ACCORDING TO SPECIAL RELATIVITY: SPACE-TIME AND PHILOSOPHY (RECOMMENDATIONS FOR STUDYING IN THE EDUCATIONAL PROCESS)

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Abstract: In this paper we consider the value and sense of Einstein's theory of special relativity, because it examines the determinations of physical law as the regulation of nature according to special relativity, and as the determination of the meaning and evidence of gnoseological and ontological implications to make up a physical theory. Einstein's notion of space and time in the special theory of relativity brought a new understanding of space and time. In the pedagogical process, the effect of interdisciplinary relations should be applied. Einstein's understanding of the laws of physics changed their way of understanding. It is good for the student to perceive the basic differences in the concept of time and space in Newton and Einstein, because he will better understand the selected basic differences between classical and modern physics.

Keywords: Einstein, Special Relativity, Space-time, Invariance, Philosophical foundations, educational process

1 Introduction

Comparing the philosophical background of Einstein's and Newton's views is important for a full understanding of their physical conception of space and time. It is good for the student to perceive the basic differences in the concept of time and space in Newton and Einstein, because he will better understand the selected basic differences between classical and modern physics. We also consider it important to know the philosophical thinking of Ernst Mach in this aspect, because his influence on the special theory of relativity was considerable. We think that learning about the philosophical positions of Newton, Mach, and Einstein will help students better understand the special theory of relativity, as well as the difference between some aspects of classical and modern physics. We try to move from Newton's to Einstein's manner of thinking. We analyse Einstein's theory of special relativity, not the theory of general relativity which is not the object of interest of the present paper. We present what it meant when Einstein abandoned the concept of absolute space and time and the classical principle of velocity-addition. Some thinkers see parallels between the special relativity theory and Kant´s understanding of space and time in his pre-critical period. There are also similarities between Popper's philosophy of science and Einstein's methodology. Interpretations of special relativity theory differ. We can distinguish between hard relativists and soft relativists. Some scientists believe that the length contraction cannot be experimentally verified. Lenin tried to criticise Mach´s understanding of space and time, however, he did not criticise the special relativity theory directly. Einstein formulated his methodological views later – after presenting his special relativity theory. The theory of space and time is closely connected with special relativity theory. For Einstein spacetime is a conglomerate of relative events, on the other hand spacetime is a holistic perspective of measurements. While until his speech they were understood as a correspondence image of reality, after Einstein, laws are considered only as statements about the knowledge we can gain about reality. The most important point in changing the understanding of time and space is their fusion into space-time, as well as leaving the absolute conception of time and space. In teaching physics, it is good to emphasize in Newtonian mechanics the absolute understanding of laws, the separation of space and time, the difference between Descartes' and Newton's perception of the dimension of the body. For Einstein, it is necessary to point out the similarity of ideas with the pre-critical period in Kant, as well as the radical difference in the understanding of the time of the special theory of relativity and Kant in the critical period. At the same time, it is necessary to explain to students the influence of Mach on STR, as well as a certain relationship between STR and Popper's methodology of science. The clarification of the philosophical positions of Newton and Einstein, the philosophical influence of Mach in the teaching of physics, will lead to a deeper understanding of the very essence of STR. The extrapolation of Popper's methodology of science, Mach's understanding of reality, Kant's pre-critical views on space and time in the teaching of philosophy will have the same effect.

2 Relativistic Values

A basic assumption in Newtonian mechanics is that the mass of a body, being one of its inherent characteristics, is independent of its state of motion with respect to the observer. Thus, equal forces impressed upon a body would produce equal accelerations, whatever the instantaneous velocity of the body. Hence, if we continue to apply a force indefinitely, the velocity of the given body would go on increasing at a "constant" rate until it ultimately could exceed any pre-assigned value. This, however, negates the idea that there exists an upper limit, given by the velocity of light in free space, to the velocities that material objects can have. Thus, a given force acting on a body should, in the initial stages, produce an effectively constant acceleration, but its influence should gradually decrease as the velocity of the body increases until finally, as the velocity approaches its limiting value – c – the influence of the force should tend to vanish (Einstein 1965: 1 – 4). Meanwhile, the quantity *mg* $[mg = m_o f(v)]$ denotes the rest mass of the body, and *mg*, on the other hand, is referred to as the relativistic mass of the body, which is a new expression from new mechanics of Einstein's Special Theory of Relativity as a very important extension of mechanics with implications for the philosophical foundations (Mc Cauley 1998: 12 – 14). In this paper we explain the sense and the foundations of classical mechanics and the critical implications for Newton's mechanics in the changeover to relativistic mechanics, or from Newton's to Einstein's way of thinking. Relativistic mechanics is a creation of the physical theories that came back from the mechanical sense of Newton.

Albert Einstein initiated an epistemological revolution in 1905 by elaborating the special theory of relativity (STR). Moreover, he did this for logical reasons, since he recognized that Maxwell's electromagnetism and Newtonian mechanics were incompatible with one another. While one theory implied that the velocity of light in a vacuum should have the same value "c" for all directions and all inertial frames of reference, independently of their relative motions, this was forbidden by the other theory.

Einstein, however, removed this paradox through a simple change of the previous concepts of space and time. He considered space and time as being defined by the possible results of measurements. These are subjected to a very precise and completely unexpected condition. The outcome of any measurements of space and time intervals in inertial frames of reference has to be such that when we measure the distance travelled by a light pulse in a vacuum during a measured time interval it must always yield the same value (Mould 2002: 20 – 35). We also stress the fact that Einstein's concept of physical laws influenced the development of quantum mechanics, a theory, moreover, that Einstein didn't accept. Naturally, we can say that his theory of relativity takes into account another restriction that Nature imposes on certain measurements, and that these restrictions are also related to the existence of the universal constant of Planck.

But Einstein saw that this led to a very important question. The principle of special relativity would require that the velocity "c"

be a universal constant for all inertial frames of reference, while Newton's mechanics did not allow for such a velocity.

However, Einstein showed that this problem could be solved by abandoning the concept of absolute space and time (Pathria 1974: 10-25). We should no longer consider space and time as some kind of physical determination but should define space and time by the possible results of measurements of an event. These then allow us to explain the space-time coordinates (x, y, z, t) of any given event in a given frame of reference. When these measurements are performed in another frame of reference for the same event, we get different results(x', y', z', t'). Einstein meant that for inertial frames of reference, these results are related to one another in such a way that a measurement of the velocity of light in a vacuum always yields the same value *c* (Einstein 1997, pp. 394-399). This position changed physics in a very profound way, since it indicated at the time that physical laws should only be considered as statements concerning the knowledge we can acquire about reality. As we mentioned in the introduction, quantum mechanics did confirm this rule, but even today this is not always emphasized (Einstein, Podolski, Rosen 1935: 777 – 780). When a finite limit exists for the smallest measurable distance $ds^2 = \sum_{i=1,2,3} dx_i^2 - c^2dt^2$ it is meaningless to formulate a physical law that would tell us what happens at a smaller scale, since physical laws should be verifiable, at least in principle. Our usual theories imply, however, that natural laws can be expressed by means of differential equations that are assumed to be valid for infinitely small intervals of space and time. They are only approximations that cease to be valid at an extremely small scale. The laws of classical physics were very good for a certain domain, but they had to be replaced by those of relativistic mechanics and quantum mechanics for larger domains.

To develop more general laws of physics that take into account the existence of a finite limit for the smallest measurable distance, we have to proceed very carefully, since we are entering into unknown territory. Past experience tells us that this has to be a universal constant, such as *c* and *h*. Distance measurements could then be performed by successive juxtapositions of the same smallest measurable length (Hill, 1964: 15-20). When we perform ideally precise measurements of the *x, y, z,* ct space-time coordinates by starting at the origin of the chosen inertial frame of reference, we can only get integer multiples of "*a*" for each of these coordinates. This yields a space-time lattice that depends on the chosen origin and the directions of the reference axes, but this lattice constant "*a*" is always the same. Einstein showed that the laws of classical mechanics have to be modified in such a way that the energy $(E = m.c^2)$ and the momentum $p = m.v$ of a freely moving particle are related to one another by means of:

$$\left(\frac{E}{c}\right)^2 = p^2 + (m.c)^2$$

Since a free particle is unperturbed by external forces, neither its direction of motion, nor the values of p and E can change in the course of time (Beauregard 1949: 87 – 96).

In classical or relativistic mechanics, we describe the motion of a particle by assuming that it has a well-defined position at any particular instant *t*, whether we know this position or not. The rate of variation of this position during a very small time (de/dt) then defines the instantaneous velocity *v*. While it may be difficult to abandon the familiar concept of a space-time continuum, the basic assumptions are in line with the evolutionary trend of classical and relativistic mechanics. Einstein insisted on the essentially constructive nature of thought and more particularly of scientific thought. For relativistic theories, the naturalness or logical simplicity of the premises is very important, as is the inner perfection of all these classical or relativistic theories. The theory of relativity leads to a concept of time that in many ways contradicts intuition. However, only the theory of special relativity will be taken in account here. The main point of importance is the fusion of space and time into four-dimensional space-time by Hermann Minkowski. The meaning of space-time can be demonstrated considering, as an example, the simplest equation of the Lorentz transformations, which are the coordinate transformations of special relativity for inertial systems of uniformly moving systems (Naber 1991: 7 – 30). The relations, which when equated define the Lorentz transformations, further show a difference in the role of the time coordinate from that of the space coordinates; for the term Δt^2 as the opposite sign to the space terms dx_1^2, dx_2^2, dx_3^2.

Then the Lorentz transformation, as a coordinate's dictionary, is defined in such a way that it first makes the equation $dx_1^2 + dx_2^2 + dx_3^2 - dl^2 = 0$ a co-variant equation, that is, an equation which is satisfied with respect to every inertial system, if it is satisfied in the inertial system to which we refer the two given events, like the emission and reception of the ray of light (Eddington 1957: 13 – 15).

The fusion of time and space leads to the concept of space-time in the theory of relativity, and this concept leads to important simplifications. Many such cases can be found in physics, especially where relativistic effects enter into play.

Accordingly, the world is considered as a space-time-block. The points in this block correspond to events. But the flow of time is a purely psychological phenomenon. Seen from a higher perspective, all events of all times and spaces simply exist.

Consciousness at any one time can only reach one three-dimensional plane of this four-dimensional space-time. This plane corresponds to the present moment. But the present is an arbitrary point of reference, arbitrary in the same way as a certain point in space (d'Inverno 1985: 116). In accordance with the special theory of relativity, as a new mechanics different than Newton's theory of physics, certain co-ordinate systems are given preference for the description of the four-dimensional space-time continuum. We call these Galilean co-ordinate systems. For these systems, the four co-ordinates (*x, y, z, t*) which determine an event or – in other words – a point of the four-dimensional continuum, are defined physically. For the transition from one Galilean system to another, which is moving uniformly with reference to the first, the equations of the Lorentz transformation are valid. These later form the basis for the derivation of deductions from the special theory of relativity and in themselves are nothing more than the expression of the universal validity of the law of transmission of light for all Galilean systems of reference (Newton's mechanics) (Nielsen 1935: 10 – 26). Minkowski found that the Lorentz transformations satisfy the following simple conditions. Let us consider two neighboring events, the relative position of which in the four-dimensional continuum is given with respect to a Galilean reference body K by the space co-ordinate differences dx, dy, dy and the time-difference dt.

With reference to the second Galilean system, we shall suppose that the corresponding differences for these two events are dx', dy', dz', dt'. Then these magnitudes always fulfil the condition $dx^2 + dy^2 + dz^2 - c^2dt^2 = dx'^2 + dy'^2 + dz'^2 - c^2dt^2$. This validity of the Lorentz transformation follows from this condition. We can express this as follows. The magnitude $dS^2 == dx^2 + dy^2 + dz^2 - c^2dt^2$, which belongs to two adjacent points of the four-dimensional space-time continuum, has the same value for all selected reference bodies (Gomes 1954: 39 – 41).

If we replace $x, y, z, \sqrt{-1}ct$, with x_1, x_2, x_3, x_4, we also obtain the result that $ds^2 = dx_1^2 + dx_2^2 + dx_3^2 + dx_4^2$ is independent of the choice of the body of reference we call the magnitude "*ds*", i.e. the distance apart of the two events or four-dimensional points. However, we can regard the space-time continuum, in accordance with special theory of relativity, as a Euclidean four-dimensional continuum. The description of the space-time continuum by means of Gauss co-ordinates completely replaces the description with the aid of a body of reference, without suffering from the defects of the latter mode of description; it is not tied to the Euclidean character of the continuum.

It was Lorentz who, in his monumental work of 1904, gave the formula: $m_c = \frac{m_o}{\sqrt{1-v^2/_{c^2}}}$

For the mass of an electron as a function of its velocity. This formula was obtained on the assumption that electrons in motion underwent Fitzgerald contraction (Kane, Sternheim 1988: 25 – 27). In his paper of 1905, the centennial of which was the reason why 2005 was celebrated as the International Year of Physics, Einstein also touched upon this question, but he did not deceive the formula: $m_c = \frac{m_o}{\sqrt{1-v^2/_{c^2}}}$. Of course, he did obtain the correct expression for the so-called longitudinal mass of the electron and its kinetic energy (see the following section). Critically it was Planck, in 1906, who carried out of systematic study of relativistic dynamics and discovered equations which were to replace the Newtonian equations of motions of a material particle. Planck also obtained correct relativistic expressions for momentum and kinetic energy, and hence, for the function $f(v)$. Nowadays, relativistic formulae are taken for granted in all considerations, theoretical or experimental, on high-energy particles, whether in cosmic rays or man-made machines (Mille 1988: 312 – 316). Relativistic formulae for mass and momentum are employed towards this end, and the resulting design is found to work exceedingly well. Therefore, this may be regarded as indirect but convincing evidence for relativistic expression. According to gnoseological criticism, Einstein's mechanics is only one generalization from Newtonian mechanics. Einstein's opportunity provides a new perspective for the laws of nature. Now there is a new mechanics that comes from Newton's mechanics.

3 The critical statements

Although it may be difficult to abandon the familiar concept of a space-time continuum, the basic assumptions are in line with the trend of the evolution of physics.

Einstein insisted on the essentially constructive and speculative nature of thought and more especially of scientific thought. For physical theories, the naturalness or "logical simplicity" of the premises is very important, as well as the "inner perfection" of all these theories. We applied these rules to establish the foundations of space-time and to test its logical consistency and to show that it has the advantage of removing a severe contradiction that subsisted between relativity and quantum mechanics (Pais 1996: 318 – 320). External confirmation is essential to special relativity, since others physical theories should not only be correct, but also true. This means that they have to be in conformity with observed facts. Their objective is to describe what actually happens or could happen in nature. Regarding the creation of a new theory, Einstein warned, however, against the prejudice that facts by themselves can and should yield scientific knowledge without free conceptual construction (Meessen 2005,: 39 – 45). The evolution of space-time quantization was mainly motivated by a search for greater harmony between various ideas and facts that carry out the basic tissue of relativistic physics (Einstein 1954: 47 – 49).

The name "theory of relativity" has greatly contributed to all sorts of misunderstandings. This name contains a clear reference to an epistemological relativism. But there were also serious thinkers who saw some links between relativity theory and Kantian transcendental philosophy. Kant opted for kinetic relativism, the doctrine claiming that one can meaningfully speak only about motion relative to other bodies. All this happened in Kant's pre-critical period; in his mature period he asserted that space and time are categories inherent in our cognitive equipment which are necessary conditions for our perceptions. But owing to the space category our perceptions can be ordered as coexistent with each other, and, owing to the time category, they can be ordered as succeeding each other (Rosales 1989: 377 – 386). Kant did not proceed in line with the future development of science not only in physics but also in mathematics. The development of formal logic did not prove him right.

The special theory of relativity seemed to satisfy positivistic postulates but did so in another respect. In his original work of 1905 Einstein started by precisely formulating the measurement procedures of such magnitudes as the length of a body in rest and in motion, or the length of time intervals. Einstein's views had a great impact not only on physicists, but also on philosophers. There are, for instance, many striking similarities between Popper's philosophy of science and Einstein's methodology. What Popper called the "hypothetical deductive method" does not differ much from Einstein's teaching on the nature of physical theory. I do not claim that Popper actually borrowed some of his theses from Einstein. I only want to say that our present philosophy of science owes many of its features to Einstein and to his theory of relativity. And because of its exceptional inner perfection and its rich physical content, this theory has been analyzed so many times by various philosophers that we can truly say that without the theory of relativity our present philosophy of science would be different from what it is today. However, I see a corroboration of this idea in Einstein's special theory of relativity, for instance, in the fact that in this theory every observer connected with the inertial frame of reference decomposes space-time into his own space and his own time. In the theory of relativity, every observer can be identified with the system of devices measuring time intervals and space distances (Pauli 1938: 1 – 4). I'm looking forward to developing, according to this paper, a new philosophical result for special relativity as a space-time metric and for it playing a very important role for the physical dimensions of nature. "Kierkegaard's claim is interestingly similar to a well-known claim of Einstein" (Evans 1998: 175); for more about Kierkegaard, see (Binetti, Pavlíková 2019), (Martin, Cobo, Kondrla 2019), (Tavilla, Kralik, Roubalova 2019).

4 Interpretation and other philosophical contexts

The interpretation of Einstein's theory of special relativity is not unequivocal in some opinions. As Novák pointed out in his notable article (Novák 1983: 115), differences in interpretations also exist in some university textbooks. A famous physicist, Professor Václav Votruba, explained the clock paradox in the following way in his book *Foundations of the Special Theory of Relativity* (Votruba 1977). If astronauts fly a spacecraft at a speed close to the speed *c* for 10 years, these astronauts will be two years younger after returning to Earth than their friends who remained on Earth. According to Votruba, the paradox arises when we count the data from Earth from the perspective of the space system on the spacecraft. However, Votruba marked this solution as incorrect, claiming that the non-inertial nature of the spacecraft system would speed up the clock running on Earth, which would not only offset but even cause it to be ahead of time. These changes, which at first look like fantasy, are regarded as objectively valid by Professor Votruba. The well-known university textbook *Concepts of Modern Physics* (Beiser 2003) clearly shows that these are seeming changes. It states that in the twin paradox one brother thinks his brother lives slower in the universe. As Novák said, "in contrast to Votruba, the changes calculated on the basis of the STR are only subjective, that is to say, seemingly according to Beiser" (Novák, 1983: 116). Therefore, Novák proposed the division of special relativity theorists into two groups: the hard relativists, who simply consider the calculations and data of the STR as an objective reality, and the soft relativists, who speak of the influence of the gravitational field and consider the change as seeming. We reject the suggested Hegelian solution of Novák to negate the STR due to the "aging of the paradigm of Einstein's theory of relativity" (Novák, 1983: 117] and to create a negation of the negation of Newtonian physics, as we find it too speculative.

Let's not forget that Minkowski also considered the so-called quasi-present in his constructions. "Minkowski's model of a relativist world considers a sphere of positive space-time intervals within so-called light cones" (Zeman, 1986: 38); there is an area of quasi-present beyond the boundary of the light cones where the space-time intervals have negative parameters.

There are some critical views on the STR valuation. The well-known physicist Miloš Lokajíček also sees many controversies in the special theory of relativity. He pointed out that the attempts that were made using long-haul planes heading in opposing directions, however, did not confirm any real consensus with the dilation of time (Lokajíček, 2002: 113). He rather weighed the argument that the dilation of time is confirmed by measuring the life of unstable particles. Lokajíček considered the length contraction to be experimentally untestable – cf. (Hsu, Hsu, 1994).

"The abandonment of the traditional conception of space and time based on the idea of a spatial continuum flowing through a temporal continuum coherently leads to the assumption of a space-time continuum (chronotope) in which distances and time intervals vary with the changing the reference system, and together vary, of course, all other sizes to those connected (speed, acceleration, mass)' (Principe 2016: 211). Lokajíček further pointed to the fundamentally different grasp of time, as well as a different grasp of determinism and causality, in the STR and quantum mechanics. The mathematical apparatus of the STR is not very complex; differential equations are used. Similar to classical physics, Laplace's determinism is preserved (Novak, 1983: 116). Quantum mechanics, especially in Copenhagen's interpretation, is indeterministic. The understanding of time in the STR is a quantity that is located outside of Euclidean space. Israeli physicist Rafi Milo attempted to interpret absolute time and absolute simultaneity fully compatible with the special theory of relativity (Milo, 2015). Quantum mechanics uses time to express the amount of change. As Lokajíček pointed out, the perception of time outside the space comes from Gassendi and Newton – cf. (Pancheri 1978) or (Palmerino 2011). Mostepanenko also stated that the STR has not moved on from Newton's idea of time that much (Mostepanenko 1976). Despite the mathematical unification of both the theories of Dirac, the basic approaches to time and determinism are inconsistent in both theories. Lokajíček even doubted the eligibility of grasping time in the sense of the STR, and he proposed redefining the concept of time. While pointing to contradictions in the interpretation of quantum mechanics (Lokajíček, Kundrát 2012), he favoured the understanding of time as quantum mechanics understands it. As we know, alternative concepts of time have appeared in the history of thinking, such as Levinas, who "determines time as an endless duration (durée) that shows the nature of non-coincidence or interruption given always by the central moment of the present moment" (Sucharek 2006: 643].

As is well known, Alfred North Whitehead postulated his own reception of Einstein's theory of relativity. Although Whitehead's reflection relates to the general theory of relativity, it is good to recall that Whitehead rejected the interconnection of physics and geometry, "the consequence of which is the rejection of the general principle of relativity" (Andrle, 2010: 265). Whitehead based his reception on a flat four-dimensional space-time, actually approximating the concept of time to the grasping of the STR. The subject was further developed by several researchers (Mc Henry 2015), (Shaharir 2008). Einstein himself held the view that pure geometry must be physically interpreted if we want pure geometry to become physical.

It is interesting to mention the objections of V. I. Lenin to Mach, especially in connection with his understanding of time. A lawyer and a philosopher, Lenin spoke of contemporary physics in his well-known book *Materialism and Empirio-Criticism* (Lenin 1952). However, he did not criticize Einstein directly, but in particular the co-creator of the STR, Ernst Mach. It is possible to agree with Marek's assertion: "Lenin was not a professional physicist and this contributed to his not being able to follow the scientific meaning of Mach's ideas, though he was speaking about their philosophical consequences" (Marek 1977: 64). Lenin's objections also concerned Mach's understanding of time. Lenin blamed Mach for building "an epistemic theory of time and space based on relativism" (Lenin 1952: 151). Mach, in the intentions of Lenin's criticism, falsifies Newton's view of time as an absolute parameter. Lenin defended the objective character of time. However, we must point out that Lenin's reading of Mach, despite the criticism of idealism and empirio-criticism, cannot be taken as fully correct, as Lenin approached the issues ideologically at some points. On the other hand, Lenin took the reflection of grasping time in the STR only very indirectly. It is apparent that he acknowledged Mach's arguments at some points, but a priori sought to condemn his understanding of time. In principle, however, it is possible to see a defence of Newton and Gassendi's concept of absolute time in Lenin's criticism. Therefore, Lenin did not declare against the fundamental concept of time in the STR. His criticism tended to refer to some of Mach's statements, and we do not think it fully appropriate in all cases. However, it is known that some fanatical Marxist philosophers considered the special (and general) theory of relativity as bourgeois pseudoscience.

The special theory of relativity was evaluated directly by several distinguished philosophers. Karl Popper argued that Einstein created the STR in the position of positivism (Popper 1976). Later, in the sense of Popper's reflection, Einstein dropped the positivist interpretation of the STR. Einstein's STR was also evaluated by Nicolai Hartmann. According to Hartmann, the manifestation of the positivist view of young Einstein was him not speaking of the unity of space and time, but of their inseparability. Hartmann did not dare attack the STR, but he criticized Einstein that space and time remain only on the physical level with him and for not performing an ontological analysis that would deepen the sense of space and time as a categorical apparatus of philosophy (Špůr 2006: 118).

Hermann Minkowski connected space and time into a four-dimensional continuum in 1908. "The four-dimensional Minkowski's variant corresponds geometrically to the space-time in the STR" (Dubnička 2011: 329). The interpretation of time and space in terms of their further mutual relationship within the STR remains an open question. Einstein himself did not understand the STR as a theoretical system but as a heuristic principle at the beginning. Within the formal approach and mathematical description, a four-dimensional description of mechanical movement is also permitted in Newton's physics (Alexeyev 1984: 165). The interpretation of Minkowski's space-time is open in many interpretations.

Einstein in all probability definitively eliminated the idea of the ether from physics. This *quinta essentia* probably most resonated with Aristotle in *De Caelo*; the origin of the term is still mythological. The determination of location with respect to the ether was still part of the arsenal of the physical categorical apparatus until the early 20th century. *Αίθήρ* as a part of physics (from Aristotle) and sometimes even metaphysics (Pseudo-Lullus) survived over two millennia. It seems that the STR banished it from science for good.

It is possible to postulate the methodological question of whether the STR is merely a complement to and refinement of the existing physical image of the world or is a new paradigm (in the sense of Kuhn). We know that a supporter of cumulativism in the development of science "Laudan criticized Kuhn (for the development of the theory of science which was in conflict with actual episodes of the history of science)" (Karaba 2012: 520). In our opinion, from a methodological point of view, the STR is a refinement, a moderating of science in terms of the addition of a new, still missing condition to the existing theory, which will result in its qualitative enrichment. This is how Henri Poincaré looked at the development of physics, for example. In terms of new conditions, the STR places Einstein's two postulates into the already existing physical theory; however, the rupture does not take place, and it is not a new scientific paradigm in the true sense of the word.

5 STR and philosophy – the need of emphasis of the problem in the educational process

A significant problem in the educational system is the lack of emphasis on the relationship between philosophy and physics. As we have shown above, there are significant correlations between STR and philosophy. Teaching in high school is the first, fundamental step to begin to shape the future intellectual. Within this framework, the basic natural science, physics, has its inalienable place. On the one hand, attention is usually paid to the technical level of aids needed to teach physics. On the other hand, especially in high schools, the interdisciplinary relationships between physics and philosophy are not sufficiently clarified, they are on the fringes of attention. There is less room left for the implementation of interdisciplinary relationships. When taking over the special theory of relativity, it is good to indicate the basic ideas of the general theory of relativity at least at the selection seminar within the grammar school. It speaks of Rieman's non-Euclidean curved space, which recognizes Kant's idea. The special theory of relativity, of course, has many philosophical consequences. First of all, it is a complete denial of an intangible and immovable substance, which as an idea that has resonated in physics for more than two thousand years. Already in De caelo, Aristotle defines αιθης, claiming that "neither that which always is, therefore, nor that which always is not is either generated or destructible" (Aristotle 1995, 282b). Classical physics counted on the ether as an immobile entity, with respect to which the position in the absolute sense can be determined. Instead of Aristotle's quinta essentia, STR introduces a postulate about the relativity of motion. It is only possible to talk about the motion of a body relative to one or another frame of reference, but not about absolute motion. While absolute position, absolute rest and absolute motion are ruled out, STR has shown that there is a maximum speed, the speed of light above which it is no longer possible to develop any speed, while the restriction c as the highest speed also applies to speed addition. There is no absolute motion of the body as a motion relative to absolute space. Marxist-oriented physicists interpret the question of space in STR as meaning that space without matter has no meaning, because space is not just a structure where matter moves, but it is a form of its existence. This idea is also illustrated by a certain interpretation of one of the conclusions of the general theory of relativity (hereinafter GTR), to which we will return later. The Marxist explanation of STR's conclusions also relates the non-existence of absolute peace, which is related to the principle of the dialectical nature of reality. This interpretation has opponents from the ranks of philosophers who say that motion is not an immanent property of bodies, because whether it is motion is decided by the question of the position of the observer. The STR has also shown that the concept of a reference system and a coordinate system are not identical. Changes in time are unknown in classical physics, specifically the contraction of length is in turn a manifestation of the relative nature of time. The question of equivalence of reference systems can also be interpreted as meaning that in terms of kinematic description the heliocentric and geocentric systems are equivalent, but they are not equivalent in terms of dynamics, which takes into account the magnitude of acting forces and their relationships.

More comprehensive philosophical consequences, applicable to grammar school teaching, can be perceived especially in connection with the general theory of relativity, which can be taken over by expanding the topics that teachers can perform by 30%, or by increasing physics lessons above the state educational program. Marxist-oriented physicists strive to interpret, in the sense that space and time, in GTR as space-time a form of matter, because its curvature is dependent on mass. The curvature of space-time is a refutation of the idea of Kant, where he considers space and time as separate a priori forms of sensuality, while clearly formulating the necessary Euclidean structure of space. The connection of time and space into space-time also contradicts Kant's and Newton's idea of space. "A. Einstein uses Leibniz's relational conception of space and time in the construction of theory" (Philosophical Foundations of Natural Sciences 1980: 141). This is evident in both STR and GTR. The general theory of relativity has some connection with the search for a unified physical theory. Einstein tried to trace the idea that all theoretical physics was not just a consequence of GTR, but was not as successful as he had not developed a unified field theory, despite the discovery of a connection between the theory of gravitation and non-Euclidean geometry. A parallel can be found in August Comte's effort to methodologically search for the most general laws possible, the invariance of which could be expressed as simply as possible quantitatively.

The development of physical knowledge, even in correlation with philosophy, requires the expansion of the base with new knowledge, which must be at least minimally presented to high school students. The incomprehensible neglect of interdisciplinary relationships between philosophy and physics deprives students not only of key physical facts, but also of the possibility of understanding philosophical consequences, thus depriving them of a large part of the holistic notion of natural phenomena in interdependence. The pedagogical process must be set in favor of the development of interdisciplinary relationships both in the field of teaching philosophy and in the field of teaching physics. The curriculum of both subjects, especially the grammar school, should point to the intertwining of philosophy and physics in the field of STR. The theory of relativity is a field where the plane of physics and philosophy intersects at several points.

6 Conclusion

"It is noted that knowledge and information are the organizing principles of the post-industrial information society" (Pushkarev, Pushkareva 2018: 176). Knowledge and information are also subject to the laws of physics. The special theory of relativity defines a new methodology for physical science, because there are, however, determinations to the measurements. Einstein only clearly formulated his methodological views much later. Physical theory cannot be reduced to a set of measurement results. By mathematical deduction from them one constructs the body of a given theory, but this is by no means a mechanical process. One should invent ways to overcome difficulties; one ponders various possibilities, and sometimes one goes back and modifies initial assumptions and so on (Schrödinger 1954: 74 – 76). Only when the theory of relativity is ready does one derive empirical predictions from it which should be compared with the results of real experiments. In Einstein's view, there are two criteria for the correctness of any physical theory, and one of them is its agreement with experimental results. The new relativistic theory is to learn a sense of space-time, as relative events, and according to the "metric". However, spacetime is a holistic perspective of measurements (Landsberg 1982: 35 – 40). Special relativity is an events theory, because it explains the sense of invariance of physical laws according to inertial systems of references.

The theory of relativity is intimately connected with the theory of space and time. We shall therefore begin with a brief investigation of the origin of our ideas of space and time, although in doing so I know that I introduce a controversial subject. The object of all science, whether natural science, is to co-ordinate our experiences and to bring them into a logical system (Heisenberg 1951: 99 – 105). But normally the theory of relativity is often criticized for giving, without justification, a central theoretical role to the propagation of light, in that it establishes the concept of time on the law of propagation of light. And there are so many others critical judgments, from natural law to the experience, to the new relativity of space and time.

The extensive space between philosophy and physics is also notable in the field of the theory of relativity. Despite the factual context, relatively little attention is paid to the overlap at the educational level. We recommend, first of all, the obligatory inclusion of the theory of relativity in the higher grades of grammar school. We also recommend that in the subject of philosophy as well as in the subject of physics, sufficient space be devoted to the interdisciplinary contexts of the theory of relativity. In physics, the theory of relativity, cosmology, as well as quantum mechanics can be done in thematic units. In philosophy, it is possible to point out the connection with the theory of relativity especially in Aristotle's cosmology, in Kant's understanding of time and space, in Whitehead, but also in the questions surrounding the methodology of science of Poincaré, Mach, Popper, Kuhn, etc. Certain connections can also be mentioned in the constellation with Lenin's work Materialism and Empirio-Criticism.

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