13. Possible experiments

In the following it shall be discussed, which possibilities exist to clarify the situation created by the survey presented in this elaboration. For this purpose, the set-up of possible experiments is introduced, and an approach will be made to evaluate output data on the basis of realistic input. The proposals for these experiments are based on the considerations presented in chapter 10, were major subjects of the theory of Special Relativity were discussed.

A new approach to the subject is, when during quantum mechanical tunneling experiments it is assumed that information – considered as a simple pulse – could be transported with superluminal velocity. This would only be possible, when in contrast to the well-known preconditions of Special Relativity a system at absolute rest is assumed as general frame.

Further an experiment will be proposed to clarify, whether differences in the synchronization within a system in motion before and after acceleration really exist. With this experiment it could be possible to find distinct evidence about the statements concerning Relativity of Simultaneity as already discussed in chapter 11.3, which is classified as not valid by some new theories. Further an experiment is described that could measure the relativistic mass increase of a non-elastic collision in an indirect way.

13.1 Measurement of tunneling in different spatial directions

It was already presented in chapter 10.1 that transport of information with superluminal velocities and Special Relativity are leading to a severe conflict. If such an effect could be verified it would be possible to solve the appearing discrepancies by assuming a state of absolute rest in the universe as general frame. In the following an experiment will be described, which would allow to detect a relative motion relative to a resting frame using quantum mechanical tunneling and the connected superluminal velocity of a pulse transport.

First the principle and limits of the experimental set-up shall be discussed in detail. As already presented in chapter 10.1 the principle to conduct measurements is that a pulse is induced into a double-prism and afterwards the reflected and the tunneled pulses are compared relating to their transit time. The reflected beam is leaving the prism with almost unchanged intensity and in contrast the intensity of the tunneled beam is much smaller. It is therefore part of the experiment to amplify the tunneled beam with an extremely high intensity.

Starting an analysis, the measured values must first be amplified to the same size, i.e. they have to be normalized. One of the most important difficulties during the evaluation of these normalized values of reflected and tunneled pulses is the fact that the results are not obeying the form of sharp rectangular pulses but appear as bell-shaped Gaussian distribution curves and must be interpreted in a correct way. As an example, for this effect in Fig. 13.1 experimental values published in the literature for a reflected and a tunneled beam after normalization are presented [64]. To show the difficulty for evaluation the "original" value of the tunneled pulse – already with high amplification – was added.

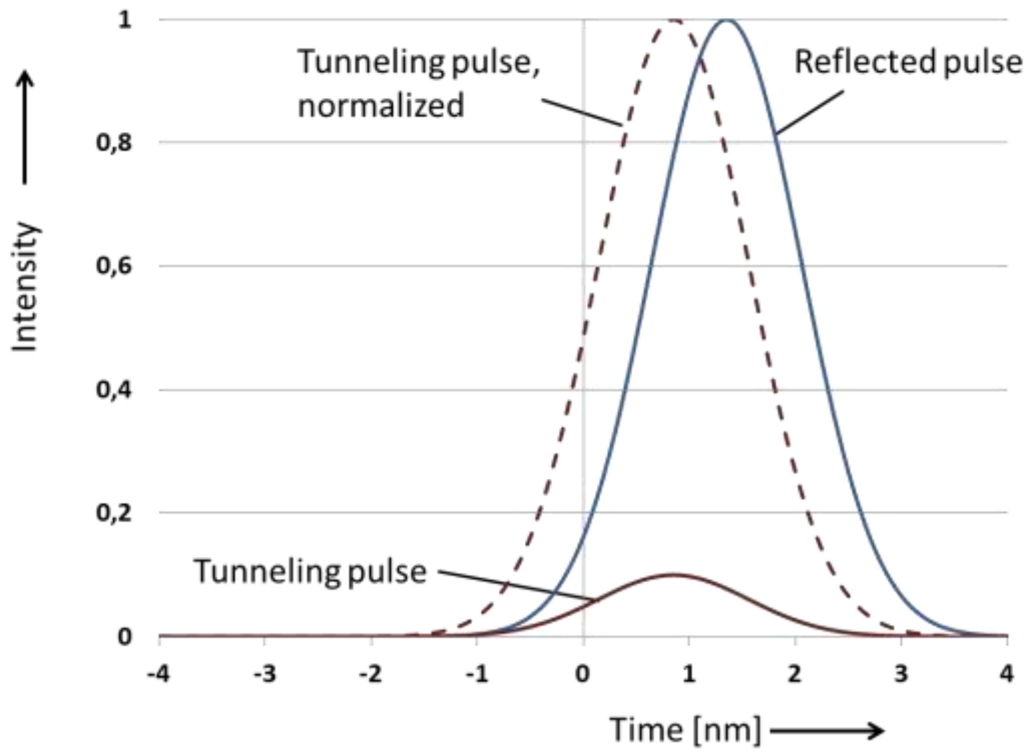

Fig. 13.1: Published data [64] of normalized values during tunneling experiments
Presentation of reflected and tunneled pulses
"Original" tunneling pulse (already with high amplification) was added.

According to G. Nimtz [64] the evaluation of these experiments showed values for the reflected beam $v_R = 0.665c$ and for the tunneled beam $v_T = 4.6c$. Although measurements like these, which were verified during several other experiments, are not generally questioned, it is argued in many cases that in fact superluminal velocities occur, but it is not possible to transport information faster than light during these trials. The general background was already discussed in chapter 10.1. Independently of considerations concerning Special Relativity, the appearing measuring effects are of general interest, and it would be worth finding out whether a single pulse, which can also be taken as small part of information, is travelling faster than light or not.

Because of the experimental challenges an unambiguous verification is very difficult. The function profile is generally expressed by

$$f(t) = \frac{exp\left[-\left(\frac{t - \Delta t}{k}\right)^2\right]}{\sqrt{k \cdot \pi}} \tag{13.01}$$

where for normalization the original values relate to the maximum of the function at point

$$f_{max} = f(t - \Delta t) \tag{13.02}$$

In this relation k describes the width of the bell-shaped curve (which is appearing smaller for increasing values of k) and Δt the distance of the maximum of the function compared to the initial value $t = 0$.

In the past already several experiments using double prisms were carried out. The largest dimensional set-up used a measuring distance of approximately 280mm. As already discussed, a superluminal transport of information is only possible when the existence of a system at absolute rest is assumed. It is well known that our solar system is moving with a speed of about 369km/s against the isotropic cosmic background radiation. When it is supposed that the latter is connected to a frame of absolute rest, then it could be possible to detect a measuring effect using an apparatus with a double prism and taking measurements in different spatial directions.

However, the effects to be expected are exceedingly small. To show this, based on the considerations in chapter 10.1 the expected values are calculated and presented in Tab. 13.1. The calculations for the measuring effects are valid for a distance of 280mm and a signal velocity of 4.6c as taken from [64]. Inserting these values in Eq. (10.07) the calculation will give the results presented in Tab. 13.1 for the orientation in moving direction ($t_1 + t_2$) and opposite to it ($t_3 + t_4$). It is instantly clear that the resulting differences in time are quite small and approximately 2-3 orders of magnitude smaller than the differences using the original experiment.

$t_1 = \frac{a}{\gamma(v_E + v_S)} = \frac{0{,}28m}{\gamma(4{,}6 + 0{,}00123)c}$	$2{,}02844 \cdot 10^{-10}$s
$t_2 = \frac{a}{\gamma(c - v_S)} = \frac{0{,}28m}{\gamma(1 + 0{,}00123)c}$	$9{,}34482 \cdot 10^{-10}$s
$t_3 = \frac{a}{\gamma(v_E - v_S)} = \frac{0{,}28m}{\gamma(4{,}6 - 0{,}00123)c}$	$2{,}02953 \cdot 10^{-10}$s
$t_4 = \frac{a}{\gamma(c + v_S)} = \frac{0{,}28m}{\gamma(1 + 0{,}00123)c}$	$9{,}32186 \cdot 10^{-10}$s
$Eq.(10.07)$: $t_T = t_1 + t_2 - t_3 - t_4$	$2{,}19 \cdot 10^{-12}$s

Tab.13.1: Maximum of expected values using prisms according to Fig. 10.1 with $a = 280\ mm;\ v_E = 4.6c;\ v_S = 369$ km/s

To increase the informational value of an experiment it is therefore necessary to adjust one of the parameters. This could be achieved by a tight decrease of the length of the pulse, i.e. using a femtolaser. However, this approach would be limited by the absorption capability of the beam at the surface of the prism and by the increasing complexity of the measurement technique. Further it is theoretically possible to enlarge the distance of the measuring device to increase the value of Δt; in this case it must be respected that an extreme reduction of the tunneling effect will appear.

An experimental set-up on basis of the discussed parameters is therefore not reasonable and has to be optimized considerably by suitable modifications. To respect this, the proposal presented in Fig. 13.2 shall be brought into discussion. In this case instead of the typically used single beam and the comparison between reflected and tunneled pulse a second beam is symmetrically passing the device. For examination only the tunneled parts of the pulses are amplified and compared with each other. Using this concept all problems with the interpretation of the experiment as discussed before, where the comparison between reflected and tunneled pulses was necessary, will be avoided.

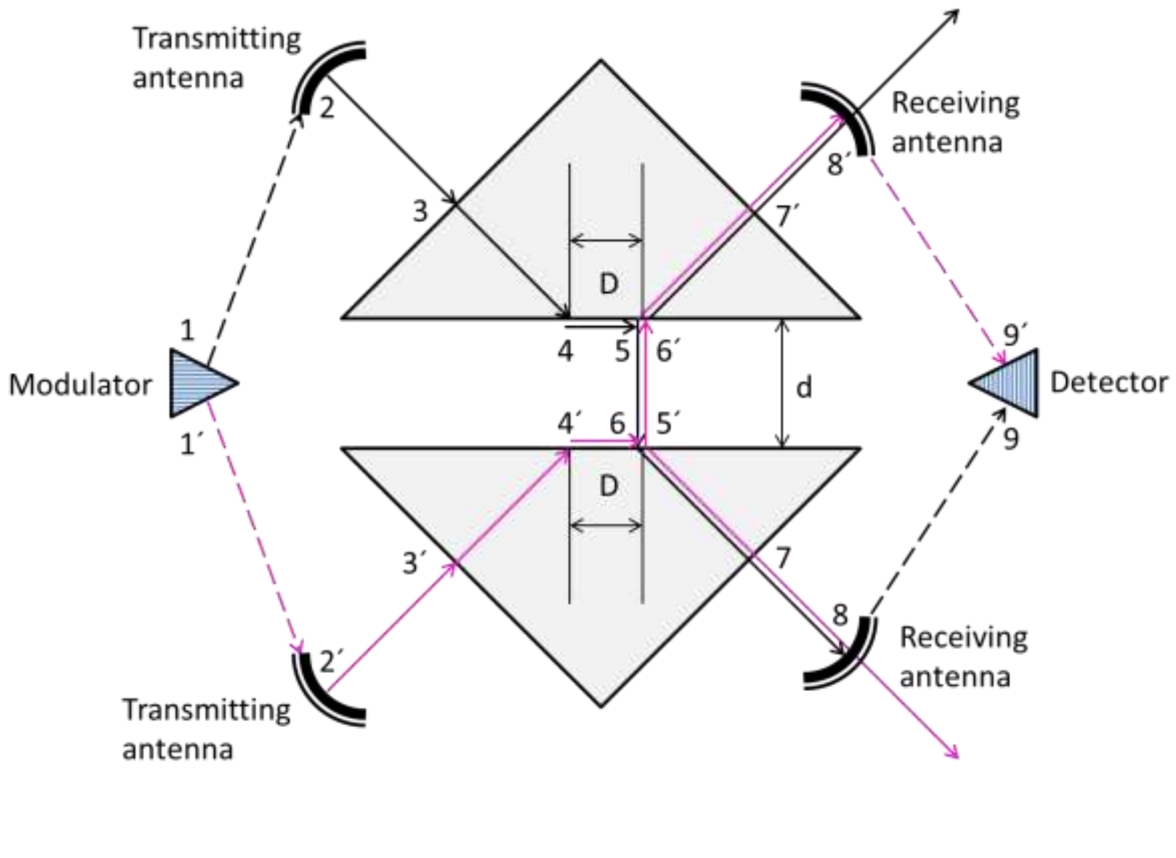

Fig. 13.2: Possible experimental set-up for the measurement of tunneling effects in different spatial directions.

Using this set-up, the experiment will start when the modulator is sending signal S and S′ to the transmitting antennas situated at opposite directions. The generated pulses will pass the device according to the presentation of Fig. 13.2.

For a reasonable evaluation, the use of differential analysis should be preferred. In this case the apparatus must be gauged in an arbitrary direction in such a way that the tunneled pulses of both prisms are exactly matching; measurements of a time-difference will in this case show by definition a zero-result. When in a second step the apparatus is turned and an effect like discussed before exists, then between both prisms a time difference for the passing pulses will appear. The height will be dependent on the direction to the state of absolute rest, the velocity of the signal and on the total length of the used apparatus.

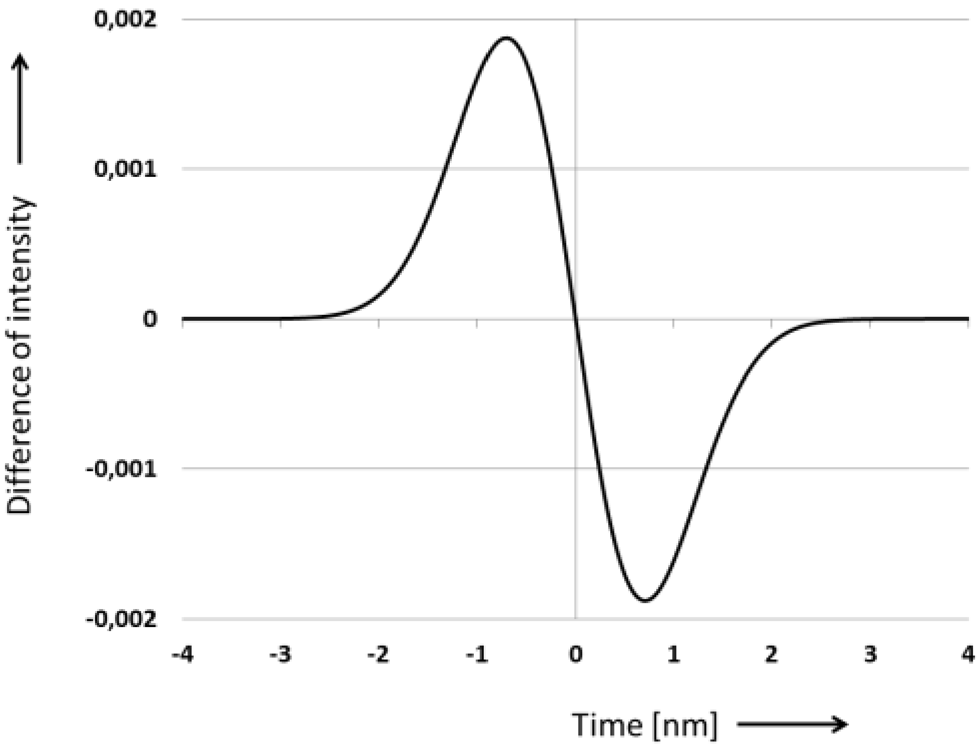

Fig. 13.3: Expected values for an apparatus with a length of 280 mm, $v_S = 369$ km/s and $v_T = 4.6c$

To amplify the signals, the enlargement of the prisms or the distance between them is no suitable option, because in these cases the measuring effects will be considerably reduced. However, it is possible to detect the signals of the prisms and after amplification to transmit these into a secondary set-up to repeat the measurements. The converting of the signals will most probably result in small differences of the measured time which will have an influence on the related values. However, these effects are not detrimental for the experiment and can be neglected because in principle only differences between both parts are measured.

It is noticeable that the expected values are exceedingly small, but that the proposed experiment has a realistic chance to provide reliable data. Particularly important is the mechanical stability of the set-up. This must be placed on a turning table to realize measurements in different spatial directions. Further on if a positive result could be achieved, the differences between values measured during the realization over a day and the connected change of the position of earth to a system of absolute rest will appear.

With the presented experiment it could be possible to provide evidence about basic physical aspects. Either a positive effect will be detected and then the already discussed consequences for Special Relativity must be considered, or, if it is not the case, the possibility of superluminal information transport during tunneling experiments is finally answered in a negative way.

13.2 Measurement of synchronization differences

As already described in chapter 10.2 the Lorentz Transformation is causing differences in synchronization because of the relativity of simultaneously for systems with different velocities. There are possibilities for measurements, when between two clocks, which are placed in a certain distance in a laboratory, synchronization is realized first, the lab is then accelerated in direction of their orientation and finally the procedure is repeated. In this case according to laws of the Lorentz Transformation synchronization differences at both clocks must appear.

In Fig. 13.4 the relations discussed before are presented. To ensure proper graphical reproduction exceedingly high velocities were chosen ($v = 0{,}5c \pm 0{,}25c$, this is corresponding to values of $v_1 = 0{,}667c$ and $v_2 = 0{,}286c$ when the correlations for relativistic addition of velocities are used).

When t_0 is the time for a signal running between positions A and B in a system at rest then for the left part of the diagram the following measuring effects will be achieved:

$$t_{AB} = \frac{t_0}{\gamma_1\left(1 - \frac{v_1}{c}\right)} \qquad t'_{AB} = \frac{t_0}{\gamma_2\left(1 - \frac{v_2}{c}\right)} \tag{13.10}$$

$$t_{BA} = \frac{t_0}{\gamma_1\left(1 + \frac{v_1}{c}\right)} \qquad t'_{BA} = \frac{t_0}{\gamma_2\left(1 + \frac{v_2}{c}\right)} \tag{13.11}$$

and

$$\Delta t_{AB} = t'_{AB} - t_{AB} = \frac{t_0}{\gamma_2\left(1 - \frac{v_2}{c}\right)} - \frac{t_0}{\gamma_1\left(1 - \frac{v_1}{c}\right)} \tag{13.12}$$

$$\Delta t_{BA} = t'_{BA} - t_{BA} = \frac{t_0}{\gamma_2\left(1 + \frac{v_2}{c}\right)} - \frac{t_0}{\gamma_1\left(1 + \frac{v_1}{c}\right)} \tag{13.13}$$

Because of

$$c = \frac{a}{t_0} \tag{13.14}$$

this leads for $v_1, v_2 \ll c$ to

$$\Delta t_{AB} \cong \frac{a[v_1 - v_2]}{c^2} \tag{13.15}$$

and

$$\Delta t_{BA} \cong \frac{a[v_2 - v_1]}{c^2} \tag{13.16}$$

Further the difference to the situation in chapter 10.2 is that in this case not 2 independent observers perform the test, but 2 clocks in just one integrated laboratory.

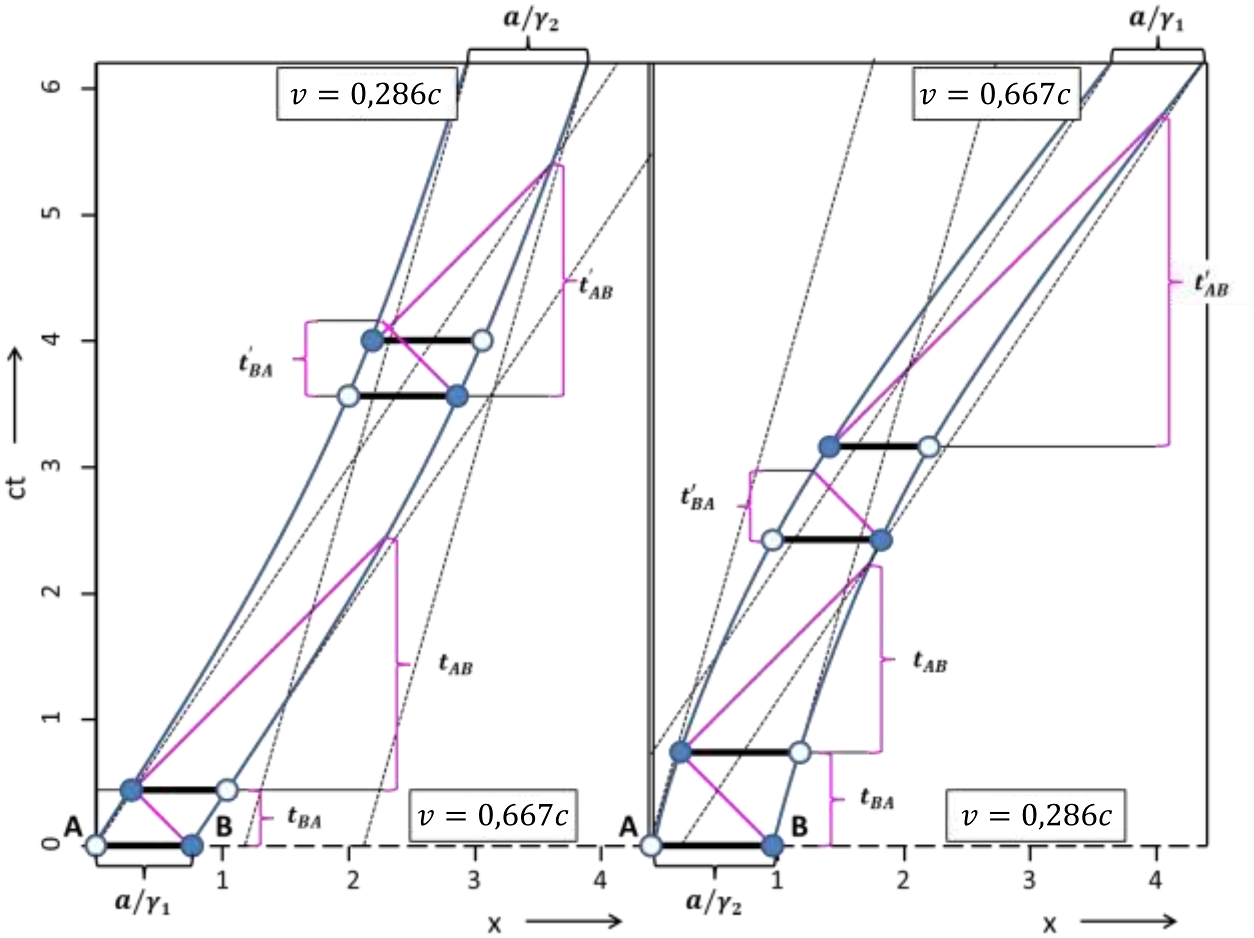

Fig. 13.4: Space-time-diagram for systems after changing velocities
Left: Reducing speed
Right: Increasing speed

For the right-hand side of the diagram the same relations apply, with the difference that γ_1 and γ_2 are changed. For the measurement of these differences the following experiment is proposed:

a) Experimental set-up

For the experiment 2 clocks are placed in a distance a at the positions A and B. In a moving system (see Fig. 13.4) the distance changes to a/γ. After the exchange of signals for each clock a synchronization procedure is carried out. It is important that the signals are not reflected to a central station for comparison because – as it is the case for the Michelson-Morley or Kennedy-Thorndike-Experiment – a null result would appear. Afterwards the laboratory is accelerated in orientation direction of the clocks and after another exchange of signals the synchronizations are repeated. Following this procedure, then because of the Lorentz Transformation a synchronization difference between the positions before and after acceleration must appear which reads Δt_{BA} for clock A and Δt_{AB} for clock B.

When an experiment like proposed before is conducted it would make sense to consider the differences between Δt_{AB} and Δt_{BA} (in this case one of the values will be positive, the other negative). First this will result in the fact that the measuring value is doubled, second distortions caused by deviations in the length of the device (i.e. by temperature changes or effects due to acceleration) of the dimension Δt_S are eliminated because effects of increasing or reducing length would have the same influence. In this case the following equation is obtained:

$$\Delta t \cong \Delta t_{AB} + \Delta t_{S} - (\Delta t_{BA} + \Delta t_{S}) = \frac{2a[v_1 - v_2]}{c^2} \tag{13.17}$$

The result is depending on the distance between the clocks a and the velocities v_1 and v_2 only.

b) Estimations of the size of possible generated results

The best and most accurate method to perform a measurement like this would be to place the whole experimental device in a rocket and drive it to space, but without doubt the effort in this case would be extremely high. On the other hand, the speed differences that could be realized would be also high and so standard 87Rb-clocks, which are already in use for the GPS satellite navigation system with a standard deviation of approx. $3 \cdot 10^{-12} s$ could create very reasonable results.

When terrestrial experiments are considered, the requirements concerning accuracy would increase significantly. An experiment like this could be e.g. conducted using an airplane. A synchronization procedure at the ground and a comparison with data after the start is useless, however, because differences in the height above ground would lead to a distortion of the values. Instead, measurements after the start using a constant height are proposed. Reasonable values are e.g. differences between 300 km/h and 900 km/h. The experiment should be repeated in several directions relative to the rotation of the earth to eliminate distortions (i.e. by the Sagnac-effect).

When a difference of 600 km/h for the velocities and a length of 30m for the set-up is assumed, then values of approximately $1{,}1 \cdot 10^{-13} s$ will be obtained according to Eq. (13.17). An experiment like this could reveal reasonable data, because using advanced atomic clocks measurements in the range of $10^{-17} s$ are possible. This is of course not a simple operation and needs careful verification processes, because it must be shown first, that the clocks needed for the experiment are sufficiently stable for the use in an accelerated system.

In alternative considerations the use of a train or magnetic levitation train transporting the experiment could be possible. Because of lower speed differences the measuring sensitivity would be reduced but the necessary budget is smaller. In an alternative experimental set-up, the complete equipment could be placed in a container, tested on the ground and then loaded into a plane. If a usual commercial 40 feet container is used values of approximately $5 \cdot 10^{-14}$s could be expected which are, with the limitations already discussed, also sufficient to create a significant result.

At this stage of the discussion, it is possible to make the objection that in principle measurements like these are not feasible inside the gravity field of earth. As a counterargument it can be stated, however, that important experiments with a positive and meaningful result were executed in this way. In particular the trials of J. C. Haefele and R. E. Keating [81,82] shall be mentioned. In this case high precision atomic clocks were transported by plane around the earth and their values were compared afterwards with reference clocks which were not transported. The flight in direction of earth's rotation showed, that the transported clocks run slow and in opposite direction they were faster than the clocks on the ground. The results were in good compliance with the values predicted by the theory. So, with these experiments it was possible to identify a condition of rest not including the rotation of the earth.

However, if a terrestrial measurement is not possible then the use of a rocket is the only alternative left for the execution of the proposed experiment.

If any of these experiments whether on ground, in air or in space will show a positive result, experimental evidence is provided, that the "Relativity of Simultaneously", which is a necessary condition when the Lorentz-Transformation is valid, reveals the expected differences in local time after acceleration. It shall be pointed out again that this experiment must generate values possible to measure. This is in contradiction to many other experiments where the theory of Special Relativity is predicting a zero result. This experiment could therefore deliver the final answer, whether the proposed Relativity of Simultaneously, which is a major and necessary part of the Lorentz-Transformation, does really exist.

13.3 Measurement of velocity after non-elastic collision

In chapter 7.1 it was already demonstrated that an increase of mass must appear during non-elastic collision to avoid conflicts with the laws of conservation for momentum and energy. When this is the case the speed of a combined body after collision can be easily derived by using the relativistic addition of velocities. If this would not be the case, or partly not, then the measurement of the speed of a joined body after non-elastic collision would provide interesting new information.

To verify this, the following experiment is proposed: Mass m_2 is accelerated to the exactly defined speed v_2. When it is hitting a mass at rest m_1, both objects form a composite body, and the resulting velocity is subject to exact measurement. This experiment could verify that during a nonelastic collision the potential energy of m_2 is completely transformed into mass. Although this conversion is verified on microscopical scale, however, for objects with large dimensions it could be possible that during deceleration a part of the energy is transformed into thermal energy and carried out of the system by radiation and not be available for reduction of the speed (concerning radiation see also chapter 7.2). This behavior would violate the principles of relativity and could be measured.

Example:

An object with mass m_1 is considered, which is at absolute rest ($v_1 = 0$), an identically second mass (i.e. $m_2 = m_1$) is hitting it with velocity v_2, both objects are joining and moving on with the speed v_3.

According to the discussions in chapter 7.1 the following values for the different concepts can be calculated:

a) Nonrelativistic

In this case the Galilei-Transformation is valid

$$v_3 = \frac{v_2}{2} \tag{13.20}$$

b) Relativistic

This requires a transformation analog to Eq. (7.04) which leads to

$$v_2 = \frac{2v_{3\mathrm{R}}}{1 + \left(\frac{v_{3R}}{c}\right)^2} \tag{13.21}$$

$$v_{3R}^2 - \frac{2v_{3R}c^2}{v_2} = -c^2 \tag{13.22}$$

and finally

$$\frac{v_{3R}}{c} = \frac{c}{v_2} - \sqrt{\frac{c^2}{v_2^2} - 1} \tag{13.23}$$

An examination of this equation shows that positive results of the square root are leading to values $v_{3R} > c$ and therefore cannot be permitted because of plausibility reasons. If this square root in Eq. (13.23) is solved by Taylor expansion (for $v_2 \to 0$) then the result

$$\sqrt{\frac{c^2}{v_2^2} - 1} = \frac{c}{v_2} - \frac{v_2}{2c} - \frac{v_2^3}{8c^3} - \cdots \tag{13.24}$$

appears. Values of higher order can be neglected. Eq. (13.23) is changing accordingly to

$$\frac{v_{3R}}{c} = \frac{c}{v_2} - \sqrt{\frac{c^2}{v_2^2} - 1} \cong \frac{v_2}{2c} + \frac{v_2^3}{8c^3} \tag{13.25}$$

In table 13.2 calculated results for impact-velocities between 1 and 100.000 km/s are shown. To allow a better comparison, only the differences to the non-relativistic case Δv according to Eq. (13.26) are presented. The value of Δv is always positive, i.e. the calculation of v_{3R} is leading in all cases to results higher than that of v_3.

$$\Delta v = v_{3R} - v_3 \tag{13.26}$$

v_2	1	10	100	1000	10.000	100.000
Δv	1,391 10^{-12}	1,391 10^{-9}	1,391 10^{-6}	1,391 10^{-3}	1,392	1,474 10^{3}

Tab. 13.2: Calculation of differences for end velocity after nonelastic collision. Initial value: Galilei-Transformation Eq. (12.20). Velocities in km/s.

The results for velocities $v_2 \geq 1000$ km/s related to the relativistic approach were calculated using the basic equation Eq. (13.23). For smaller values, the precision of a standard computer with 15 digits accuracy is no longer useful, and Eq. (13.25) must be used instead. This equation, however, must be extended with higher order terms using velocities of more than 10.000 km/s, so, a combination of both approaches was chosen.

For the realization of the proposed experiment, it would be reasonable to use a massive and compact body for the moving part, e.g. a sphere. For the not moving object it is proposed to use a ring with high plasticity. The ring should have an inner diameter slightly smaller than the diameter of the sphere. A set-up like this should allow precision measurements of the velocity directly on the surface of the sphere and would avoid problems which appear, when a plate or a deformable foil, which is wrapping around the sphere during the execution of the experiment, is used instead for the body at rest. Because of the expected small effects, the experiment must be conducted using a vacuum.

An evaluation of the expected results clearly shows that with increasing velocity by one order of magnitude the measuring effect will be boosted by 3 orders (with other words: factor 10 compared to factor 1000). It is therefore reasonable to increase the speed as much as possible. On the other hand, the demands concerning the precision of the required testing equipment will rise considerably with increasing speed so that it is necessary to find a reasonable compromise. When for example the value of 1 km/s is chosen, which is corresponding to the speed of a projectile of firearms, then according to the calculations presented here, a result of 10^{-9} s per meter of the measuring length would appear. It should be possible to detect values like this with a suitable experimental set-up.

For experiments like this an exact monitoring would be essential. It could for example happen, that because of the high accelerations at the start of the sphere and also during deceleration of the connected body the applied stresses on the material will be quite high and so vibrations could occur which could affect the results of the measurements. In this case maybe the use of composite materials with a soft inner core is necessary. The experiment must be conducted in different spatial directions. Although as pointed out in chapter 7.1 it is not likely that the result will differ from the relativistic addition of the velocities, this experiment is a reasonable addition to provide evidence about the relativistic increase of mass for non-elastic collisions on a macroscopic scale.

Finally, the question may be raised why an experiment like this should be performed at all, when theoretical considerations conclude that the result must be in accordance with the relation of relativistic addition of velocities. However, as already shown in chapter 11.3 effort is made since many years to provide evidence that Lorentz invariance can be violated and thus expand the theoretical basis. An experiment like it is presented here could therefore extend the range of possibilities in an interesting way.