(This is a part of the book The Concept of Reality.pdf)

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2. New Interpretation and Explanation of Special Relativity

2.1. Introduction

In the physics of the second half of the 19th century there was a gap between mechanics and electromagnetism:

In the field of *mechanics*, all uniformly moving systems were considered as being physically indistinguishable, that is to say: identical experiments and measurements within different uniformly moving systems were supposed to lead to identical results. Here movement was thus *relative*. The conversion from one system to another (Galilean Transformation) conformed completely to the *a priori* concept of space and time. (The difference of the velocities of an object with respect to two different systems, in particular, corresponded exactly to the difference of the velocities of these systems themselves.)

As the electromagnetic equations are *not* covariant with respect to Galilean Transformations, it had to be postulated that in the field of *electromagnetism* a preferred system exists (the ether, carrier of the electromagnetic waves), in which the description of nature assumes its simplest form. That system was thought to be at rest. With electromagnetic phenomena, identical experiments and measurements in different uniformly moving systems ought to lead to different results. For this reason movement was here *absolute*.

Accordingly it should have been possible to determine the movement of the earth with respect to the ether by means of measurements on suitable electromagnetic phenomena. In contrast to this expectation, however, all attempts to measure such a movement with the aid of the velocity differences of light waves traveling in different directions came to naught: never was any difference found to occur.

The special theory of relativity eliminated the gap between mechanics and electro-magnetism and, at the same time, resolved the contradiction with the experiment by establishing two postulates:

1. The impossibility of distinguishing between uniformly moving systems with respect to *all* physical phenomena (– this is the principle of special relativity);

2. The constancy of the speed of light for all uniformly moving observers.

The second of these postulates determines which transformation must be chosen: that with respect to which the electromagnetic equations are covariant (the Lorentz Transformation).

The *a priori* Galilean Transformation is thus valid only by approximation, i.e. the mechanics connected with it must be corrected.

2.2. Why does Nature conform to the Space-Time Conditions determined by Light?

During the first years after the theory of special relativity was born, all involved parties – and indeed all parties not at all involved, too – were so occupied with expressing their fascination or aversion that they didn't think at all about the *actually* important question:

***Why** does nature conform to the space-time measures determined by light signals?*

Later, when the correctness of the theory could no longer be doubted, dealing with the relativistic formalism had become so ordinary that this question didn't cross anyone's mind. Why ask for the reason of something so reliable and self-evident?

However, actually only the consequent investigation of this question permits a true understanding of relativistic phenomena. Yet not only for this reason it is important to ask for the ontological cause of relativity, even more relevant is that the answer entails a rearrangement of the conceptual foundations of the description of nature and leads to a radical change in our understanding of reality. To say it with the words of John Archibald Wheeler: [1]

Some day a door will surely open and expose the glittering central mechanism of the world in its beauty and simplicity.

It is remarkable that for this purpose neither physical nor mathematical knowledge is required. I am tempted to say: on the contrary! Here it can in fact be an advantage to possess no such knowledge. Because of their everyday handling of mathematical formulas, physicists tend to identify reality and description – or, to put it correctly: to confuse the one with the other. Then, however, the question formulated in the title of this section disappears: if nature *is* the formalism, then it is senseless to ask

[1] In: *Gravitation*, Freeman, San Francisco 1973, p.1197. (Wheeler himself did not believe that such a mechanism could be found.)

why it *conforms* to it. To be able to ask this question at all, a concept of nature is needed which substantiates the formalism and can be confronted with it. [2]

Nature is *never* identical with its formal description. Reality *is not* a four-dimensional Minkowski space with the coordinates x_1, x_2, x_3 and ict – just as a fish-population *is not* the logistic equation.

Reality is *motion of objects in three-dimensional space,* and therefore the question arises *why* it is appropriate to describe this reality by the Minkowski space, in other words: why all uniformly moving observers measure the same value for the speed of light.

Without the conception of moving objects in space, the principle of relativity would not exist at all; as is well known, this principle originates from the insight that motion cannot be defined against (empty) space. Motion of an object can only exist relative to another object. Space itself is not such an object.

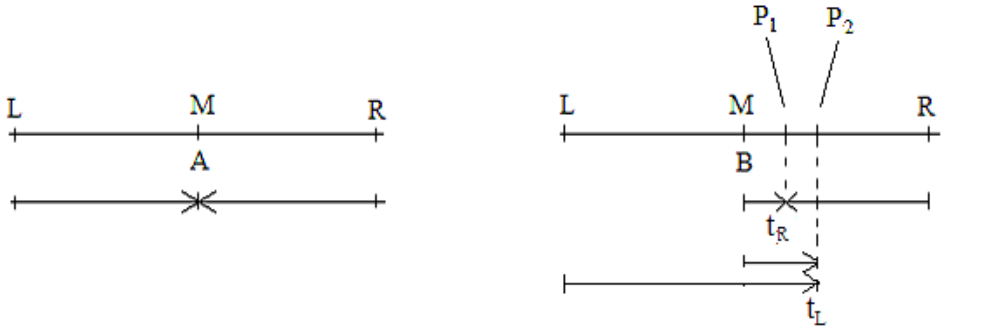
2.3. Einstein's Scenario

At the contemporary level of physical knowledge, the necessity of SR can be realized, but the relativistic phenomena *as such* must simply be accepted. Certainly, a model would be preferable that permits *understanding* these phenomena by providing insight into the underlying coherences.

Such a model will be presented in the following. However it lies far beyond the usual physical reasoning. In order to arrive there, as already mentioned, no formal tools are required. It is a purely interpretational question, or say: a question of geometrical and logical reasoning.

To begin with let us enter the well-known scenario which Einstein invented for illustrating the relativity of simultaneity.

[2] The first step to this confusion is the wide-spread conviction that "mathematics is the language of nature". This may be true – however if one believes that *everything* can be said with mathematics, then one will fall short and, in the end go astray.



(S1)

In this outline, M is the medium point of the line segment between L and R.

A and B are two observers, who are both at the time $t_0 = 0$ in M. A rests and remains in M, B leaves M and travels uniformly towards R.

Light signals emitted from L and R at the time t_0 (with respect to A) which arrive at A simultaneously do *not* arrive simultaneously at B: the signal from R will arrive *earlier* at B (at point P_1 at the time t_R) than the signal from L (which arrives at point P_2 at the time t_L).

Let the time difference between the arrival of the left and the right signal be Δt:

$$t_L - t_R = \Delta t$$

So much to the relativity of simultaneity. This time however we will extend the discussion of the scenario a bit further.

Say, for A the moment t_0 in L and R is *now*, that is: A's *present*. The suspension of simultaneity with respect to B means that the time of the emission of the light signal from R must be shifted into B's *past*: B is moving towards the signal, therefore it must arrive at him earlier than it arrives at A, which means that, in comparison with A, it must have been emitted earlier. Thus, for B, the emission of the signal from R must be a *past* event. In the same way holds that for B the emission of the signal from L is a *future* event.

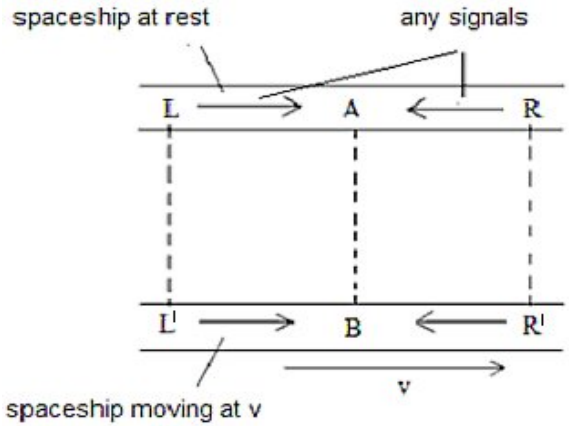
However this shift of the one event into the past and of the other one into the future of B – always in comparison with A – is only then possible and necessary if the following is true:

Each pair of identical signals, which belong to the system of the moving observer B and originate at L and R at the same time t_0 as the light signals (or, to put it more generally: each pair of identical processes which start at L and R simultaneously at t_0) and move towards B in a straight line, arrive at B with the same time difference Δt as the light signals.

Only under this premise, the suspension of simultaneity – and with it also the determination of the altered times that apply to L and R with respect to B – is a possible and necessary act. If there were any pair of signals or processes which would not meet this condition, then the determination of the space and time measures by light signals would be wrong.

Now, if one does not proceed immediately, as usual, to the relativistic formalism, but instead keeps looking at this circumstance as it is seen in that kind of reality, which Einstein's scenario is about – objects moving in three-dimensional space – then it becomes evident how immensely strong the condition is which, in this way, is imposed on this reality.

Let us demonstrate this by an example. Let A and B be observers in spaceships. Let the spaceship of A be at rest, the spaceship of B move relative to A with velocity v.



(S2)

LA = AR = L'B = BR' (with respect to A at the instant depicted in the outline)

From R and R', L and L', light signals are emitted, simultaneously with respect to A. They arrive of course simultaneously at A and again with the time difference Δt at B.

However now, simultaneously with the light signals and at the same positions, also other signals are generated, say: sound signals in the metal bodies of the spaceships or in the air contained within them. (However one could also fire bullets or produce any other shenanigans.)

At first, the light signals will arrive at B, and then, with different delays, the other signals. However for *all* pairs of identical signals holds: the time difference between their arrivals at B is always the same, and it is equal to the time difference of the light signals.

As regards the light signals, this time difference is a matter of course. One can "see" that B moves towards the one signal so that it will arrive at him earlier than the other one. But as regards the sound signals, this is evidently not true: these signals are *carried along* by the spaceship of B, and no reason is in sight, why any time difference at all should occur.

In order to demonstrate how strange that is, even after a hundred years of SR, we shall take a closer look at this issue:

With respect to A, the sound signals are emitted simultaneously. Some resting observer A', who is positioned before A (with respect to the direction of motion of B), can later inform A that these sound signals arrived at B with a certain time difference. As seen from A, this can only mean that the signal which came from the front must have been *faster* than the one from behind. Yet again: both signals are *traveling within the spaceship* of B, and whereas it is self-evident to A that the simultaneously emitted light signals must arrive at the moving observer B with a certain time difference, it seems absolutely inconceivable to him why also the sound signals, which are propagating within the metal body of B's space ship, should arrive at B with the same time difference. There is just no obvious reason for that.

Of course the problem disappears immediately if we take into account what we already know – i.e. that for B the events in L' and R' are *not* simultaneous, and that, therefore, with respect to B the velocities of the signals are identical. However with this "solution" we would use as explanation exactly that what we want to explain!

Above all, the whole issue seems altogether paradoxical for the following reason:

On the one hand, it is true that motion cannot be defined relative to space.

On the other hand the following can be stated: A *sees* that the sound signals are generated simultaneously. He *knows* that the distances between the positions of their generation and the position of the observer B are identical, and he *learns* that the signal from the front reached the observer B earlier than the one from behind. So he *must conclude* that the movement against space – *which cannot exist at all* – has influenced the velocity of the sound signals: the one from the front was accelerated, the one from behind decelerated.

Once again: of course one can apply the SR formalism and in this way eliminate the problem. But actually it does not disappear at all. With this formal act, one has just disposed of nature by a set of rules. And indeed nature obeys! – However it has not in the least become clear why. The connection between reality (moving objects in three-dimensional space) and formalism (Lorentz transformation) remains unexplained.

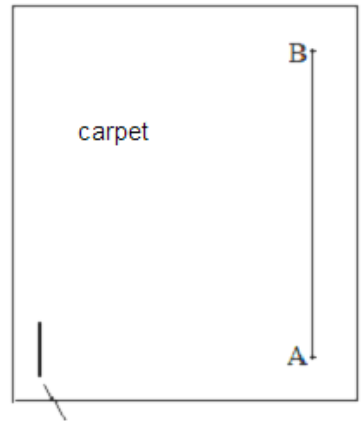
The space in which the problem dissolves is the four-dimensional Minkowski space. But the space, in which the just mentioned experiences and conclusions of the observer A are located, is the normal three-dimensional space with objects moving therein – i.e. exactly the space which Einstein's considerations about the relativity of motion relate to. And in exactly this space, which should be indifferent against motion, now – for A – an alteration of the sound speed occurs, and it has to be cleared up, what the reason for this alteration is.

The general question posed at the beginning of this section: "Why does nature conform to the spatial and temporal measures determined by light?" has now been concretized to the question of our example: Why does the sound signal from the front arrive earlier at the moving observer than the one from behind – and, moreover, why is the interval between the two signals equal to the interval between the light signals?

As preparation, we proceed to another scenario. Though it is completely trivial, it is still useful for the following considerations, because here questions and answers are possible without any limitations by entrenched thinking habits that would otherwise be inevitable.

2.4. The second Scenario

We are standing on a widely extended plane. Above the plain there is air, of normal pressure and unmoved. We look from above at a flying carpet, which however for the moment is lying flat on the plane.



(S3)

On the carpet there are two observers A and B and a sound reflector R.

Both A and B carry a sound reflector, too. In addition, each of them has two clocks of the following kind: an empty dial with a single hand that rotates uniformly. Both observers carry a pen for marking the dials.

Now the following procedure is performed:

1. A sends repeatedly sound signals towards B and simultaneously towards the reflector R. B reflects the signals back to A. A beckons B to come closer until he receives both reflected signals at the same time. From this moment on B remains at his position.

2. A takes one of his clocks; then he sends a sound signal towards B and writes simultaneously **0** onto the position of the dial where the hand points at that very moment.

3. B receives the signal, reflects it back to A and writes simultaneously **1** onto his dial.

4. A receives the signal, reflects it back to B and writes simultaneously **2** onto his dial.

5. B receives the signal and writes **3** onto his dial.

With this, we have defined a full measurement system of lengths and times. A and B can complete their scales. (A has the points 0 and 2, B has 1 and 3.) We call the time unit *second*, the length unit *sound second* – which in this case is the distance AB (or AR, respectively). The sound velocity is 1.

Now the carpet rises, accelerates and eventually moves uniformly at a speed near the speed of sound parallel to the distance AB (B is ahead of A).

A and B take their other clocks and perform the same procedure as before. Afterwards we have again a complete measurement system. Again we call the time unit *second* and the length unit AB (or AR, respectively) *sound second*.

During the course of the flight the following phenomena can be observed (A and B are able to read some of them directly by comparing the clocks marked at rest with those marked at the flight).

a) At 1.: B has to move closer to A.

b) At 2. and 3.: It takes a long time until the signal arrives at B, because B is moving away from the sound signal at a speed near the speed of sound. (In spite of that A writes **0** and B writes **1** onto his dial.)

c) At 3. and 4.: In contrast, the way back is very short: A moves towards the sound signal.

d) From a) follows that in the direction of motion the length unit is contracted.

e) From b) and c) follows that the *second* which applies during the flight is expanded compared to the *second*, which applied at rest. (If the carpet moved at sound speed, the flight *second* would last forever.)

f) From b) and c) follows also that simultaneity has changed, that is: if the clocks marked at rest indicate identical times, the other clocks do *not.* (An observer at rest could say: the second towards the front lasts much longer than the second towards the rear.)

g) Again the sound velocity is 1: if a sound signal coming from ahead or from behind passes the first observer at the moment when the dial points at n, then it will pass the other observer at n+1; the clocks are set that way. (However the sound velocity is 1 at all other directions, too.)

It is clear what we have done: We have built a measurement system on the flying carpet, which – compared with the measurement system on the resting carpet – is Lorentz-transformed. All relativistic phenomena can easily be observed.

And now we are going to pose an absurd question:

On the flying carpet, the *second* lasts much longer than on the resting carpet. Therefore the time of the flying observers progresses slower than the time of the resting ones. Does this mean that the flying observers will age more slowly than the inhabitants of the plane?

Of course not! – and why can we be so sure?

Because what we have done is purely arbitrary. To regulate space and time by sound signals (thereby making the sound velocity identical for all uniformly moving observers) means setting a standard to which nature will pay no attention at all.

The reason for this conviction is:

A time system, which is based on sound signals, can only apply to sound speed and to phenomena derived from it, and to nothing else.

What is meant by *"phenomena derived from sound-speed"?*

E.g. the velocities, with which superpositions of sound waves propagate. They could be described by the measurement system established on the plane and on the flying carpet, which means: in a *relativistic* manner, just in the way in which usually the analogous light phenomena are described. To sound waves the relativistic Doppler Effect would apply. Clocks, which could function on the basis of sound would show the "right" – which means: the "carpet"-time, but only if they were open so that the air would not be contained within them, and if their extent parallel to the direction of motion were corrected according to the sound-relativistic length-contraction.

Here the answer is clear and simple; it relates to the essence of the matter: Sound itself and everything which can be derived from it conforms to the measurement system based on sound signals. With respect to any other circumstances, this measurement system does not hold true.

Now we are prepared to answer the question we asked at the beginning.

2.5. The Answer

In the previous section, we realized: if length and time measures are determined by any arbitrarily chosen wave-signals, then this measurement system applies only to the waves themselves and to phenomena derived from them. Nothing else obeys this measurement system.

Only with light, this does not seem to be true. The measurement system which is based on light signals applies to *all* phenomena.

The explanation of this fact is blocked by an apparently insurmountable problem: there seems to be no reason why the velocities of *all physical processes* – which occur indeed in three-dimensional space and not in Minkowski space – should change with respect to other reference systems exactly in such a way, that they conform to the scheme determined by light. The fact itself appears ontologically impossible, and the causal connection between reality and formalism remains a secret.

However only as long as we suppose that the phenomena are independent from light in just the same way as they are independent from sound! As follows:

To the carpet-system the following applies: The biological processes (the aging of the observers) are no sound-speed phenomena. Therefore they do not conform to the measurement system determined by sound.

Accordingly, for the measurement system determined by light, the following *should* hold true: The sound propagation in the metal, or the aging of the observers, are no light-speed phenomena. Therefore they cannot conform to the measurement system determined by light. But still they do! And no reason can be seen why.

This contradiction is eliminated by the following assumption:

There is in fact no difference between light and sound regarding the area of validity of the measurement systems based on them: both systems apply only to the phenomena that can be derived from the respective kind of waves.

This means that there is only one possible reason for the fact that in the case of light – contrary to sound – from this assumption does not follow any restriction (as indeed everything which exists conforms to the light-system):

Nature conforms to the measurement system of space and time determined by light because there <u>is</u> only light speed and phenomena derived from it.

What about other velocities? The assumption *there is nothing but light speed* leaves only one possibility for other velocities, that is: *interference.*

Everything which exists and which occurs is an interference phenomenon, a pattern of superpositions of waves with light speed.

To restrict myself – after this proposition which, if it was true (what I cannot doubt), would be one of the most important statements ever thought – to the narrow scheme of scientific descriptions which, though it is unavoidable, is so lifeless and emotionally flat, as if nothing has happened, would seem completely inadequate to me. Thus I ask:

Isn't this a fantastic hypothesis with a downright magical explaining power?

It is not only necessary and sufficient for the explanation of relativity, but permits also, as promised, a first glance onto *the glittering central mechanism of the world in its beauty and simplicity.*

However at first it is only a glance from great distance, and in order to see the mechanism more clearly – and also to just vindicate what can be seen here from afar, comparable to the moons of Jupiter in Galileo's simple telescope, against the physical inquisition – many further steps must be taken. [3]

However some may consider my answer not magic but crazy. I think this is due to the fact that, in our insights about nature, we are subject to a double prejudice: about *being* itself and about its physical

[3] The relationship between my hypothesis and the system of contemporary convictions is of the same kind as the relationship between Aristarchos' hypothesis (that the earth is rotating and moving around the sun) and the worldview of that time. *Actually,* everything becomes very simple. But ostensibly verified knowledge is blocking the way to this simplicity.

However is it in fact justified to compare scientifically motivated objections against my hypothesis with the arguments that were brought up against Aristarchos? Is it possible to compare e.g. the argument that – if the earth rotated – storms would occur, with the argument that *particles* are an indispensable element of the scientific description of the world? Yes, of course it is justified. And, at that, I consider myself in a substantially better position as Aristarchos: He could not refute the storm-argument, because at that time the concept of uniform motion did not exist. But I can show that, at least in some cases of fundamental relevance, the particle concept can be dispensed with, and, additionally, that the abandonment of this concept is a necessary condition for the elimination of interpretative lack of clarity and of the occurrence of paradoxes.

description. In our experience, *being* is given *substantially*, and physics has originated from this premise and has never transcended this background – at least not in the field of interpretation.

Just before, it seemed to be natural and self-evident that a time based on sound applies only to sound phenomena and to nothing else. We posed the question: "Will the flying observers age more slowly than the resting observers?" and called this question quite rightly *absurd.*

But wouldn't the question if, in the case of a measurement system determined by light, moving observers were aging more slowly than resting observers, be equally absurd – *unless* aging would *ultimately* be a light speed phenomenon, an alteration of patterns shaped by waves?

Why is it not possible to draw the same conclusions with respect to the light-time as with respect to the sound-time? Because then it would be necessary to conclude that there is only light speed and phenomena derived from it, and it seems evident to us that the objects of our experience cannot be of that kind.

It is the aim of the next paragraph to challenge this conviction.

2.6. The short Path to Matter

In a universe where nothing but light-speed exists, objects must be wave superpositions.

In the theory of special relativity, at the transition from one frame of reference to another frame of reference – if appropriate coordinates are chosen – only the measures of two dimensions change: of the time dimension and of the space dimension parallel to the direction of the relative motion of the two systems.

Therefore, for the following analysis of relativistic circumstances, a simple model will suffice, where all objects are moving only along the x-axis.[4]

It may appear that the hypothesis: "There is nothing but light speed" has brought us into an almost absurd distance from "normal" physics. Thus our first aim is to show that this assessment is not true and that, on the contrary, there is actually a very short path back to the usual physical model conceptions.

[4] In the following, this model will serve for reconstructing the relativistic space-time structure.

Let S1 be a reference system at rest, S2 a reference system moving with velocity v relative to S1. An object which rests in the moving system S2 can be represented by a wave superposition in the form of a *standing wave:*

$$y = \sin(2\pi\, f\, t)\cos(2\pi\, x\, \frac{1}{\lambda}) \qquad (f\lambda = c)$$

Transformation to the resting system S1 leads to the wave superposition

$$y = \sin 2\pi\,(t\, f\, \frac{1}{k} - x\, f\, \frac{v}{c^2}\frac{1}{k})\ \cos 2\pi\,(t\, v\, \frac{1}{\lambda k} - x\, \frac{1}{\lambda k}) \qquad (k = \sqrt{1-\frac{v^2}{c^2}})$$

The *first wave* is a *de Broglie matter wave*.

Its frequency is $f\,\frac{1}{k}$, its wave-length $\frac{1}{f}\,\frac{c^2}{v}\,k = \lambda\,\frac{c}{v}\,k$ (λ Compton wave-length)

and its phase speed $u = \frac{c^2}{v}$.

The *second wave* has the velocity v – this is the velocity of the particle associated with the matter wave.

Therefore the following holds:

A standing wave in a moving system, which is generated by two waves with light speed, is – seen from the system at rest – the superposition of a matter wave and a wave with the velocity of the wave packet, i.e. of the associated particle.

In other words: Just the substantial being, the materially existing objects – which means: exactly that what seemed to be in blatant contradiction with the hypothesis: "There is nothing but light speed" – can be reconstructed by this very hypothesis by a very short thought train; – at least in the simple form of de Broglie's description, which however is of course the most we can get from our one-dimensional model.

2.7. Theory of Relativity without Relativity

The aim of this section is to determine explicitly the spatial and temporal relationships of the phenomena in the following way:

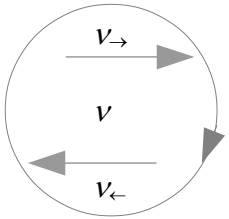
1. without postulating relativity or the constancy of the speed of light for all uniformly moving observers,
2. in a way which makes these relationships directly understandable,
3. based on the premise that everything which exists and which occurs – every object and every process – is ultimately a superposition of waves with light speed.

Objects at rest will be represented by standing waves, accordingly moving objects by waves with different frequencies. Frequencies and wave lengths of waves traveling in opposite directions will be indexed with arrows ($_{\rightarrow}$ or $_{\leftarrow}$). All waves travel at light speed.

Let S be the system at rest. Let Ψ' be a superposition of two waves traveling in opposite directions with frequencies $\nu_{\rightarrow}'$ and $\nu_{\leftarrow}'$. Our first objective is to determine the velocity v of the system S' where Ψ' is a standing wave with frequency ν_T.[5]

The circumstances correspond to those in the normal (non-relativistic) Doppler Effect, where an observer who travels with velocity v measures the same frequencies on waves from the front and from behind.

[5] However, the idea of wave superpositions is applicable not only to standing waves. E.g. it can also be transferred to a case where the direction of the wave propagation is curved so strong that a rotating wave structure develops:



ν is the frequency of the rotating wave structure. If this structure is at rest relative to the observer, then $\nu_{\rightarrow} = \nu_{\leftarrow} = \nu$. If it moves in the plane normal to the axis of rotation, then $\nu_{\rightarrow}$ becomes $\nu_{\rightarrow}'$, $\nu_{\leftarrow}$ becomes $\nu_{\leftarrow}'$, ν becomes ν_T, and the subsequent derivations apply.

(Obviously, this model is not meant to be realistic; what is required is only the existence of the two countermoving waves.)

Thus it applies that $\nu_{\rightarrow}' \ (1 - v/c) \ = \ \nu_{\leftarrow}' \ (1 + v/c) \ = \ \nu_T$ (1)

from which follows: $\nu_{\leftarrow}' \ / \ \nu_{\rightarrow}' \ = \ (c - v) \ / \ (c + v)$ (2)

and $v \ / \ c \ = \ (\ \nu_{\rightarrow}' - \nu_{\leftarrow}' \ ) \ / \ (\ \nu_{\rightarrow}' + \nu_{\leftarrow}' \ )$ (3)

as well as $v \ / \ c \ = \ (\ \lambda_{\leftarrow}' - \lambda_{\rightarrow}' \ ) \ / \ (\ \lambda_{\leftarrow}' + \lambda_{\rightarrow}' \ )$ (4)

From (3) follows that the velocity v of the object represented by the superposition depends on the frequencies of the two countermoving waves. Thus an alteration of the velocity is equivalent to an alteration of the frequencies.

According to our premises, Ψ' is a standing wave with frequency ν_T in S'. Let us now assume that Ψ' has emerged from a wave Ψ with frequency ν, which was a standing wave with respect to S, by an *acceleration* along a line segment AB. (In the usual view: an object at rest has been accelerated up to the velocity v.) Which alteration of the frequencies of the countermoving waves corresponds to this acceleration?

In the case of *any* acceleration, we assume for the frequencies of the waves traveling to the right

$$\forall \ \nu_{\rightarrow} : \quad \nu_{\rightarrow} \quad \mapsto \quad \nu_{\rightarrow}' \ = \ f(\nu_{\rightarrow}) \tag{5}$$

and – as any wave which has traveled along AB, should, after the reverse travel BA, again have the original frequency – for the frequencies of the waves traveling to the left

$$\forall \ \nu_{\leftarrow} : \quad \nu_{\leftarrow} \quad \mapsto \quad \nu_{\leftarrow}' \ = \ f^{-1}(\nu_{\leftarrow}) \tag{6}$$

We postulate the acceleration as independent of frequency. By inserting (5) and (6) in (3)

$$v \ / \ c \ = \ (\ f(\nu) \ - \ f^{-1}(\nu) \ ) \ / \ (\ f(\nu) \ + f^{-1}(\nu) \ ) \qquad (\text{note} \quad \nu_{\rightarrow} \ = \ \nu_{\leftarrow} \ = \ \nu \ ) \tag{7}$$

it is easy to see, that this postulate is met in the simplest way by setting

$$\nu_{\rightarrow}' \ = \ f(\nu_{\rightarrow}) \ = \ q \ \nu_{\rightarrow} \quad \text{and} \quad \nu_{\leftarrow}' \ = \ f^{-1}(\nu_{\leftarrow}) \ = \ q^{-1} \ \nu_{\leftarrow} \qquad (q \in R, \ q > 0) \tag{8}$$

Then the equation of the velocity of the standing wave reads as follows:

$$v / c = (q\,\nu - q^{-1}\,\nu) / (q\,\nu + q^{-1}\,\nu)$$

or – after canceling the frequency

$$v / c = (q - q^{-1}) / (q + q^{-1})$$

$$v / c = (q^2 - 1) / (q^2 + 1) \qquad (9)$$

According to (1) and (8):

$$\nu_T = \nu\, q\, (1 - v/c) = \nu\, q^{-1}\, (1 + v/c)$$

therefore $\nu_T^{\,2} = \nu^2 (1 - v^2/c^2)$

and, at last $\nu_T = \nu\, (1 - v^2/c^2)^{1/2}$. (10)

Thus the frequency of Ψ' is reduced by the factor $(1 - v^2/c^2)^{1/2}$, compared with the frequency of Ψ.

In this model, times and lengths are *defined* by frequencies and wave lengths of standing waves.

Therefore (10) means:

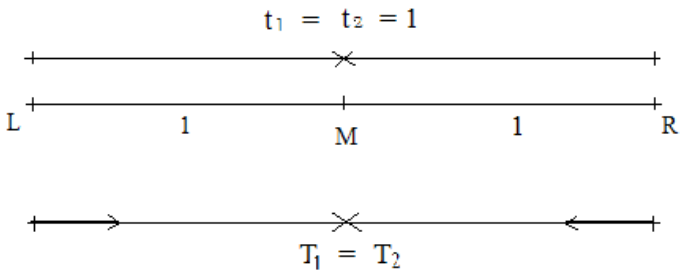
In a reference system S' that travels with velocity v *relative to the reference system S, time passes slower by the factor*

$$k = \sqrt{1 - \frac{v^2}{c^2}} \qquad (11)$$

Now to the fundamental question of special relativity, which was introduced in section 2.3, i.e. the question why all signals (or objects, or processes), which arrive simultaneously at an observer at rest, arrive at a moving observer always *with the same time difference* as light signals which were emitted at the same time and at the same positions.

Since we postulate neither the validity of the principle of special relativity nor the constancy of light-speed for all uniformly moving observers, the equality of these time differences cannot be presupposed but must be demonstrated.

Let as first look at the resting system S. Let M be the medium point of the line segment LR.



(S4)

The upper arrows represent light rays. t_1 and t_2 are the time points when the light rays from R and L arrive at M ($t_1 = t_2$).

The lower arrows represent objects, which travel from L and R towards M with equal velocity. T_1 and T_2 are the time points of their arrival ($T_1 = T_2$). The distances between M and R and between M und L are 1.

The object at L is represented by a superposition of waves with the frequencies $\nu_{\rightarrow} = a$ und $\nu_{\leftarrow} = b$, accordingly the object at R by a superposition of waves with the frequencies $\nu_{\rightarrow} = b$, $\nu_{\leftarrow} = a$ ($a > b$). At M, an object at rest is located with $\nu_{\rightarrow} = \nu_{\leftarrow} = m$.

Let v_L be the velocity of the object at L, v_R the velocity of the object at R ($v_L = -v_R$), and v_M the velocity of the object at M ($v_M = 0$).

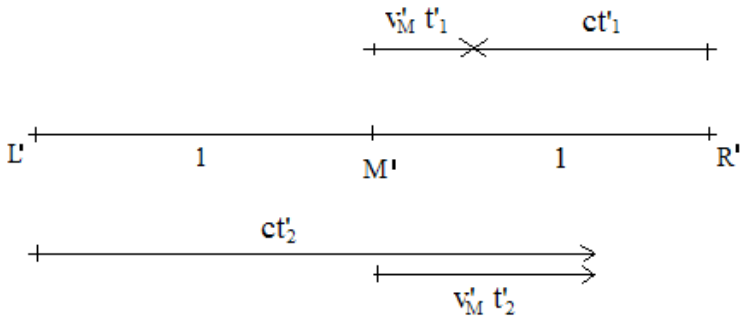
Now we change over into a system S' which travels uniformly to the right with velocity v_M'. S' is defined in the following way: the *very same* objects as before in S – which however we denominate now L', M' und R' – are located at the same positions at the same time point t = 0, but *after an*

acceleration, that is: transformed according to (8). Thus their frequencies can be determined by multiplying or dividing the frequencies of the corresponding objects in S by a real number $q > 0$.

Now we will demonstrate, using this scenario, that the time difference of the arrivals of the moving objects is equal to the time difference of the arrivals of the light rays.

At first we calculate the time difference, with which the light rays emitted from L' and R' (simultaneously with respect to the system at rest) arrive at M'.

From the below outline



(S5)

the following relationships can be read off:

$$v_M' t_1' + c t_1' = 1 , \quad - v_M' t_2' + c t_2' = 1$$

According to (9) holds

$$v_M' = c (q^2 - 1) / (q^2 + 1)$$

Therefore

$$\left(c (q^2 - 1) / (q^2 + 1)\right) t_1' + c t_1' = 1 , \qquad t_1' = (1 / c) \left((q^2 + 1) / (2q^2) \right)$$

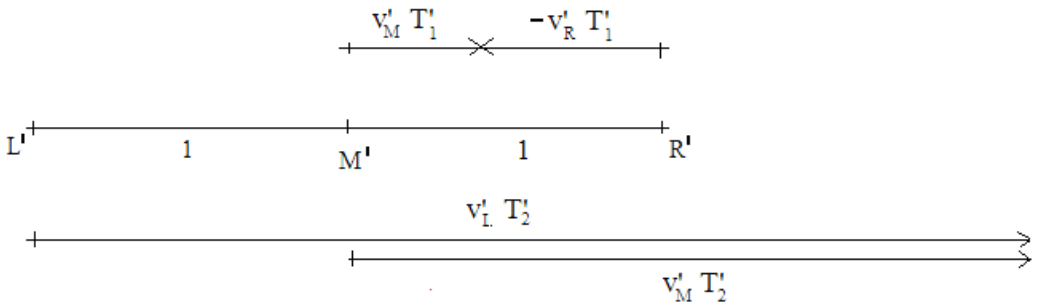
$$- \left(c (q^2 - 1) / (q^2 + 1)\right) t_2' + c t_2' = 1 , \qquad t_2' = (1 / c) \left((q^2 + 1) / 2 \right)$$

From this follows

$$t_2' - t_1' = (1 / c) \ ((q^4 - 1) / (2q^2)) . \qquad (12)$$

Thus this is the time difference with which the *light rays* arrive at M'.

Now to the time difference, with which the *objects* arrive at M'.



(S6)

$$- v_R' T_1' + v_M' T_1' = 1, \quad v_L' T_2' - v_M' T_2' = 1$$

According to (3) and (8) applies

$$v_L'/c = (a q - b (1/q)) / (a q + b (1/q)) = (a q^2 - b) / (a q^2 + b)$$

$$v_R'/c = (b q - a (1/q)) / (b q + a (1/q)) = (b q^2 - a) / (b q^2 + a)$$

As before, $v_M' = c (q^2 - 1) / (q^2 + 1)$

The short calculation leads to:

$$T_2' - T_1' = (1 / c) ((q^4 - 1) / (2q^2)) . \qquad (13)$$

The comparison with (12) shows:

$$T_2' - T_1' = t_2' - t_1' .$$

The time difference of the arrivals of the moving objects at M' is equal to that of the light rays.

Thus we have demonstrated:

If a resting system S is changed into a system S' by transforming all objects of S according to (8), then all symmetrical signals (processes, objects) – traveling at light speed or at any other arbitrary speed – which arrive at M in S simultaneously, arrive at M' in S' with the same time difference Δt.

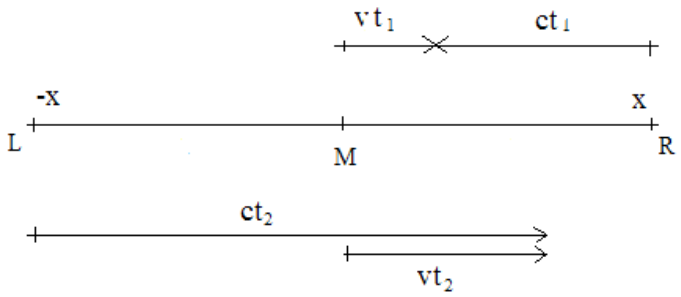
Therefore, points located *ahead of* M' must be shifted into the past with respect to an observer in M', and points *behind* M' into the future.

2.8. Derivation of the Lorentz-Transformation

If *now* the measures of space and time are determined by light signals (on the basis of Δt), then this is *not* substantiated by the principle of special relativity and by the principle of the constancy of light speed for all uniformly moving observers, but by the fact that – due to the above result – it is *already known* that the space-time measures determined by light hold true for all physical processes and events.

For the sake of simplicity, in the following we will omit the dashes of the primed quantities that belonged to the moving system, and also denominate v_M' as v.

The scenario is now again the one that Einstein invented. From L and R light rays are emitted, simultaneously with respect to an observer resting at M.



(S7)

The outline shows that

$$t_1 = x/(v + c) \qquad t_2 = x/(-v + c)$$

$$t_2 - t_1 = 2\,vx/(c^2 - v^2) = 2\,(vx/c^2)/(1 - v^2/c^2)$$

Thus if, with respect to the resting observer, the signal from point R is emitted at the time $t_R = 0$, then, with respect to the moving observer, this time point must be shifted by the interval

$$(vx/c^2) / (1 - v^2/c^2)$$

into the past: the signal arrives at the moving observer earlier than at the resting observer. (Half of the time difference, because the origin of coordinates of both systems lies in the middle between L and R and the dependency from x is linear.)

Accordingly, with respect to the moving observer, the time point t_R° of the emission of the signal from R is given by

$$t_R^\circ = -(vx/c^2)/(1 - v^2/c^2)$$

Let us now assume, the signal is not emitted at the time 0 but at an arbitrary time t from a point located at the distance x from the resting observer.

Then, with respect to the moving observer, the x-coordinate of this point has been diminished by vt, and it follows (by plugging in the value of x and adding t)

$$t^\circ = t - (v\,(x - vt)/c^2)/(1 - v^2/c^2)$$

$$t^\circ = (\,t - v^2t/c^2 - vx/c^2 + v^2t/c^2\,)/(1 - v^2/c^2)$$

$$t^\circ = (\,t - vx/c^2)/(1 - v^2/c^2) \qquad (14)$$

The coordinate x° that belongs to this altered time t°, results from

$$x^\circ = x - vt^\circ$$

$$x^\circ = x - v(\,t - vx/c^2)/(1 - v^2/c^2)$$

$$x^\circ = (\,x - xv^2/c^2 - vt + xv^2/c^2\,)/(1 - v^2/c^2)$$

$$x^\circ = (\,x - vt\,)/(1 - v^2/c^2) \qquad (15)$$

Up to know, only the time shift along the x-axis has been taken into account. However it must also be factored in that, according to (11), in the moving system the time is passing slower by the factor k.

Therefore we set

$$t' = t^\circ\sqrt{1-\frac{v^2}{c^2}}$$

Then follows from equation (14)

$$t' = (\,(\,t - vx/c^2)/(1 - v^2/c^2)\,)\sqrt{1-\frac{v^2}{c^2}}$$

$$t' = (\,t - vx/c^2)\Big/\sqrt{1-\frac{v^2}{c^2}} \qquad (16)$$

Lengths and times are connected by $x^\circ = ct^\circ$. Therefore also applies that

$$x' = x^\circ \sqrt{1-\frac{v^2}{c^2}}$$

$$x' = (x - vt) \Big/ \sqrt{1-\frac{v^2}{c^2}} \qquad (17)$$

(16) and (17) are two of the four equations of the Lorentz-Transformation. About the other two, nothing further has to be said.

2.9. Additions

1. Basis of our considerations was the time difference Δt. However it would also have been possible to start with the formula for the velocity addition, which here, according to (9), assumes the following form:

Let be $v = c\,(q_1^{\,2} - 1) / (q_1^{\,2} + 1)$, $w = c\,(q_2^{\,2} - 1) / (q_2^{\,2} + 1)$

Then it can be shown by a simple calculation that the combined velocity W, which is composed of v and w, is given by

$$W = c\,\frac{q_1^{\,2}\,q_2^{\,2} - 1}{q_1^{\,2}\,q_2^{\,2} + 1} = \frac{v + w}{1 + vw/c^2}$$

(At last I should mention that q corresponds to the factor of the relativistic Doppler effect:

from equation (9) follows $q = \sqrt{\frac{1+v/c}{1-v/c}}$)

2. In the above considerations, special relativity has been derived from the assumption that there is nothing but light speed.

The train of thought that leads to the insight that there can be only one single velocity has been performed *without any physical premises.* Special relativity thus appears as a result of a series of ontological conclusions.

Here is a short recapitulation:

The first step is to realize that the relationships between the times that apply at different positions cannot be substantiated by a hypothetical entity called *universal time,* but must be mediated by physical processes: If I am *now here,* and I want to know *which time (out) there* is, then the only way to find that out is using signals or processes.

Times determined in this way change with the state of motion of a system: signals used for determining these times arrive at an observer A not at the same points in time as an observer B who is moving relative to A.

The achieved results must meet the *postulate of uniqueness*: independent of the kind of signals used for determining the times, for every observer – with respect to his reference system – the operation must lead in any case to identical results.

With this, we have arrived at the point where the conclusions of sections 2.3, 2.4 and 2.5 come into effect: the demand of uniqueness can only be met *if there is just one single velocity.* This means: *Reality consists of fundamental processes which propagate at the same speed.* (It is also possible that there is only one such process.)

From the considerations of sections 2.6 and 2.7 follows that these fundamental processes have to be *wave-like.* Therefore, all other velocities must be generated by wave superpositions.

This means: everything which exists – every object and every interaction – is ultimately a superposition of the fundamental wave-like processes. The limit of their velocities will then of course be the speed of the waves themselves. [6]

[6] In the Second Part, these statements will be derived once again, however from completely different preconditions.

As demonstrated in 2.7, in a reality determined in this way the postulate of uniqueness of the times at different positions with respect to any reference system is met. And at last, according to (8), the transformation between systems moving relative to each other is the Lorentz-Transformation.

2.10. What has been achieved?

1. The relativistic space and time phenomena are completely evident.

The assumption: "Everything which exists and which occurs is a superposition of waves with light speed" makes it possible, to *construct* and thus to understand the relativistic space and time measures on the basis of reality *as it is,* that is: dynamics of objects in three-dimensional space.

With this, it is no longer necessary to *justify* the principle of special relativity. This is especially important as this principle can actually *not at all* be justified within the framework of the usual model conceptions. As follows:

If there is no motion against space but only relative to objects, then this must apply to *any* motion, thus also for accelerated motion. Against space, also acceleration cannot be defined. Therefore, there is no reason for the distinction of uniformly moving reference systems.

The theory of general relativity does *not* solve this problem. It represents a generalization of the theory of special relativity only with respect to permitted coordinate systems but not with respect to the relativity of motion: this relativity is *not* extended to accelerated systems by GR. In actual fact, as a consequence of acceleration, *inertia forces* occur. Of course these forces can be treated as if they were the consequence of a time-dependent gravitational field – however this is a purely formal act. Is relativity of accelerated motion demonstrated by this act? Not at all! – there *is* just no gravitational field, and the question remains open, *what* the accelerated motion must be related to and *why* uniform motion is distinguished by nature.

First it may seem that Mach's proposal – that motion is to be defined relative to the masses in the universe – was a way out. Then the assumption of motion against space could be dispensed with. However if mass should serve as reference point for accelerated motion, then not only motion itself but also the phenomenon connected with it, that is: *inertia*, has to be related to the surrounding mass.

However also in GR, the total mass that surrounds an object that is accelerated (e.g. rotating) relative to this mass, is not the source of the inertia caused by the acceleration but contributes to it just a small part.[7]

Thus, against general conviction, the result of Einstein vs. Newton as regards relativity of motion is 1:1, a draw: uniform motion is *relative*, accelerated motion is *absolute*. However this is of course not a possible result but a contradiction within the concept of relativity of motion; and this means that the principle of special relativity cannot be substantiated consistently within the framework of the usual physical conceptualizations.

However in actual fact, the principle of special relativity *does* apply. But as clear and simple the idea may seem that motion against space cannot exist and that *therefore* motion has to be relative – it is still impossible to derive the relativity principle from this idea.

This problem disappears with our approach. Here, the relativity principle does not represent the necessary starting point of SR. It is substituted by the basic assumption: "There is nothing but light speed", from which ensues the direct construction of the relativistic space-time relationships, as was demonstrated in the previous sections. The problem of motion does not appear at all, because motion is *defined* as interference phenomenon and, as such, behaves *inherently* in a relativistic way. From this *follows* the principle of special relativity.

2. A consequence of the interpretation of SR presented here is the maximal extension of the nomological status of light speed and, accordingly, of the importance of the natural constant c. In this regard, the assertion "There is nothing but light speed" cannot be outperformed.

3. If there is nothing but light speed, then particles are wave superpositions. From this ensues directly that the quantities energy and momentum must be defined by frequency and wave length, and that acceleration is tantamount to frequency alteration. Moreover, the derivation of de Broglie's matter waves in 2.6, shows that for defining momentum a phase wave-length is needed.

4. Formally, SR is nothing but a system of transformation equations. Einstein adopted it from Lorentz. The only – but indeed very important! – difference was the interpretation: The one of Lorentz was *ad hoc:* he saw the cause for the alterations of time and space measurements in a mechanical deformation of the ether which had – without any reason, purely by chance – just the value needed for canceling out any difference of light speed measurements performed by moving observers (e.g. in the Michelson

[7] See e.g. H. Thirring: *Über die Wirkung rotierender ferner Massen in der Einsteinschen Gravitationstheorie*, Phys. Zeitschr. 19, 33 (1918).

Morley experiment). Einstein's interpretation, on the contrary, was based on general principles. Only through this interpretation, the Lorentz transformation could become the foundation of modern physics.

Now, this transformation is again re-interpreted, in fact in a way by which the hitherto existing, purely formal view is deepened through the knowledge of the context of justification.

As regards the transformation itself and its applicability to all physical phenomena, nothing changes. However, by virtue of this new knowledge, for the first time the fundamental layer of reality comes in sight, and surely it need not be specifically emphasized that the consequences will be at least as serious as with the first interpretational changeover: at one blow, the conceptual basis of physics changes, and our view of reality is radically transformed.[8]

2.11. Some philosophical Remarks

The Problem of the Relation between *Existence* and *Time* in Physics

Any conception of reality whose constitutive elements are *space* and *material objects,* i.e. elementary entities existing *in* space, imposes a fundamental restriction on our understanding of time.

Here, the concept of a material object is *timeless.* Therefore, in a worldview of this kind, the concept of *existence* is also timeless.

The mental picture of a material body is *without* time. Time is added to this picture as a further, different element. There is existence, *and* there is time.

Newton formulates explicitly: *"Absolute, true, and mathematical time, in and of itself and of its own nature, without reference to anything external, flows uniformly…"* Thus it is not necessary that anything *moves* – time flows by itself.

Though this conception of time is corrected by quantum mechanics and by the theory of relativity – by quantum mechanics, because the energy cannot become zero, and by the theory of relativity, because space and time are united formally to space-time – there still remains the idea of *something which*

[8] At this moment, nothing more can be said. All considerations of the First Part are pointing to this new vision of reality. In the Second Part, it will assume a more clear shape.

moves; and this "something" – if it is *without* motion, so to speak *purely existing* – is still timeless. In this conception, the idea of *timeless material existence* is conserved. (Motion is only an accident of that which exists.)

So this concept of existence lacks the relationship with time. Within the interpretation network of standard physics, this conceptual separation is uncorrectable.

In the model presented here, reality is *dynamic form.* Unlike a particle, a wave is *unthinkable* without motion. Thus there is no reality without motion, and accordingly also not without time. Therefore, time is not an *additional,* but a *necessary* element of the concept of existence. Its "flow" does not follow from its nature – in this case it would remain a mystery – but from the definition of reality.

There is no longer the idea of objects as material entities which *could* move or not; Reality *is* motion.

What is Time?

"Time" is an entity which, though we use the term quite carelessly, is ultimately inconceivable.

In contrast, the entity "motion" can be understood intuitively . We know what motion is.

Due to the hypothesis "There is nothing but light speed", not only any kind of dynamics but also any kind of existence is bound to a motion with invariable speed. Thus it is possible using *motion* instead of *time* as basic concept.

Reality will then be *space and motion* – just in the way in which it has been designed in this chapter already from the beginning.

Formally, nothing changes. However now we know what time is. As a fundamental concept, it is inaccessible to us; but as a derivative concept which originates from the concept *motion,* it can be understood.

This modification affects the very basis of our view of the world. Of course we will continue to use phrases like "time passes by". However because of the inaccessibility of the concept "time", such statements hitherto have been just associatively connected with changing circumstances, but in fact it has been completely unclear *what* that actually is which "passes by".

But now, this statement has a meaning which is mediated through the concept of motion. All the changes and transformations that objects undergo *in time,* are manifestations of one perpetual motion, which forms, alters and dissolves patterns.

Substance or Form?

If matter is thought as consisting of particles, then it is *static*.

If it is thought as consisting of waves, then it is *dynamic*.

Then, however, it is no longer appropriate to state that matter *consists* of waves – rather it must be seen as a perpetual dynamic process of generating and maintaining shape.

Therefore, what remains identical over time is not the *substance* of an object but its *form* – as stationary (or near-stationary) wave state.

2.12. What remains open?

The theory of special relativity contains a conceptual defect, which we have not eliminated.

It manifests itself in several different ways. The simplest way to reveal it is by posing the question:

***What** oscillates actually in the case of light waves?* [9]

The answer: "The electrical and magnetic field vector" cannot be accepted – that would be the same as if, in the case of water waves, the water were removed and then stated that now kinetic and potential energy take the place of the water. The *subject* of the periodic change, which is the basis for the wave propagation, cannot simply be replaced by general description quantities.

The same question appears also as *the problem of mediation:*

Two spaceships are located at a great distance from one another. The question is:

[9] Due to the aforementioned identification of reality and description, this question has disappeared from the awareness of physicists. But light *is not* just a wave equation – light *exists!*

***What** is it actually, which provides for the correct – which means: relativistic – progress of time in both spaceships? By **what** is the connection between the two systems mediated?*

Here, the theory of special relativity does not offer anything. The absolute reference system has disappeared, and instead there are only coordinate systems. But a coordinate system does not exist – it cannot mediate anything.

This question about "what" – i.e. about the subject of the oscillation that generates the light waves, or about the subject that mediates the progress of time – appears especially clear in the following scenario:

Think of a closed two-dimensional universe, the geometric structure of which is that of a spherical surface.

In this universe, there are two observers, who move uniformly relative to each other along the same great circle. At their first encounter, they set their clocks to 0.

The question is: *What will be the result of the clock comparison at their next encounter?*

There is in fact no answer. Both A and B travel on geodesics. As seen from A, time passes slower at B, as seen from B, time passes slower at A. The situation is completely symmetrical.

Of course we can also introduce other observers, who travel along the same great circle with different velocities. Each of them has the same right to judge the circumstances with respect to his reference system and, accordingly, to expect another result of the clock comparison. Only an *actually performed* comparison can inform about how the different observer times are *in fact* related to each other.

Among all possible observers, there is exactly *one*, whose judgment was correct. It is the one, whose time passes most quickly. His reference system is *in fact* the absolute frame of reference.

If we now opened the great circle and extended the ends to infinity, then the situation would change completely: A and B would then encounter a second time only if one of them turned around, whereby the symmetry would be lost. Everything would remain relativistic. However if we closed the ends again, we would again be compelled to introduce the absolute reference frame. A most peculiar circumstance: The topology of the universe, i.e. a *global* attribute, determines directly what the case is *locally* (the respective time).

Doesn't this introduction of a system at *absolute* rest, which is in fact necessitated here, suggest a re-institution of the ether – all the more, as the contradictions of the old ether theory would be eliminated by the assumption that there are only waves? [10]

Though this conclusion seems indeed unavoidable, it is actually not necessary. In the Second Part it will be answered why – together with the question of what oscillates in light waves and by what the relativistic time relationships are mediated.

2.13. Michelson-Morley: The Overlooked Opportunity

The experiment, which Michelson and Morley performed in 1887, was meant to measure the velocity of the earth relative to the ether. Since they found no difference between the velocities of light in different directions, they considered their experiment failed.

Currently, however, the following conclusion is held to be correct: The constancy of the speed of light for all uniformly moving observers is a natural law, the ether does not exist, and light does not require a medium for its propagation.

Here, it was shown that there is a further option: the medium exists, but there are no particles – at least not in the form in which they are presently understood –, but only waves. The constancy of the speed of light for all uniformly moving observers is not set by natural law, but derived.

Thus the alternative in which we find ourselves reads as follows:

A: We abandon the assumption of a medium for the light waves.
B: We abandon the assumption of indivisible *substantial* objects that are always identical with themselves.

Alternative A – even if it is held to be true for more than a century and thus seems a matter of course –, must ultimately be suspected to be merely an ontological aberration: a wave without medium is nonsensical. Such an assumption can only be eligible if it is inevitable because there is no alternative.

[10] The problem of the ether was that, on the one hand – due to the high value of the light speed – it would have had to be very hard, and, on the other hand, it should have offered no resistance at all to material bodies. An obviously absurd concept! In a model in which no particles exist but only waves, this contradiction would be eliminated.

However, there *is* the alternative B, and, as it will turn out in the following, B is reasonable and well founded – although it contradicts beliefs that lasted for more than a century.

In the case of A, it is impossible to understand the relativistic phenomena. Relativity is a purely formal fact.

By contrast, in the case of B special relativity can be derived *and* explained.