each propagation of a light pulse of the observer 2 with certain direction and certain length, e.g. perpendicularly to the axis of motion, belongs the propagation of a complementary light pulse of the observer 1 in another direction with another length, e.g. obliquely inclined to the axis of motion.

The length of propagation of each individual light pulse of one spherical wave of light is related to the length of propagation of each individual complementary light p ht in a relation of relational symmetry wl velocity v. Here is an example:



The sketch shows in which direction, dependent on the relative velocity v, the observer 1 must emit his light pulse 1, so that the photon at the tip of this light pulse 1 can propagate together with the photon at the tip of the light pulse 2 emitted by the observer 2 perpendicular to the axis of motion.

The special theory of relativity assumes that distances perpendicular to the axis of motion are of the same length from the point of view of both observers (compare the height of passing trains in Thirring, Die Idee der Relativitätstheorie, Springer 1921, p 57f). The length of a distance is the product of velocity times time. The perpendicular distance $c*t_2$is of the same length from the point of view of both observers. If we take the motion sequences from the point of view of observer 1 as a basis, we get a right-angled triangle with the sides $v*t_1$and $c*t_2$as well as the hypotenuse $c*t_1$. From the Pythagorean theorem follows that the process duration $t_1$is longer than the process duration $t_2$by the so-called "Lorentz factor" $1/sqr(1-v^2/c^2)$. If c = "1", the Lorentz factor is simplified to $1/sqr(1-v^2)$.

Now, for all other conceivable directions in which the complementary light pulses are emitted, the ratios of the respective light paths or the process durations to each other can be calculated, in particular - depending on the direction of movement - for the light pulses emitted along the axis of movement described above: $t_1= t_2*(1+v)/ sqr(1-v^2)$ or $t_1= t_2*(1-v)/ sqr(1-v^2)$. It shows in the case of propagation of light pulses of equal length in all directions along the radii of a sphere from the point of view of one system that the complementary light pulses from the point of view of the other system moving relative to it must follow the focal rays of a rotational ellipsoid.

The formula for a conversion of the coordinate values (three spatial and one temporal) of an event from the point of view of system 1 into the coordinate values of the same event from the point of view of system 2 results from the following consideration: Two light pulses emitted in the above sense coordinated along the spatial axis x, then reflected and returning, propagate from the point of view of system S to the extent a in the direction and to the extent b in the opposite direction.

From the point of view of the other system S', the lengths of propagation of the complementary light pulses are a' and b'. Considering the respective common emission of the two photons at the tip of the complementary light pulses (at the event 1 taking place in the origin of coordinates as well as at the event of reflection) and the respective common return of the photon pair (event 2), the coordinate values of the event 2 result from the view of the system S with x=a-b; t=a+b, therefore a=**(t+x)/2 and b=(t-x)/2,** resp. from the point of view of the system S' moving relative to it with v with x'=a'-b'; t'=a'+b', therefore **a'=(t'+x')/2 and b'=(t'-x')/2**.

The light pulses of the two systems are in the relation of the relational symmetry a'=a*(1-v)/sqr(1-v ^{2}) or b'=b*(1+v)/sqr(1-v ^{2}) which can be derived from the above thought experiment. Substituting a' and a or b' and b from the above equations gives t'+x'=(t+x-v*t-v*x)/sqr(1-v ^{2}) and t'-x'=(t-x+v*t-v*x)/sqr(1-v ^{2}). From the two equations with the two unknowns t' and x'results:

Time coordinate value:

t'=(t-v*x)/sqr(1-v ^{2})

Spatial coordinate value in the direction of the axis of motion:

x'=(x-v*t)/sqr(1-v ^{2})

The two other spatial coordinate values remain the same as being perpendicular to the axis of motion:

y' = y

z' = z

From time and place of an event from the view of the coordinate system S, time and place of the event can be calculated from the view of the coordinate system S' moved relatively to it ("Lorentz transformation"). The Lorentz transformation describes a physical event which is based on the constancy or unpassability of the propagation of the effect (speed of light). It gives information for arbitrary events, which clock (location, pointer position) of the one system S meets which clock (location, pointer position) of the other system S'. The "world lines" constructed from it (e.g. in Minkowski diagrams) are actually "clock encounter lines", from which results where and when a certain event of the one system takes place from the point of view of the other system moving relative to it.

7. the effects of "time dilation" and "space contraction" can be understood by these clock encounters.

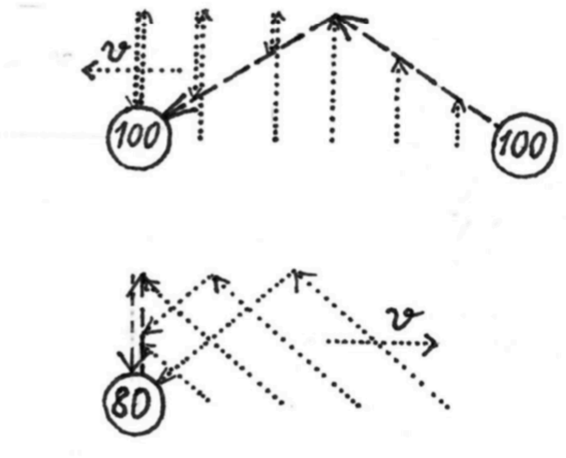
A light pulse covers the space, which it needs in time for it. This connection remains, even if it changes its direction on the way (is reflected at imaginary mirrors) and at most even returns to the starting point. At every arbitrary termination of this compound light path one of the resting clocks of a reference system distributed in the whole space can be thought, which shows the total propagation of the light pulse from the event of its emission to the event of its arrival (the total temporal distance of the two events from each other) from the point of view of this system.

With the photon oscillating up and down perpendicularly to the axis of motion at the tip of the light pulse of the light clock of observer 1 - it is a composite propagation of a light pulse in the sense described above - a photon running in zigzag at the tip of the light pulse of observer 2 propagates together.

The hands of the clocks of system 1 advance to the extent of the sum of the light paths traveled perpendicularly by the photon at the tip of the light pulse of observer 1.

The hands of the clocks of system 2 advance to the extent of the sum of the light paths zigzagged by the photon at the tip of the light pulse of observer 2.

The length of the propagations of the vertically running light pulses of observer 2 are shorter than the length of the propagations of the obliquely running light pulses of observer 1. Therefore increasingly less time has passed on the clock at observer 2 than on the clock of the system of observer 1, at which observer 2 just passes and at which the peaks of the two light pulses propagating together just arrive. This process is shown for a relative velocity v = 0.6 (c = "1") in the following sketch.

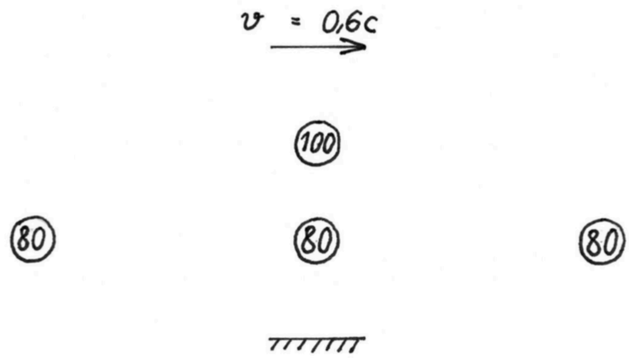


The upper part of the sketch shows, from the point of view of observer 1, two contiguous oblique propagations of his light pulses 1 (dashed lines with a total length of 100) as well as (considering the relative motion of observer 2 with v) some snapshots, added by observer 1, of the complementary light pulses 2 (dotted lines) running perpendicular to the axis of motion.

The lower part of the sketch shows, from the point of view of observer 2, two contiguous perpendicular propagations of his light pulses 2 (dashed lines with a total length of 80) as well as (considering the relative motion of observer 1 with v) some snapshots of the obliquely running complementary light pulses 1 (dotted lines) added by observer 2.

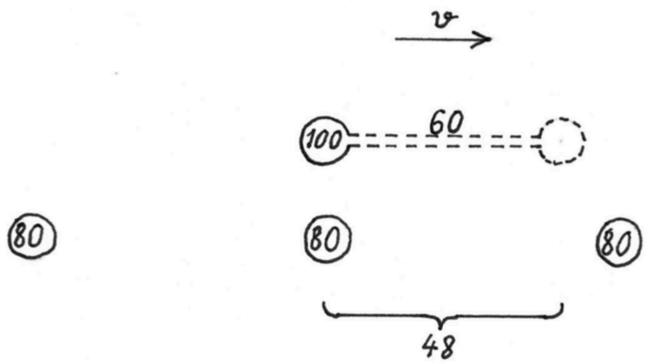
From the point of view of the observer 1 (in the upper part of the sketch at the clock rdchts) the clock on the left of his system 1, which is 60 light seconds away from him, shows the time t_1= 100 light seconds at the event of its encounter with the observer 2 (t_1= s/v = 60/0,6 = 100). The length of the propagations of the light pulses from the view of the observer 2 are shorter by the factor sqr(1-v^2) = sqr(1-$0,6^2$) = 0,8 than the length of the propagations of the complementary light pulses from the view of the observer 1. From the view of the observer 2 (lower part of the sketch) his clock on his left shows the time t_2= 0,8*100 = 80 light seconds at the encounter with the mentioned clock of the system 1.

When directly comparing the display of his watch with the display of the passing watch of watch row 1, observer 2 notices that the time display of his watch increasingly lags behind the time displays of the passing watches. If the clock of clock row 1, which was set to 60 seconds above with the light signal of observer 1 and is 60 light seconds away from observer 1 from the point of view of observer 1, passes by observer 2, then this clock of clock row 1 displays a time span of 100 seconds which has elapsed since the zero setting, while the clock of observer 1 only displays a time span of 80 seconds which has elapsed since the zero setting.



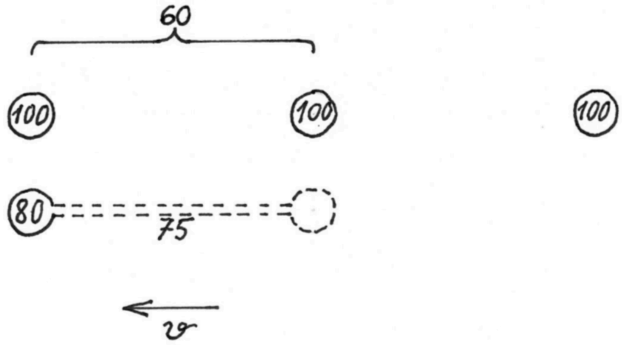
From the point of view of observer 2, observer 1, with whom he had met 80 seconds ago, has moved away from him by a distance of 48 light seconds (distance = speed times time = 0.6*80 = 48). The distance "moved past" observer 2 between that clock of row 1, which now shows 100 seconds, and observer 1, which as said has a "rest length" of 60 light seconds measured by observer 1, has thus shrunk from the point of view of observer 2 by the factor sqr(1-v^2) to a length of 0.8*60 = 48 light seconds ("space contraction").

(Which time the clocks of the row of the observer 1 indicate, if the observer 1 meets a clock of the clock row 2 indicating 80 seconds, is left open for simplification reasons. Only so much is said in advance that at this event less than 80 seconds have passed on his clocks).



From the point of view of observer 1, observer 2, with whom he had met 100 seconds ago, has moved away from him by a distance of 60 light seconds (distance = speed times time = 0.6*100 = 60). The distance "moved past" observer 1 between that clock of row 2, which just passes observer 1, and observer 2, which has a length of 75 light seconds measured by observer 2, has shrunk from the view of observer 1 by the factor sqr(1-v ^{2}) to a length of 0.8*75 = 60 light seconds ("space contraction").

(Which time the clock of row 2 shows, which observer 1 encounters when his clock shows 100 seconds, is left open for reasons of simplification. Only so much is said in advance that at this event on the clock of row 2 more time than 100 seconds have passed).



The reason for the deviating time indication of the respective encounter clocks is summarized in the fact that the effect propagation represents the passing of time and that two photons cannot overtake each other.

8. a violation of the scientific economy principle is the thesis, complicated and unnecessary in its consequences, that time would pass slower with moving observers ("moving clocks go slower"). This thesis only takes into account the fact that the indication of the clock, which is at a "moving" observer, lags behind the indication of a clock of the "resting" clock row, which he just passes. The contradictoriness of this thesis or of the conception underlying it, that time is a substance which could pass slower or faster, consists in the fact that this lagging behind would occur in exactly the same way with respect to a clock of a "moving" series of clocks which encounters a clock located at the "resting" observer. To be aware of this symmetry is more purposeful than to deal with the often paradoxical consequences of the thesis of a time passing more slowly with moving observers.

9. in an accelerated motion, the divergence of the time indications of clocks meeting each other leads to an impressive effect, the "twin paradox".

With every smallest acceleration step a previously "resting" observer makes an imaginary infinitesimal jump to the just passing clock of another, infinitesimally faster "moving" inertial system and thus brings himself to its speed. The clock, which he meets (and to which he "jumps"), shows after the said always an already further advanced time than his own clock (whose course is not influenced by the individual infinitesimal acceleration steps). The infinitesimal acceleration steps add up to a total effect during the whole acceleration process. The ratio of the time span of the own time of the accelerated t to $_B$the time of the initial system t_A, from whose point of view he was originally at rest, is determined with uniform acceleration a and a time span of the acceleration process from the point of view of the initial system of t_A according to the following formula derived from the above considerations (see essay hyperbolic motion):

$$t_B=(\operatorname{asinh}(a*t_A))/a$$

The time span t_B is smaller than the time span t_A . An accelerated observer remains permanently younger than an inert observer who remains at rest with respect to him. For an accelerated observer - independent of the direction of the acceleration, i.e. also during a braking process - less time passes in comparison to non-accelerated observers. A twin accelerated and decelerated several times in the course of a journey has aged less on his return than his brother waiting at home, the longer the journey has lasted and the higher velocities have been reached.

Vienna, January 7, 2022

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