1. Introduction

In this investigation first the basic principles of the theory of Special Relativity will be presented in detail. In further steps the consequences derived out of the theory and later the existing limits will be discussed. A major contribution for the understanding of the discussions arising during the presentation of the theory is taking a close view on the historical development. To realize this, three important parts of physical science were chosen (classical mechanics, light and its radiation, electromagnetism) and connected with this, important persons are presented, who had major influence on the developments. The presented selection out of numerous researchers is most probably partly unfair but must be limited for obvious reasons because of the almost unlimited number.

1.1 General historical preconditions

After the fall of the Roman Empire as a result of the barbarian migration a general loss of transferred knowledge of Greece and Roman origin was observed in Europe. Many old scripts were saved only, because they were translated and interpreted by Arabian scientists who were at that time part of scientific communities with generally much higher standards compared to those in Europe. The situation did not change until the end of the millennial when a warm epoch began, which had a high impact on the development of the society. Until the year 1300 the population tripled, land was reclaimed on a large scale and many new cities were founded.

For the “dawn of mankind” and the connected explosion of knowledge many different reasons are considered to be important (for further studies the very interesting book “The Morning of the World” [1] by Bernd Roeck is strongly recommended). First in the cities with sufficient supply of food and other necessary things for daily life a group was established which we would today call “middle class” and was formed by craftsmen and merchants. This structure can be defined as “horizontal”, because it was not dominated by aristocratic authorities and was therefore able to develop in a free manner [1]. Furthermore, during the 12th century, the first universities were founded (starting in Bologna, followed by Paris and Oxford) and with the appearance of the professor at these universities the class of the intellectual was founded. The skills of the men appointed for this purpose (women were excluded from this profession and also from studying) certainly did not meet our expectations of the quality of a professor today in most cases, but the procedures of discussion and application of logic originating from the Greek/Roman tradition were generally used. In general, it can be stated, that in Europe starting from the foundation of the first universities until the end of the17th century science and the structures for teaching were quite uniform.

Academic studies included – according to the ancient ideal – the seven liberal arts of classic antiquity comprising the Trivium (grammar, dialectic, and rhetoric, finishing with nomination as "bakkalaureus") and further the Quadrivium (arithmetic, geometry, music and astronomy [including astrology], nomination as magister). In a further step the higher faculties (theological, juridical, and medical) could award the degree of a doctor. The language used was generally Latin, which was of great advantage in the linguistic fragmented environment of that time. Knowledge was generally acquired through the study of the Holy Bible and using scripts of ancient origin mainly from Greek philosophers; experimental work as it is established today was generally not common.

Beside the already presented general issues further advantageous developments occurred towards the end of the 13th century. Important inventions were made, which had a great impact on the progress of science and technology. The most important included quite different subjects like the production of paper and gunpowder (both based on ideas imported from Asia), also the invention of the mechanical clock and of spectacles (and connected with this the knowledge to produce glass of sufficient quality). During the following little ice age starting with the beginning of the 14th century and lasting for over 500 years which caused hunger and distress, developments were possible which improved science in an important and positive way.

Paper showed a clear advantage compared to the parchment used before which was produced out of animal skin, and it was possible to produce it at lower costs and with a better quality and higher quantity. Combined with the letterpress printing invented by Gutenberg and the developing postal services an information exchange was possible not imaginable before. In addition, the use of gunpowder had a great influence on the development of metallurgy and metal machining necessary to produce firearms and a first nucleus of a sector later called "heavy industry" appeared.

It is often said that letterpress printing and the use of gun powder are the major facts for the explanation of the developments happening at that time. The progress of science, however, is also connected with the permanent improvement of precision mechanics which led e.g., to the production of clocks with increasing accuracy which are for obvious reasons necessary for quantitative measurements of physical parameters. This long-term development was also witnessed for the production and processing of lenses. In contrast to this at the beginning of the 17th century the knowledge about the inventions of telescope and microscope spread over Europe in a very short time and had a great influence on natural science. Further the first introduction of property rights (copyright, patents) was also responsible for important promotion effects.

With the beginning of the 17th century first scientists questioned the opinion, that knowledge could only be acquired by studying old scripts but that it was also possible to expand it by own considerations and observations. Francis Bacon (1561-1626) was the first to propose an empiric approach for the development of science. He was sure that knowledge of mankind is cumulative (his considerations finally led to the expression: "knowledge is power"). Initiated by René Descartes (1596-1650) mathematical procedures were identified as an important instrument to derive scientific progress. He was the first to use equations which are quite similar to the form we know today. He used, however, a symbol similar to „æ“ (derived from the Latin word „aequalis“), the equality sign “=” was used for the first time by the Welsh mathematician Robert Recorde (1510-1558) It did not spread over Europe before 1700 but finally became the standard for the formulation in scientific publications. Together with the “invention” of the figure zero at the end of the 13th century, which slowly found its way into mathematics, these were no necessary requirements but led to enormous accelerations in the progress of natural science.

The sociologist Robert K. Merton (1910-2003) made further interesting statements concerning the developments of that time [2]. First, he expressed the opinion that changes and progress in natural science were caused by an accumulation of observations, improved experimental techniques and also the development of additional methodic approaches; this concept is apparently corresponding to the thesis of Roeck [1]. In further considerations he is arguing that the revolution in natural science during the 17th and 18th century was mainly promoted by Protestantism, in particular by English puritans and German pietists. This was not changing before the French Revolution happened and the disempowerment of the Catholic Church was enforced by Napoleon after the conquest of almost complete Europe. This thesis is not without dispute and is for sure partly unfair against many important scientists of that time. It is symptomatic, however, that publications of Descartes and Galilei (after 1633) banned by the Catholic Church could only be printed by the publishing house Elsevier because it was situated in the protestant town of Leiden and was therefore not under the jurisdiction of the Catholic Church.

1.2 Classical mechanics

One of the most important founders of modern natural science is Galileo Galilei (1564-1642). From 1609 on he improved the technique of the telescope which was invented a year before by Hans Lipperhey (1570-1619) by own production of better lenses and the use of enhancements in the construction. He was the first to monitor the sky in a systematic way and discovered already in 1610 the moons of Jupiter, which could not be seen before with the naked eye. It was of great influence on the view of the world that beside earth now another planet possessed moons. He also discovered that the Milky Way is formed as a cluster of many stars and is not a shiny band as it was believed to be before and that planets are not point-shaped but show the form of a disk during observation. He calculated the height of the mountains on the moon by the visible shadows and estimated the value to 8000m [3]. Further he performed experiments concerning the free fall of objects. It is sometimes claimed that these were conducted at the leaning tower of Pisa, but this is most probably not true, he presumably used spheres made of different matter and measured their acceleration rolling down a ramp.

It shall be mentioned that Lipperhey was not able to have his invention patented, because in the following months other competitors on their part claimed it as theirs. Obviously, the time was ripe for the invention of the telescope and further for the microscope shortly before and soon a broad distribution of these important instruments took place.

However, the most important finding of Galilei concerning the following discussion was the first definition of the principle of relativity. The easiest way to understand this is to have a look on his book

> Dialogo di Galileo Galilei sopra i due Massimi Sistemi del Mondo Tolemaico e Copernicano (Dialogue of Galileo Galilei about the most important systems of the world, the Ptolemaic and the Copernican), first edition 1632.

In the following the "case Galileo Galilei" shall be discussed briefly. The book was not written in Latin but in Italian language and was supposed to attract a wide educated audience. It was not structured like a typical scientific publication at that time but is arranged as a conversation between three persons.

The names of these persons were Salviati, Salgredo and Simplicio. While Salvati and Salgredo were the names of old friends of Galilei deceased long ago [4a] and had access to wide range of knowledge, Simplicio is acting as the simple-minded. It can be clearly seen, that Salvati, and partly also Simplicio, is taking the role of Galilei while Salgredo is an ordinary but well-educated person [4b]. Salvati is also explaining the relativity principle already mentioned before. Fig. 1.1 shows in an English translation by Thomas Salusbury the relevant passage [5]. It dates to the year 1661 and was one of many translations in different languages written shortly after the first publication by Galilei. It is a prosaic form at its best and surely can be understood without using a single equation.

The scientific conclusions of the book are today generally outdated. For the understanding of the thinking and the state of knowledge at that time a later translation by Erich Strauss shall be recommended, were a comprehensive introduction and interpretations of the intentions and actions of the involved persons are added [4].

The form of a dialogue was chosen because the acting persons could argue in an open way and so it was possible to discuss positions not obeying the official doctrine. Although the publications of Copernicus about the heliocentric world system were banned by the Catholic Church it was allowed to use his calculations for the planetary motion, which were much easier and more precise compared to the equations utilized before, when in a separate statement it was claimed that these were only founded on a hypothetic basis and the Ptolemaic world system with earth in the center was really valid [4]. Galilei believed that he had obeyed this rule when he passed this obligation to Simplicio. As well-known this went wrong in a disastrous way.

Although his book first got the imprimatur by the inquisition, which means that he was officially allowed to print it, Galilei was charged with blasphemy. Main reason for this was most probably the animosity with the Jesuits; this originated because Galilei was in a fierce controversy with a member of this order named Christoph Schreiner (1573-1650) concerning the first observation of sunspots.

After Pope Urban VIII withdrew his grace (allegedly because his vanity was offended by statements made by Galilei) he was eventually put to court. Galilei had to retract his statements and was sentenced to life-long dungeon imprisonment. Shortly later this was changed to house detention, and so he was not allowed to leave his premises until the end of his life even not for medical consultations he asked for later. In addition, after his death a dignified funeral was refused.

Shut your self up with some friend in the grand Cabbin between the decks of some large Ship, and there procure gnats, flies, and such other small winged creatures get also a great tub (or other vessel) full of water, and within it put certain fishes; let also a certain bottle be hung up, which drop by drop letteth forth its water into another bottle placed underneath, having a narrow neck and, the Ship lying still, observe diligently how those small winged animals fly with like velocity towards all parts of the Cabin; how the fishes swim indifferently towards all sides; and how the distilling drops all fall into the bottle placed underneath. And casting any thing towards your friend, you need not throw it with more force one way then another, provided the distances be equal and leaping, as the saying is, with your feet closed, you will reach as far one way as another. Having observed all these particulars, though no man doubteth that so long as the vessel stands still, they ought to succeed in this manner; make the Ship to move with what velocity you please; for (so long as the motion is uniforme, and not fluctuating this way and that way) you shall not discern any the least alteration in all the forenamed effects; nor can you gather by any of them whether the Ship doth move or stand still. In leaping you shall reach as far upon the floor, as before; nor for that the Ship moveth shall you make a greater leap towards the poop than towards the prow; howbeit in the time that you staid in the Air, the floor under your feet shall have run the contrary way to that of your jump; and throwing any thing to your companion you shall not need to cast it with more strength that it may reach him, if he shall be towards the prow, and you towards the poop, then if you stood in a contrary situation; the drops shall all distill as before into the inferiour bottle and not so much as one shall fall towards the poop, albeit whil'st the drop is in the Air, the Ship shall have run many feet; the Fishes in their water shall not swim with more trouble towards the fore-part, than towards the hinder part of the tub; but shall with equal velocity make to the bait placed on any side of the tub; and lastly, the flies and gnats shall continue their flight indifferently towards all parts; nor shall they ever happen to be driven together towards the side of the Cabbin next the prow, as if they were wearied with following the swift course of the Ship, from which through their suspension in the Air, they had been long separated; and if burning a few graines of incense you make a little smoke, you shall see it ascend on high, and there in manner of a cloud suspend it self, and move indifferently, not inclining more to one side than another: and of this correspondence of effects the cause is for that the Ships motion is common to all the things contained in it, and to the Air also; I mean if those things be shut up in the Cabbin but in case those things were above deck in the open Air, and not obliged to follow the course of the Ship, differences more or lesse notable would be observed in some of the fore-named effects, and there is no doubt but that the smoke would stay behind as much as the Air it self; the flies also, and the gnats being hindered by the Air would not be able to follow the motion of the Ship, if they were separated at any distance from it. But keeping neer thereto, because the Ship it self as being an unfractuous Fabrick, carrieth along with it part of its neerest Air, they would follow the said Ship without any pains or difficulty. And for the like reason we see sometimes in riding post, that the troublesome flies and hornets do follow the horses flying sometimes to one, sometimes to another part of the body, but in the falling drops the difference would be very small; and in the salts, and projections of grave bodies altogether imperceptible.

Fig. 1.1 First formulation of the principle of relativity by Galileo Galilei
Translation by Thomas Salusbury [5] dating back to 1661.

Although the verdict did not include an explicit publication-ban his main work finalized later concerning the foundation of kinematics and the science of strength of materials could not be published in Italy but was presented by the publishing house Elsevier in Leiden.

Is not easy to explain the principle of relativity presented by Galilei using "gnats, flies and other small winged creatures" for a presentation based on equations. To maintain the basis of a moving ship, in the following the situation shall be discussed, that this is passing a harbor mole were at the same time a flag is rising with constant velocity and is finally reaching the top at time t_0. For an observer at the mole the movement of the flag appears to be vertical (coordinates $x = 0$, y and time t with variable values) whereas in view from the ship, which is moving with the velocity v, the flag relative to the coordinates of the ship (connected to the coordinates x', y', t') is falling behind by the factor $v \cdot t_0$ (see Fig. 1.2)

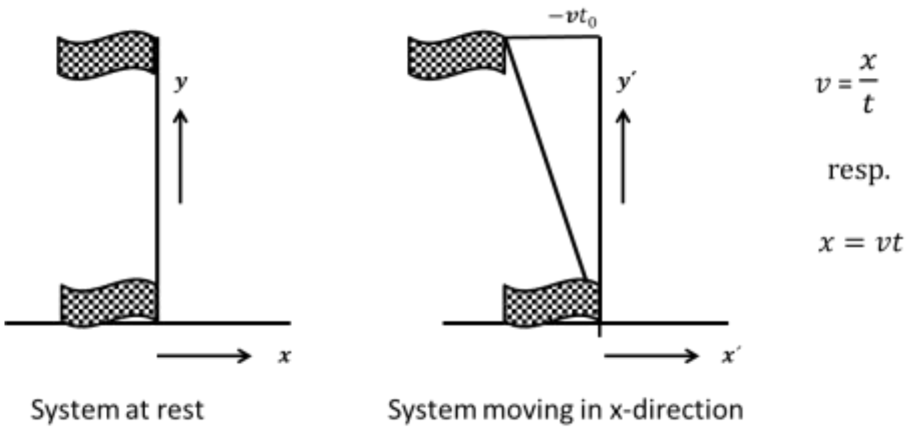


Fig. 1.2: Varying perceptions of the same event observed from different reference systems

It is thus possible to carry out coordinate transformations using the following calculations:

$$x' = x - vt, \quad y' = y, \quad z' = z \quad t' = t \tag{1.01}$$

If on the other hand a flag is rising on the ship the reverse effect will occur and in view of the observer at the mole the flag is moving in x-direction

$$x = x' + vt, \quad y = y', \quad z = z' \quad t = t' \tag{1.02}$$

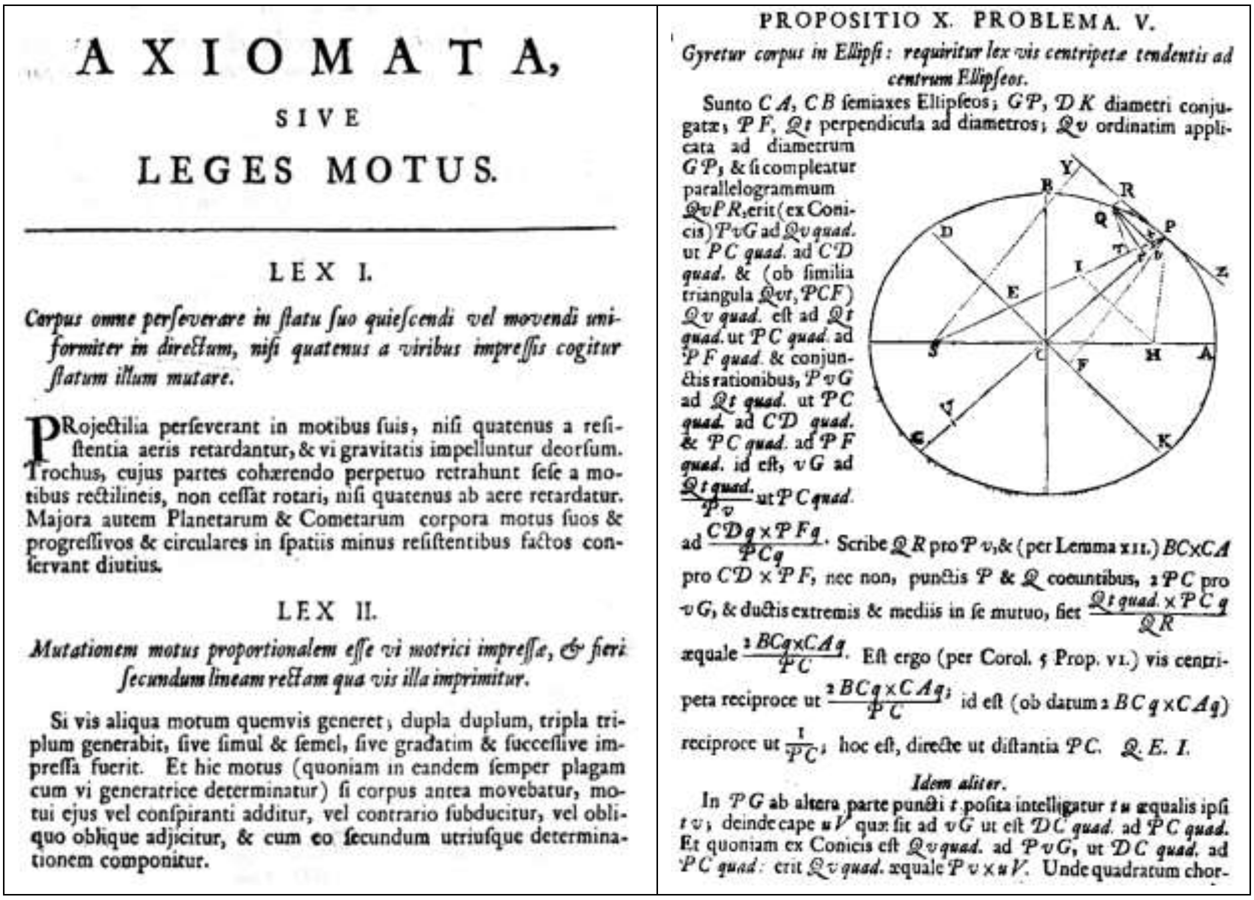
The description requires only a simple conversion of Eq. (1.01). This equation system is called the "Galilei-Transformation" of classical mechanics. It is important that only a variation in the direction of the movement occurs, all other spatial directions are not affected and in addition time is constant for all systems.

This interpretation was taken as a priori valid for centuries because it is conforming to daily experience of human life, and thus was not questioned for a long time. It will be presented later that according to today's knowledge the validity is only (approximately) granted when the velocity of the system (in this case the speed of the ship in x-direction) is far lower than the speed of light.

Although an important foundation was created by Galilei the main work to complete classical mechanics was done by another great scientist. In the year 1687 Isaac Newton (1643-1727) published his book

Philosophiae Naturalis Principia Mathematica (Mathematical Principles of Natural Philosophy)

which is certainly one of the most important books in modern science. It contains the axioms later named after Newton and also many comprehensive calculations and arguments. For the presentation the form of a continuous text was used, and it is hard to understand from today's point of view, not only because it is written in Latin, but also because no equations using the equality sign were used (see Fig. 1.3). The publication is available as original and in several modern transcriptions; a remarkably interesting example is the original book used by Newton with his handwritten remarks which is provided by Cambridge University and is available online.



AXIOMATA,

SIVE

LEGES MOTUS.

LEX I.

Corpus omne perſeverare in ſtatu ſuo quieſcendi vel movendi uniformiter in directum, niſi quatenus a viribus impreſſis cogitur ſtatum illum mutare.

Projectilia perſeverant in motibus ſuis, niſi quatenus a reſiſtentia aeris retardantur, & vi gravitatis impelluntur deorſum. Trochus, cujus partes cohærendo perpetuo retrahunt ſeſe a motibus rectilineis, non ceſſat rotari, niſi quatenus ab aere retardatur. Majora autem Planetarum & Cometarum corpora motus ſuos & progreſſivos & circulares in ſpatiis minus reſiſtentibus factos conſervant diutius.

LEX II.

Mutationem motus proportionalem eſſe vi motrici impreſſæ, & fieri ſecundum lineam rectam qua vis illa imprimitur.

Si vis aliqua motum quemvis generet, dupla duplum, tripla triplum generabit, ſive ſimul & ſemel, ſive gradatim & ſucceſſive impreſſa fuerit. Et hic motus (quoniam in eandem ſemper plagam cum vi generatrice determinatur) ſi corpus antea movebatur, motui ejus vel conſpiranti additur, vel contrario ſubducitur, vel oblique adjicitur, & cum eo ſecundum utriuſque determinationem componitur.

PROPOSITIO X. PROBLEMA. V.

Gyretur corpus in Ellipſi: requiritur lex vis centripetæ tendentis ad centrum Ellipſeos.

Sunto *CA*, *CB* ſemiaxes Ellipſeos; *GP*, *DK* diametri conjugatæ; *PF*, *Qt* perpendicula ad diametros; *Qv* ordinatim applicata ad diametrum *GP*; & ſi compleatur parallelogrammum *QvPR*, erit (ex Conicis) *PvG* ad *Qv quad.* ut *PC quad.* ad *CD quad.* & (ob ſimilia triangula *Qvt*, *PCF*) *Qv quad.* eſt ad *Qt quad.* ut *PC quad.* ad *PF quad.* & conjunctis rationibus, *PvG* ad *Qt quad.* ut *PC quad.* ad *CD quad.* & *PC quad.* ad *PF quad.* id eſt, *vG* ad $\frac{Qt\ quad.}{Pv}$ ut *PC quad.* ad $\frac{CDq \times PFq}{PCq}$. Scribe *QR* pro *Pv*, & (per Lemma XII.) $BC \times CA$ pro $CD \times PF$, nec non, punctis *P* & *Q* coeuntibus, 2*PC* pro *vG*, & ductis extremis & mediis in ſe mutuo, fiet $\frac{Qt\ quad. \times PCq}{QR}$ æquale $\frac{2\,BCq \times CAq}{PC}$. Eſt ergo (per Corol. 5 Prop. VI.) vis centripeta reciproce ut $\frac{2\,BCq \times CAq}{PC}$; id eſt (ob datum $2\,BCq \times CAq$) reciproce ut $\frac{1}{PC}$; hoc eſt, directe ut diſtantia *PC*. *Q.E.I.*

Idem aliter.

In *PG* ab altera parte puncti *t* poſita intelligatur *tu* æqualis ipſi *tv*; deinde cape *uV* quæ ſit ad *vG* ut eſt *DC quad.* ad *PC quad.* Et quoniam ex Conicis eſt *Qv quad.* ad *PvG*, ut *DC quad.* ad *PC quad.*: erit *Qv quad.* æquale $Pv \times uV$. Unde quadratum chor-

Fig. 1.3: Extract of Newton's Philosophiae Naturalis Principia Mathematica
Left: First and second axiom
Right: Typical text with diagram and calculation without using the equality sign "="

In this book for the first time the fundamental laws of classical mechanics were defined which we today call Newton's Axioms. In the following they will be described in detail. Doing this a modern wording is used and in addition the connected equations will be presented using vectors. The definition of physical parameters as vectors, i.e. the combination of magnitude and direction was first used by the German teacher Herrmann Günter Graßmann (1809-1877) and was therefore not established in the 17th century. Although Newton could not know this kind of presentation, it is today's standard and therefore it shall be utilized here.

1. *The Principle of Inertia*

   An object with constant mass either remains in a state at rest or continues to move at a constant velocity, unless acted upon by force.

$$v = const. \quad if \sum_i \vec{F}_i = 0 \tag{1.03}$$

   This determination needs a high degree of abstraction because all motions, that can be observed in daily life, are more or less superimposed by effects like friction or gravitation.

2. *The Basic Principle of Dynamics*

   The rate of change of momentum is directly proportional to a force applied. For constant mass systems, force is mass multiplied by acceleration.

$$\vec{F} = m\vec{a} \tag{1.04}$$

3. *The Principle of Reaction*

   When one body exerts a force on a second body, the second body simultaneously exerts a force equal in magnitude and opposite in direction on the first body.

$$\vec{F}_{12} = -\vec{F}_{12} \tag{1.05}$$

   or generally „action is equal to reaction".

There is a further basic principle that can be derived out of the publication, but this was not assessed as an axiom by Newton. It is also particularly important and therefore today often referred to as Newton's 4th axiom.

4. *The Principle of Superposition*

   If several forces interact, they add up like vectors.

$$\vec{F}_{res} = \sum_i \vec{F}_i \tag{1.06}$$

These 4 axioms form the foundation of classical mechanics, where all processes can be referred to.

It is worth mentioning that the imprimatur for the Philosophiae was granted by Samuel Pepys (1633-1703). Newton belonged to his large circle of friends. Different to countries controlled by the Catholic Church, where representatives of the inquisition were responsible for the approval of publications, in England this was his duty as the president of the

Royal Society. Pepys is well known until today for his secret dairies written between 1660 and 1669, which were found shortly after his death and then published. They contain interesting reports e.g. about the Plague 1665 and the great fire in London 1666. Further on the drastic comments on his fellow citizens and the notes about his many extramarital relations are to be mentioned which he described in any detail. He is one of the most important authors of that time and his books are still published today.

Beside his publications Newton also created the first reflecting telescope, which was much valued by the scientific community. Further on he was co-founder of the infinitesimal calculus. This led to a bitter dispute with Gottfried Wilhelm Leibniz (1646-1716) about the first priority of the discovery. He brought him to the court of the Royal Society – whose president he was at that time – accusing him of plagiarism and not surprisingly Leibniz lost the struggle. Newton vaunted himself later that he had broken his heart. Today Newton and Leibniz are considered the independent co-founders of this part of mathematics.

However, beside his epoch-making discoveries Newton's main passion belonged to alchemy, on which he concentrated a broad part of his research work. A major part of the books belonging to his heritage, now preserved by the Kings College in London, is dealing with themes connected to alchemy. Further, he served as Warden (1696-1700) and Master (1700-1727) of the Royal Mint in London. So, he finally was not able to produce gold or silver, but this appointment brought him into a position to rule money.

Due to his special character Newton carried out his job at the Royal Mint in a very serious way. One of the main problems of this institution at that time was the coining of counterfeit money. The silver coins minted by the Royal Crown were fined down and the produced swarf was remelted and coined into false money. He persecuted the offenders in a rigorous way and brought them to court, what at that time generally meant that they were sentenced to death. This and many other additional occurrences are presented in the very unorthodox book of F. Freistetter (Newton, the way an asshole reinvented the world, in German language [83]).

1.3 Light and radiation

Beside classical mechanics further important foundations for the following considerations are the nature of light and the basic physical principles of radiation. Early history shows, dependent on the particular cultural background, that different myths exist to describe the origin of light and corresponding to it the ability for man to see. In Greek mythology goddess Aphrodite created the eyesight out of the four elements earth, water, wind and fire; the main understanding of this divine gift was, that light was leaving the eyes, and, in a reaction, different objects became visible.

About 300 BC the important Greek Philosopher Euclid started examinations concerning the behavior of light and found out, that light beams travel in straight paths and in a further approach he also discovered the laws of reflection. In addition, he concluded that it is not reasonable to adhere to the opinion that light leaves the eye because in such a case no differences between day and night would be possible. Although these observations paved the way for further discoveries and improvements of the theory, it took about 2000 years to take the next steps.

Newton followed the idea, that light is consisting of small corpuscles with different sizes and properties. He carried out experiments with mirrors, lenses, and prisms to verify the laws of reflection and to discover the general nature of light. He was partly successful, but his theory using corpuscles was not able to explain some of the experimental results; especially the nature of interferences caused conflicts to his approach which could not be solved.

In the year 1690 the Dutchmen Christiaan Huygens (1629-1695) developed the first complete wave-theory of light. With this comprehensive theoretical approach, it was possible for the first time to explain the phenomena of reflection and refraction of light without discrepancies. Beside his pioneering work concerning the wave-theory he was also very successful as astronomer; he was the first to discover Titan, the moon of Saturn, and he identified the rings of Saturn. For this purpose, he used an improved telescope, which he had constructed and built co-working with his brother Constantijn. He also developed mathematical basics concerning the figure π using arithmetic series, further to the application of logarithms and he is co-founder of the calculus of probabilities.

The wave-theory of light was discussed highly controversial for a long time, especially because the theory using corpuscles was the idea of the great Isaac Newton. One of the main arguments of supporters of Newton's theory was that light is completely shielded by barriers and no wave can be seen behind it, like e.g. visible on a water surface when a wave is passing an obstacle. It was not known at that time that the wavelengths of light are very small (approx. 400-700 nanometers). It was not before the double-slit experiment was performed by Thomas Young (1773-1829) at the beginning of the 19th century, which supported the contention that light is composed of waves, that the discussion ended. Young also solved the problem to explain the effect of polarization, because he interpreted light as a transversal wave. According to our today's vocabulary this means, that the vectors of the electric and magnetic field are perpendicular to each other and also to the propagation direction (see Fig. 1.4). This contrasts with the behavior of a sound wave which is propagating longitudinal; this means that the transporting medium e.g. air or water is oscillating in moving direction and thus no polarization is possible. Linear polarization of light is observed when many superimposing waves show the same orientation.

In the year 1676 Ole Christian Rømer (1644-1710) was the first to provide evidence that the velocity of light is limited. He observed the eclipse of the Jupiter-moon Io, which occurs during perigee (shortest distance to earth) earlier than during apogee (farthest distance). This result was in contradiction to the established understanding of many others, from Aristotle to Descartes, who were convinced that the speed of light was unlimited, so it was only reluctantly accepted. The results found by Rømer, who just measured the time delay, were converted by Huygens 1678 using calculations to a velocity of approx. 212000km/s, which is approximately 70% of the correct value. Evaluated in comparison to the available resources at that time the result was already remarkable exact.

According to the understanding of that time it was presumed that light needs a transportation medium for propagation. This idea was transferred from the knowledge about the conditions valid for the transport of sound, where atoms resp. molecules are forced to oscillate. The center of the oscillation is always constant, which means that atoms or molecules in an observation of the average position are not moving but that just energy is transported by the waves.

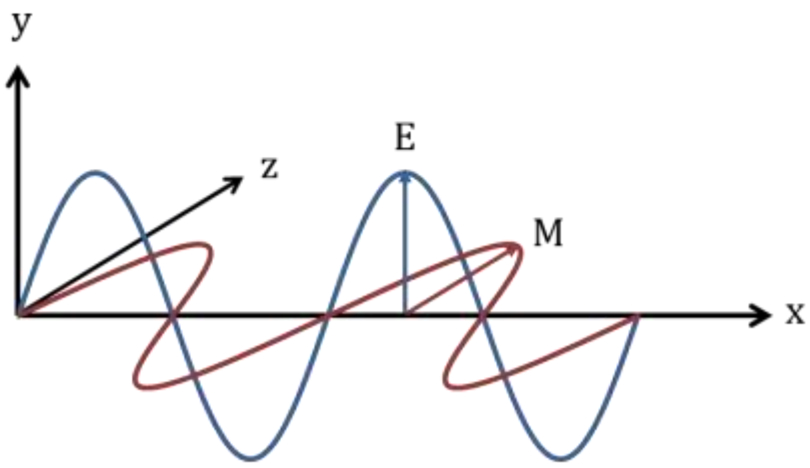


Fig. 1.4: Propagation of an electromagnetic wave with the components of the electric and magnetic field (E and M)

First knowledge concerning this was collected by Otto von Guericke (1602-1686). In the year 1649 he invented the vacuum pump and used it for many experiments. The most spectacular was surely the demonstration of the action of force caused by air pressure. He produced two half spheres made of copper (diam. approx. 42 cm) and during the Reichstag 1657 held in Regensburg he combined these with a sealing and used his pumps for evacuation. In presence of Kaiser Ferdinand III, it was shown that eight harnessed horses at each side were not able to tear the combination apart. This experiment was so impressing to the audience, that Archbishop Johann Philip von Schönborn bought and passed it to his Jesuit College at Würzburg. Beside this spectacular experiments Guericke also performed basic investigations and was able to show that a vacuum is not conducting sound, but that light is passing.

The medium that, according to the knowledge of that time, was needed to transport light was called "luminiferous ether" or just "ether". The word is originating from the Greek myths and is in its genuine sense describing the (blue) sky. In contrast to the four earthly elements (these are earth, wind, water, and fire which are interestingly complementary to the conditions of aggregation solid, liquid, gaseous and ionized), ether was the 5th element, which stood in relation to heaven and therefore in contrast to the others was inalterable [4d].

During the passing centuries, many theories were developed to describe the nature of ether. As its main characteristics it was expected to permeate anything but not to produce any resistance to objects, because in this case it would influence physical laws. It was the general view that light is transported by ether in the same way as sound by air. However, there were two observations from experiments which prevented a distinct determination because they are in fundamental contradiction:

1. The effect of stellar aberration first detected in the year 1725 by James Bradley (1693-1762).

2. The effect observed in moving transparent media (e.g. glass or water) of dragging light in the direction of motion. This effect is dependent on the refraction index of the media.

Point 1:

Stellar aberration is a definition used in astronomy to describe a small apparent shifting of the position of stars, when an observer is moving in transverse direction. Earth is travelling around the sun with a speed of about 30km/s; this means that after half a year a measuring effect of 60km/s compared to the position of an unmoved sky will appear. This is causing a misalignment for the incoming light, which was first detected by Bradley with precision measurements using a zenith telescope. This type of telescope is designed to point straight up to or near to the zenith. Bradley installed it in his house along the chimney and spent most of his observation time upon a bench underneath the instrument.

The major precondition for the occurring of an aberration effect is that the speed of light is limited. Bradley was able to measure that the speed of light is 10210-times higher than the velocity of the earth orbiting the sun. He achieved a remarkable precision of 2% compared to the exact value we know today. Furthermore, he concluded that ether could not be affected by mass like that of earth. If earth would drag ether with it, then no aberration effect could be detected.

This effect must not be mixed up with the measurement of the parallax, i.e. the deviation of the angle of a star relatively close to earth depending on the position of earth to the sun during the year. Such a measurement was first successfully completed by Friedrich Wilhelm Bessel (1784-1846) in the year 1838 during observation the star 61 Cygni. Out of the measured angle he calculated a distance of 10.28 lightyears to the sun (today's value is 11.4 lightyears). The parallax effect is approx. 2 orders of magnitude smaller than that of aberration.

Distance determinations are an essential part of cosmology today. However, the measurement of the parallax is possible with earthbound telescopes only up to distances of about 100 light-years. In 1912 Henrietta S. Leavitt (1868-1921) found out by extensive investigations on stars of the Magellanic Clouds that the absolute value of the maximum brightness of periodically changing stars is directly related to their period. Since there are enough variable stars in the near-earth region, a first calibration was possible, and the extent of our galaxy could be determined (100,000 light years) and consequently the distances to the Large and Small Magellanic Cloud (163,000 and 200,000 Lj. respectively) and later by Edwin Hubble (1889-1953) to the Andromeda Galaxy (2.5 million Lj.).

Point 2:

In the year 1810 Francois Arago (1786-1853) made an experiment where he used a prism for aberration measurements. The expected alteration effect, however, could not be observed. Already in 1818, a theory was presented by Augustin Jean Fresnel (1788-1827), that light is partly dragged by the medium in moving direction and that the appearing effect is dependent on the refraction index of the media.

In the year 1851 Hyppolyte Fizeau (1819-1896) performed an experiment where he measured the speed of light in running water. He found the result that the speed of light is increasing when the examined beam has an orientation in moving direction of the water and decreasing when the direction is opposite. He also verified the equations first postulated by Fresnel. This result changed the view on ether and the characteristic of a dragging effect by matter was added.

Because of the fundamental importance of the presented experiments these will be discussed in detail. Aberration is presented in chapter 2.1.2 and the dragging effect in moving transparent media in chapter 4.2.

Towards the end of the 19th century due to the inconsistent experimental results many different ether-theories were discussed, who should be able to explain the complex situation. Even Einstein, in his most probably first publication as a youth discussed an approach to the problem. Looking at the situation at that time it can be summarized, that no consensus on the nature of ether could be achieved, but that nobody seriously denied the existence.

1.4 Electromagnetism

Phenomena connected to electrostatic effects were already known to Greek philosophers in ancient times. When amber (Greek: electron) is rubbed with a fur or cloth it will show visible effects like e.g. the emission of sparks or attraction of dust and other small particles. Also, magnetism is well known since a long time; in this case the observed phenomena were generally connected to the availability of magnetic iron ore named magnetite. The origin of the word is deriving from the Greek region called Magnesia, where these stones were found already in ancient times. A practical use was solely for application as a compass, which was known in China already in pre-Christian times and in Europe from the beginning of the 13th century on.

This did not change before the electrostatic generator was invented. Otto v. Guericke made experiments using a rotating Sulphur sphere and tried to find evidence for the existence of cosmic forces. The experimental set-up is referred to as the first electrostatic generator; although Guericke found attracting and repelling force, he had most probably no idea about the background of his experiment. Later constructions by successors using glass and leather were able to create quite high voltages. A further progress was made when the “Leiden Jar” was developed. This is the early form of a capacitor and from now on it was possible to generate and to store charges. Although now first experiments were possible and different electrical phenomena became known the invention was mostly used for spectacular presentations to an interested audience. It was e.g. immensely popular to pass electric shocks to a crowd of people who were taking each other by the hand.

However, during the 18th century also some new scientific perceptions were derived, e.g. the frog leg experiment by Luigi Galvani (1737-1798), where he found that a leg of a dead frog is kicking as if alive when it is touched with an electrostatic generator. Further the experiments of Benjamin Franklin (1706-1790) proving that lightning is a form of electricity shall be mentioned. However, because of the limited experimental capabilities these approaches were exceptions, and it is not reasonable to talk about a comprehensive scientific approach concerning this matter.

A turning point was reached when in the year 1799 Alessandro Volta (1745-1827) constructed the first stable electric power supply in form of a battery, which was later called "Volta's pile". For the pile he used elements made of copper and zinc, which were separated by pieces of leather or paper soaked with sulfuric acid and so electrochemical cells were built. The pile was consisting of several cells and so it was possible to produce more than 100 Volt (a physical unit later named after him). It is for sure one of the most important inventions of all time and the public paid high tribute to him. He also drew admiration from Napoleon Bonaparte for his invention and in 1810 he was made a count.

This invention laid the basis for many new experiments and subsequently to further important discoveries. Namely Faraday, Ampère, Heavyside and Lorentz are to be mentioned, who examined the properties of electric charge, electrical current and the relation to magnetism. André-Marie Ampère (1775-1836) was the first to introduce the concept of a field and discovered an electromagnetic relationship, which was of great importance for scientific progress.

Further knowledge was established by theoretical considerations of James Clerk Maxwell (1831-1879) who was able to show, that the existence of electric and magnetic effects is connected. He also used for the first time the expression of electromagnetic fields. Maxwell demonstrated that electric and magnetic fields travel through space as waves moving at the speed of light. He proposed that light is an undulation in the same medium that is the cause of electric and magnetic phenomena; this medium was supposed to be the "luminiferous ether". A further important result of his investigation was that the relations he developed, which later were called "Maxwell-Equations", are not conform to the Galilei-Transformation and so this was in contradiction to classical theories.

The experimental work of Heinrich Hertz (1857-1894) later confirmed that the shining of light can in fact be interpreted as propagation of electromagnetic waves. From 1889 until his death, he was professor for physics at the University of Bonn. To this very day the experiments built by him are working and presented during the lectures of experimental physics. They provide an impressing view at the technical possibilities of that time.

Towards the end of the 19th century knowledge concerning electromagnetic effects had improved significantly. The gathered knowledge both on theoretical and experimental basis made clear for anybody that ether for the transport of electromagnetic waves must exist. This view was generally also expanded to gravitation.

1.5 The Michelson-Morley Experiment and first interpretation

Albert A. Michelson (1852-1931) was one of the most important physicists at the end of the 19th century. In the year 1869 he joined the US Naval Academy and graduated in 1873. After 2 years at sea, he became instructor in physics and chemistry at the naval academy until 1879. Then he was posted to the Nautical Almanac Office in Washington and in the following year he obtained leave of absence to continue his studies in Europe (Berlin, Heidelberg, and Paris). In the year 1877 he married the daughter of a wealthy stockbroker and so he achieved financial independency. He was extremely interested in physical experiments, especially in measurements of the speed of light; his special knowledge as a naval officer was very helpful, because during his duty one of his tasks was the measurement of distances by optical means. In the year 1881 he resigned from the navy and started his scientific career. In 1907 he was the first American to receive the Nobel Prize in physics.

The first experiment by Michelson to provide evidence of "luminiferous ether" performed 1881 at the Helmholtz' laboratory in Berlin was not successful, because the vibrations of the city traffic made it impossible. It was repeated at the observatory in Potsdam and there he found a zero result [6]. Due to experimental shortcomings in the execution the result was first generally rejected by most scientists. Together with Eduard W. Morley (1838-1923) the apparatus was improved, and the experiment was repeated in Cleveland in 1887 [7]. It was now detected and verified without doubt, that the measurement of the speed of light led to the same results in every direction, irrespective of the movement of the measuring device in comparison to the supposed ether. Because of the paramount importance of the experiment the set-up of the device and the interpretation of the results will be discussed in detail (see chapter 9.1).

During the following years, the experiment was widely discussed and addressed in many publications, of which the most important shall be mentioned shortly here. George F. Fitz-Gerald proposed already in 1889 the idea, that the length of material bodies is contracting at velocities close to the speed of light [8]. He expected this contraction to be dependent on the square of the ratio of their velocities. The same issue was also predicted independently by Hendrik A. Lorentz (1853-1928) three years later [9]. Because of further contradictions Lorentz and also Henri Poincaré (1854-1912) introduced in the year 1900 the concept of "local time" [10]. This means, that in view of an observer at rest the clocks of other moved observers show different times during a synchronization process depending on their distance. It was now possible to perform calculations between systems with different velocities. The basic equations were converted into their modern appearance by H. Poincaré, who also created the name "Lorentz-Transformation [11]. It was shown that contraction of space and dilatation of time is covered by the same factor (Poincaré named it k, Einstein β today usually the Symbol γ is used).

The transformation equations are

$$t' = \gamma\left(t - \frac{v}{c^2}x\right) \tag{1.07}$$

$$x' = \gamma(x - vt) \tag{1.08}$$

with

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{1.09}$$

In these equations x and t are the coordinates of a reference system and x' and t' the coordinates of another system moving constantly relative to this, the coordinates in y- and z-direction are not changing. These relations today are normally called Lorentz-Transformation (LT) or "Lorentz-boost". Although the term "boost" implies the existence of an accelerated system this is not the case. In contradiction to this the equations describe relations between systems, which are constantly moving relative to each other and are not subject to acceleration or rotation. Furthermore, these equations show similar characteristics compared to the Maxwell equations which are valid for the interpretation of electromagnetic fields.

A detailed derivation of the equations will be presented later. It must be mentioned further, that at velocities $v \ll c$ the factor γ is approaching 1 and the equations are merging with the Galilei-Transformation in Eq. (1.01).

1.6 Einstein's Theory of Special Relativity

In the year 1905 Albert Einstein published his famous paper "On the electrodynamics of moving bodies" and presented a main contribution to the theory of relativity (later called "Special Relativity" or SRT). For an exact representation it is necessary first to introduce the concept of an inertial system. Inertial systems are defined by the fact that they are moving in arbitrary speed to each other but are not accelerated or show a rotational motion.

Fundamentals of SRT are the principle of relativity and the principle of constancy of the speed of light. In the original version Einstein has chosen the following formulation [12]:

> "Principle of Relativity: The laws by which the states of physical systems undergo change are not affected, whether these changes of state be referred to the one or the other of two systems in uniform translatory motion relative to each other.
>
> Principle of constancy of the speed of light: Every light ray moves in the "resting" coordinate system with a certain speed V, independent of whether this light ray is emitted by a resting or a moving body. Here is
>
> $$\text{velocity} = \frac{\text{lightpath}}{\text{time period}}$$
>
> where "time period" is to be understood in the sense of the definition of § 1."

The interpretation is not easy, also because Einstein speaks here of a "resting" system. But the meaning, especially of the 2nd paragraph, is clear, when it is considered that the procedure chosen in the further text, especially the application of the synchronization procedure (today: Einstein synchronization, see chapters 3.4 and 12.2). Because of the complexity, details will be discussed later in this paper.

Important here is the radical break with the previous approach to the establishment of a physical theory. While Lorentz and Poincaré interpreted the available experimental results, derived the transformation equations from them and then found the principle of relativity, Einstein put this first and was able to derive the equations in a relatively simple way. Generally speaking, these are the principles bottom-up (Lorentz, Poincaré) and top-down (Einstein).

Lorentz in 1892 first assumed that there must be an absolutely resting fundamental system [9]; then in 1910 he was of the opinion that it would never be possible to distinguish between the two approaches [13]. Independently, however, he welcomed Einstein's formulation of relativity and became its advocate [14,15], especially because of the "boldness" of the approach [14].

At the time of development, it was not foreseeable that a metrological verification of the theory would ever be possible. In the following decades, however, new experiments were added, the most important of which are those of Kennedy-Thorndike [16] and Ives-Stilwell [17,18], which will be discussed in detail later. In addition, the measurement accuracies were improved more and more; modern measurements with very high precision showed among other things the validity of the time dilation formulated by Lorentz impressively [19,20,21]. On the other hand, however, the Theory of Special Relativity in its general form cannot be proved in principle. Every positive experiment strengthens the theory, but a single unambiguous counterexample would lead to the fact that it must be considered as disproved.

In the first part of his publication, Einstein derived the transformation equations from the principles already mentioned. However, since these had already been discovered by Lorentz before, they are generally called "Lorentz equations" today. Einstein's publication does not contain any literature references and thus a parallel development to Lorentz can be concluded. Moreover, it is clearly the merit of Einstein to have combined the photoelectric effect with these relations and thus to have been able to break completely with the ether concept.

In further considerations of the principle of relativity, Einstein also predicted already in 1905 the effect that the kinetic energy of a moving mass at higher velocities according to the formula

$$E_{kin} = m_0 c^2 (\gamma - 1) \tag{1.10}$$

must increase [22]. This effect has been experimentally confirmed and is now commonly referred to as relativistic mass increase. It is important to see here that the designations are different. Lorentz chose x, t for the reference system, while Einstein used m_0. In Einstein's probably best-known formula

$$E = mc^2 \tag{1.11}$$

the total mass m includes the part of the kinetic energy defined in Eq. (1.10). Also, the mass increases with higher velocity by the factor γ. Both representations are used in parallel until today.

	Lorentz-equations	Relativistic mass increase
Equation	$t' = \gamma\left(t - \frac{v}{c^2}x\right)$ $x' = \gamma(x - vt)$	$m = \gamma m_0$ $\{E = mc^2 = \gamma m_0 c^2\}$
Reference system	$x,\ t$	m_0
Moving system	$x',\ t'$	m

These relations together form the basis for the Theory of Special Relativity.

For the description of the principles postulated by Einstein, today often called Einstein axioms, there is no uniform definition, and it is chosen differently in every publication. In some cases, the description for both axioms are descriptive ("no differences can be found in measurements"), in others the properties are put in the foreground ("the speed of light is the same in all inertial frames", "all inertial frames are equivalent"). Although these expressions are identical at first sight, there are important differences which have to be discussed in more detail in the following. The already mentioned relativistic increase of mass is not mentioned in the axioms, but without this effect the statement concerning the principle of relativity would not be possible.

However, the principle of relativity formulated by Einstein also requires a precise interpretation. First, this can be divided into the following detailed statements:

a) If identical experiments are carried out by different observers in reference systems moving uniformly relative to each other, the results will be the same.
b) An observer can describe results of any experiment in another inertial system that shows a constant relative movement using only the Lorentz transformation equations and the relativistic increase of mass. In particular, the observation of the time sequence of events is the same in all cases.
c) All systems moving uniformly relative to each other are equivalent and there is no absolute "system at rest".

The statement a) will now be defined as “principle of identity”, b) as “principle of equivalent observations” and c) as “principle of complete equivalence of all inertial systems”. While points a) and b) are backed up by multiple test results, this must be considered in a differentiated manner for point c). Although there is a wide consensus about the validity of the SRT within the physical research community, there are still many theoretical and experimental attempts to refute individual points. This concerns in particular measurements concerning minor violations of the Lorentz equations, which have been predicted by theoretical considerations concerning a general, unified theory of all laws occurring in nature. Furthermore, a possibility to integrate a state of absolute rest is still searched for.

Finally, some interesting historical questions should be addressed. Einstein became involved with physical topics at an early age. At the age of 16, he wrote a letter to his uncle in which he outlined possible experiments to prove the existence of ether [99]. In 1901, around 6 years later, he already had more far-reaching ideas and wrote about himself and his future wife Mileva Marić, whom he met while studying physics and mathematics at the ETH in Zurich: " How happy and proud will I be, when we both together have brought our work on the theory of relativity victoriously to an end". She was the only woman in this field of natural science, which was clearly dominated by men at the time. However, her contribution to the development of the theory is unclear, and it is also doubted whether the ether theory had already been overcome at this time [85]. In the epilogue to his work, Einstein expressively thanked his friend and fellow M. Besso that he was faithfully standing at his side during the work and that he owes him valuable suggestions; his wife was not mentioned at all [12].

Although there is no clear evidence, it seems very plausible that Einstein had the extensive support of his wife in 1905, the year in which he submitted his dissertation and wrote another 4 publications in addition to his work at the patent office. In 2005, Mileva Marić was officially honored as a co-founder of the theory of relativity by the university ETH Zurich [84]. However, there are a large number of publications on this topic and also dissenting opinions (e.g., [85]). In 2003, television stations in the USA broadcast the documentary “Einstein's wife”. During and after the broadcast, viewers were asked online for their opinion and 75% of viewers were convinced that his wife had indeed collaborated with him. However, “history is not a matter for democratic voting” [85]. Due to the lack of sources, it must be stated today that we simply do not know the details.

This also applies to information about her first child. Mileva Marić gave birth to a girl in 1902, before her wedding (which took place in 1903). For this purpose, she returned alone to her parents in Novi Sad (today Serbia, then Austrian Monarchy); it is not clear whether the child died there or was given up for adoption. Even though Einstein was a public figure as the most famous scientist of his time, there are mysteries about this early period that will probably never be disclosed.

1.7 Current discussions

Already at the beginning of the second half of the last century it became clear that the background radiation of the Big Bang, which was discovered at that time, runs completely isotropic and constant in all space directions. This has made it possible to measure a velocity relative to this background radiation. Recent measurements with extreme accuracy have shown that our sun moves with 369.1 ± 0.9 km/s relative to it [23]. It should be noted here that the sun is orbiting the galactic center at a speed of approx. 220 km/s, and that the velocity is directed almost opposite to it. This means, that our galaxy is moving with a speed of approximately 600 km/s relative to the detected background radiation [19].

In particular because of these observations there have been considerations to bring special relativity in accordance with a state of absolute rest (i.e. “relativity without relativity” [24]). None of these theories were able to show results without severe discrepancies to experimental findings. Details are summarized in chapter 12.1.

Moreover, a problem has recently arisen from the measurements of velocities faster than that of light. Experiments carried out by different research groups for several years already show that such velocities can be measured in connection with tunnelling experiments. However, there are great differences in the interpretation of these results. While some researchers are convinced that despite of observed superluminal velocities no information can be transmitted with this speed, others expect this to be the case. If the latter is true, this is basically not compatible with the theory of special relativity. The effects will be discussed in detail.

Further theoretical considerations disclose a severe problem, which is a fascinating part of today’s discussion within physics: It is broad agreement that the fundamental physical theories of our time, the theory of (general) relativity and quantum mechanics are in contradiction [20]. The problems which occur are presented in a very comprehensive way by T. Müller [25].

Generally, it can be stated, that after more than 110 years since the first presentation of Special Relativity many questions are still open. It is the aim of this presentation to develop proposals for a modification.

1.8 Contents of this presentation

Today, the Theory of Special Relativity (SRT) represents a fundamental standard within physics. There is an almost unmanageable number of books, literature, and lecture notes on this subject. This paper is intended as a supplement to other books on this subject, in particular the excellent work of Max Born (1882 -1970), a contemporary and friend of Einstein [26]. The book was first published in 1920 and is still reprinted today with some necessary additions. In addition to the theoretical part, which is deliberately kept simple for training purposes, the developments in physics that took place in the 19th century are also very accurately reproduced here. This also applies to the important subject of electromagnetism, which is only briefly touched upon here.

Usually, papers on special relativity follow the scheme that first the results of classical experiments are presented and based on them the theory is formulated. In the present case, however, the theory shall be chosen as axiomatic framework and then the consequences resulting from it shall be discussed. As will be shown, this systematic approach also captures effects that otherwise are not in focus but are of great importance. The resulting calculations partly require the use of numerical methods. Their execution is described in detail in an appendix (A to D).

The central approach of the presented investigations is the following: First, all investigated phenomena are presented from the point of view of an observer at rest. Based on this, it will be evaluated how the same facts arise for a moving observer; for this, exclusively the formalism of the Lorentz transformation and the relativistic mass increase will be used. It will be shown for a large number of investigated relations that the same results are obtained for both observers and that no counter example exists.

In the following, first an exact representation of the connections within special relativity is given. This begins with investigations to the signal exchange between two observers moved relatively to each other. Afterwards the Lorentz transformation is derived from the basics of Special Relativity (equivalence of all inertial systems and constancy of the speed of light).

In addition, the important item of the synchronization of events is considered in more detail. This is done first on the basis of synchronization by means of signal exchange, later also by exchange of clocks. Subsequently, the relations between several moving observers are the subject of considerations. In addition, the relations of signal exchange in moving transparent media are also investigated. In all examples it can be stated that the validity of the equations developed by Lorentz is guaranteed without restrictions.

The synchronization with slow clock transport presented in detail in chapter 5 contains some new approaches for the unambiguous proof of a zero result.

In chapters 6 and 7 considerations of relativistic influences on mass, momentum, force, and energy are made. Further the situation of observers exchanging signals with others during acceleration and afterwards will be investigated. For this purpose, the conditions during elastic relativistic collisions are investigated, and the relationship for a relativistic rocket equation is derived from this. It is also shown here in all cases that there are no differences in the considerations for an observer assumed to be at rest or to be moving.

Further investigations on the conditions during the exchange of light signals with constant frequency show new aspects for the interpretation of classical experiments (chapter 8). It will be shown that at the transition between systems with a movement relative to each other not the speed of light, but the phase velocity of light is the relevant parameter. As a consequence, classical experiments like the Michelson-Morley experiment and also the Kennedy-Thorndike experiment have to be re-evaluated, although their basic statements remain the same.

Furthermore, the case is discussed, when superluminal velocities occur, which are observed in connection with tunnelling experiments. If it is possible to transfer information in this case faster than light, contradictions will occur between identity and equivalence principle.

A proposal is developed, how these contradictions can be eliminated. In contrast to the basic idea developed by Einstein, a top-down concept with given principles, a different approach is chosen. Instead, the Lorentz equations are used as a basis and, in addition, the concept of relativistic mass increase with increasing relative velocities derived by Einstein from the principle of relativity. Their combination into an "Extended Lorentz Theory" allows to describe all phenomena occurring in nature in the same way as the Theory of Special Relativity. Absolute precondition is that information is transmitted at the speed of light. If a transport should ever be possible with superluminal velocity, then SRT is proofed to be false, for the Extended Lorentz Theory then the opportunity would arise to determine the position of a system of absolute rest.

Finally, on basis of these considerations, different experiments will be proposed. With their help, clear statements on the validity of the proposed theory could be made.