The Hidden Face of *c*, or The True Meaning of the Kennedy-Thorndike Experiment

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"The theory decides what we observe." – Albert Einstein

Since the Kennedy-Thorndike experiment in 1932 led to a Null result as the historical Michelson-Morley experiment did in 1887 it was almost collectively believed, that special relativity was proven right again. But in truth a completely new face of c was discovered, which Einstein's theory had not been taken into account.

1. Introduction

Nowadays the Michelson-Morley experiment (in brief: the MM experiment) is widely supposed to have prompted, if not caused, the advent of Einstein's special theory of relativity. Whenever this theory is presented or explained, the MM experiment is cited as the most important experiment to justify Einstein's theory as a true theory about the universe. The weirdness of special relativity is very often defended by it. It is said that the relativistic effects of time dilation and length contraction may be counter to commonsense but the MM experiment would prove them right: The universe is just as bizarre and weird as Einstein' theory tells us.

All textbooks about physics are following this view. As the result of this historical development the Kennedy-Thorndike experiment (in brief: KT experiment) is extremely rarely mentioned. Neither in Feynman's famous red books nor in Fölsing's great biography of Einstein, to give only two examples, can a single remark about this experiment be found. Only a handful of scientists discuss and study this experiment critically [1].

But this experiment is, as I like to show in this paper, perhaps the most important one performed in the physics of the 20th century. It could change our understanding of the speed of light tremendously. It is claimed that by the KT experiment a hidden face of *c* has been revealed; a discovery that remained unnoticed until today.

This hidden face of *c* is geometrically codified by a square, whereas the already known face of c is codified by a (quarter) circle. Special relativity bases exclusively on this face - and it was this face that has been revealed by the MM experiment in 1887. By the MM experiment it has been proved that light is propagating in a highly isotropic fashion. The (quarter) circle is nothing else than the geometrical expression of this central statement of special relativity.

Although the blueprints of both faces of c are quite different, their internal parameter is exactly the same, that is, $c = 1$. That's one of the main reasons why the hidden face of c remained unnoticed for such a long time. When the KT experiment was performed and the parameter $c = 1$ (i.e. a Null result) was measured, it was erroneously concluded, that nature has confirmed the already known face of *c* **a second time**. But actually a new face of c has been discovered; a face that is geometrically expressed by a square – and not by a (quarter) circle.

This **dual parameterization of c** implies a completely new understanding of the speed of light. It suggests that the speed of light is a quantum mechanical quantity, i.e. an integral part of the *wave-particle-duality of light*. We know that light is characterized by a dual pattern of behaviour: sometimes it behaves like a particle, sometimes it behaves like a wave. It is therefore natural to assume, that the speed of light *c*, too, is codified accordingly. The dual parameterization of *c* is perhaps that piece of theory that makes the picture of the universe provided by quantum mechanics more complete and more understandable [2].

If this piece of theory is true, it would change our view of the universe tremendously, because the speed of light *c* is one of the fundamental constants of nature. We know from the history of science that a discovery of a new fundamental constant usually involves significant changes in physics – and the discovery of a still unknown face of *c* can be considered as such a discovery [3].

This discovery can be explained in the most transparent way by using a specific approach to special relativity. This approach was developed by the physicist C. L. Epstein to make the key effects of special relativity, especially the effect of time dilation, theoretically more accessible [4].

2. An Alternate Approach to Special Relativity

The main geometrical blueprint of Epstein's approach to special relativity is a quarter circle, which he himself called the *cosmic speedometer*. This quarter circle is parameterized by means of $c = 1$ in all directions [5].

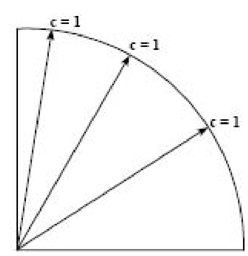

Fig. 1. The First Face of *c*

To derive the (quarter) circle as the fundamental geometrical blueprint of special relativity Epstein has used a specific light clock. It is an empty tube, in which a flash of light is trapped inside and bounces back and forth. Each bounce would have to be 1 second, because the tube is 300.000 kilometres long.

By this hypothetical setup the clock is calibrated in such a way, that it can be easily understood why the speed of light *c* - if supposed of being invariant for every observer - leads to the geometrical blueprint of a (quarter) circle: If the speed of light is set up as an absolute parameter then the photon inside the tube can only travel the distance of c in one second independently how fast this light clock is moving aside. To establish this physical restriction for all velocities from $v = 0$ to $v = c$, we have therefore to draw a circle with the radius of $c = 1$. This geome-trical blueprint is as already mentioned physically connected with the isotropy of light. It was the MM experiment (1887), by which this connection has been experimentally established. When the two physicists Michelson and Morley performed their experiment they expected to measure an anisotropy of light, but such an anisotropy was surprisingly not found. The speed of light was instead of that always the same in all directions.

Many physicists even today are interpreting the null result of the Michelson-Morley experiment as an experimental proof of the constancy of light [6]. In his book **The Character of Physical Law** the well known physicist Richard Feynman commented the MM experiment like this: „The facts of nature are not so easy to under-stand, and the fact of the experiment was so obviously counter to commonsense, that there are some people who still do not believe the result! But time after time experiments indicated that the speed [of light] is 186.000 miles a second no matter how fast you are moving." [7]

This usage contrasts tremendously with Einstein's treatment of this experiment. He considered it *without any exception* as evidence for the relativity principle. He *never* cited it as evidence for the principle of constancy of the velocity of light [8]. In 1915 e.g. he declared that the successes of the Lorentz theory were so significant that physicists would have unhesitatingly dropped the principle of relativity, if an important experimental result like the MM experiment had not existed [9].

Einstein's view determined in a somehow tragic way how the KT experiment has been interpreted later on, because the special principle of relativity is insensitive with respect to the theory of light adopted. Einstein's principle makes no difference between the wave-like aspect or the particle-like aspect of light, as it is described by the quantum mechanical concept of the wave-particle-duality. It is only looking for a null result, that means: It is only asking whether the parameter of $c = 1$ is physically realized or not. This indifference of the principle of relativity is still regarded as its strength, but it is actually its blind spot as I want to show in the subsequent chapter.

3. The True Meaning of the KT experiment

When the Kennedy-Thorndike experiment was performed in 1932 special relativity was already a well-established theory within the physics of that time. As a result of this development the MM experiment was meanwhile considered as a strong proof of the principle of relativity – and not as a proof of the constancy of light. It seemed to prove that the speed of light measured by some observer did not depend on the direction of the observer's velocity relative to the hypothetically assumed ether. For Einstein himself this experimental proof was even so strong that he had no doubt about its fundamental validity. To him it made the relativity principle to an "almost indisputable fact, which seems to be valid not only in mechanics but in all branches of physics." He therefore prophesized already in 1912 a null result, if the *magnitude* of the observer's velocity relative to the ether would be measured some time in the future [10]. In 1912 this measurement was not yet made. It was not yet proved experimentally whether the speed of light was really independent of the magnitude of the observer's velocity, too.

This was achieved by the experiment performed by Roy Kennedy and Edward Thorndike twenty years later. They used a slightly different version of an interferometer: One arm of the interferometer was made much shorter than the other. In the MM experiment the two arms of the interferometer were approximately equal. By this modification it was possible to measure whether shifts of interference fringes occurred if the apparatus had changed the magnitude of its velocity relative to the hypothetically assumed ether frame. When this experiment was finally performed, no significant fringe shift was found: The speed of light was always the same *at all velocities*. In brief, the relativistically expected parameter of $c = 1$ could experimentally be confirmed again. The physicists came thus to the conclusion, that the special principle of relativity had held again as Einstein once had prophesized. But just this conclusion is possibly the wrongest scientific conclusion that was ever made in the history of 20th century, because it was implicitly believed that nature has confirmed the first face of *c a second time*, but possibly it did not. Instead of that a new face of *c* could have been discovered.

This discovery can also be explained in a clear way by referring to Epstein's approach. As in the KT experiment the measurement of time dilation is implied, the derivation of this relativistic effect within the geometrical context of the (quarter) circle helps to understand this far-reaching discovery [11].

If the speed of light is regarded as being invariant then the idea of an absolute time must be changed. This was the revolutionary insight of Albert Einstein. In terms of Epstein's geometrical language this insight can be given a quite simple form [12].

In the following diagram three situations are depicted. The first diagram shows the clock in a stationary state, i.e. $v = 0$. The second diagram shows it now moving with the velocity of half the speed of light, that is, $v = 0.5$ c. In the third case the clock is travelling with the speed of light $v =$ c.

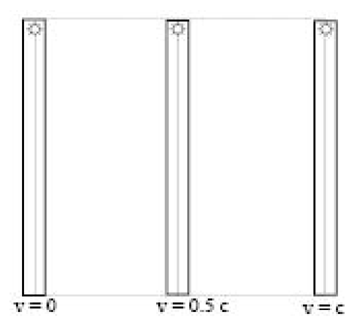

Fig. 2. The Post-Relativistic View of Absolute Time

If time is assumed of being absolute, then the flash of light starting from the bottom would reach the top always at the same time, that is, after one second, independently how fast the clock is moving. That's the inner meaning of the absoluteness of time: The flow of time does not depend on the motion of the clock. But if we introduce the speed of light c as an absolute parameter, then the flash inside couldn't get any longer to the top of the tube, as it is stated by the notion of an absolute time, because the light has always the same speed c = 1 independently of the velocity of the clock. If the light clock is f.e. moving with the velocity of v = 0.5 c the flash of light can reach only a specific part of the temporal distance, which means time is slowed down accordingly. As the exact amount of time dilation can be derived by the Pythagorean Theorem only it is considered as a friendly approach to special relativity [13].

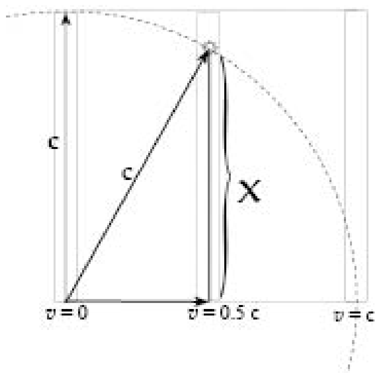

Fig. 3. Relativistic Derivation of Time Dilation

This diagram shows how the relativistic derivation of the effect of time dilation has to be calculated within the geometrical blueprint of the (quarter) circle. We can directly read from the diagram, how the measure of the effect of time dilation depends on the relative velocity of the moving clock (here: v = 0.5 c). In the next five equations the rules of this calculation are given.

$$X = \sqrt{c^2 - v^2} \tag{1}$$

$$X = c \cdot \sqrt{1 - \frac{v^2}{c^2}} \tag{2}$$

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{3}$$

$$X = \frac{c}{\gamma} \tag{4}$$

$$c = 1 \quad \rightarrow \quad X = \gamma^{-1} \tag{5}$$

The effect of time dilation is geometrically expressed by the triangle. It shows how time is *slowed down* if we are moving with the clock. The quarter circle (the dotted line) plus the triangle can thus be summarized as the geometrical pattern that special relativity has predicted with respect to the experimental outcome of the KT experiment. This prediction includes two specific equations that nature had to confirm with respect to the discussed case of v = 0.5 c:

$$c = 1 \tag{6.1}$$

$$\gamma = 1.15 \tag{6.2}$$

Equation (6.2) shows how much the time of the moving clock is "dilated" with respect to an (external) observer. When the two physicists Kennedy and Thorndike finally performed their experiment these two equations (6.1; 6.2) were actually confirmed. The physicists came therefore almost naturally to the conclusion that special relativity is a true theory about the universe. This conclusion includes, of course, the assumption, that the geometrical blueprint of the quarter circle resp. the first face of was confirmed again, that is, a second time. But just this conclusion could be wrong.

If we look very attentively to the diagram of Fig. 2, then we can see an interesting feature: The notion of an absolute time is closely connected with a geometrical blueprint of a square, that is parameterized in exactly the same way like the quarter circle, that is, c = 1.

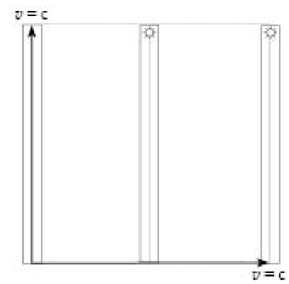

Fig. 4. The Hidden Blueprint

But no physicist introducing and explaining special relativity on the ground of this specific approach didn't realize the existence of this geometrical blueprint of c (i.e. the square) *clearly*. Even C. L. Epstein who has developed and elaborated this alternate approach to special relativity, didn't recognize that. As special relativity has abandoned the notion of an absolute time, Epstein came obviously to the conclusion, that the geometrical blueprint connected with it (i.e. the square) has to be abandoned as well [14]. But possibly there is no need to make such a decision against the blueprint of the square. If we assume that the two geometrical blueprints, that is, the quarter circle and the square, are closely "entangled" with each other, then we can make two surprising observations:

1. The square is as already mentioned parameterized in the same way like the quarter circle:

$$c = 1 \tag{7.1}$$

2. If we consider *the relationship between the vector of the quarter circle and the vector of the square* at the velocity of v = 0.5 c, then a factor occurs, which is exactly the same as predicted by special relativity - 1 .00 : 0.86 = 1.15:

$$\gamma = 1.15 \tag{7.2}$$

In the following diagram these two observations are geometrically depicted:

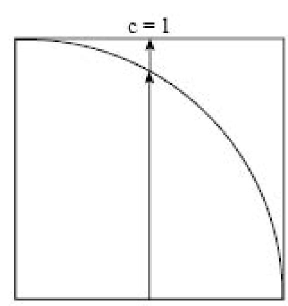

Fig. 5. The Second Face of c

As these observations given by this geometrical pattern are exactly the same as those predicted by the geometrical pattern of special relativity, it could be possible that nature has confirmed this geometrical pattern *and not the relativistic one*.

But does this geometrical pattern really describe the outcome of the KT experiment? The KT experiment is designed in such a way, that only the magnitude of the observer's velocity matters - not the direction. The geometrical pattern shown in diagram of Fig. 5 is obviously in accordance with this design: The magnitude of the velocity and the vector pair are closely related to each other. Any dependence due to the direction is geometrically excluded. [15]. This gives us the right to announce the diagram of Fig. 5 as geometrical representation of the KT experiment. Assuming that the KT experiment has actually confirmed the "entangled" geometrical pattern, which I am calling the MA_0-Blueprint [16], what does it mean for modern physics?

In general, it can be said, that it implies an interpretation of the KT experiment that is quite different from the relativistic one in many respects. The most important point is surely the fact, that the measured null result has possibly not confirmed the quarter circle a second time, as it is still unconsciously believed, but it has revealed instead of that a completely new face of *c*, that is, the square.

Although this second face of c differs dramatically from the first face of *c*, this difference cannot easily be discovered, because both blueprints the quarter circle and the square are parameterized in the same way, that is, $c = 1$. In other words, as long as we are looking only for a null result, as requested by the special principle of relativity, we don't know which of these two geometrical blueprints was actually measured by the KT experiment: **They are empirically equivalent.**

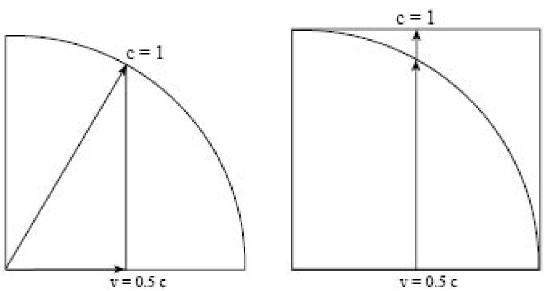

Fig. 6. The empirical Equivalence of SR and MA_0

But the dual parameterization of *c* is not the only reason, why the second face of *c* remained hidden for more than one hundred years. The Lorentz symmetry provided by the relativistic pattern is the other reason. It is generally believed that this symmetry being connected with the isotropy of light excludes any anisotropic aspect so far - and the second face of c represents by its geometrical design (i.e. the square) a truly anisotropic blueprint. Tragically this almost collective belief seems to be proved by experiment, too.

Line of Argument	Name of Experiment	Year of Discovery	Internal Parameter	Physical Content	Geometrical Matrix	Theoretical Explanation	
No. 1	MM	1887	c = 1	Wave			Wave-Particle-Duality
No. 2	KT	1932	c = 1	Particle			

Table 1. The Quantum Mechanical Description of *c*

When the KT experiment was performed, Kennedy and Thorndike concluded that the null result of their experiment implied time dilation as well, but this was not the case. It was merely assumed, but not experimentally established [17]. In other words, only the parameter of $c = 1$ was confirmed but not the Lorentz symmetry (i.e. the Gamma factor γ of the time dilation effect; the x-factor of the diagram in fig. 3). But six years later in 1938 the physicists H. Ives and G.R. Stilwell performed an experiment which was designed to test just this Lorentz symmetry resp. the Gamma factor γ. It was the first direct, quantitative test of the time dilation factor. And nature should also confirm this factor to a very high degree.

Since that time the truth of the special relativity was no longer doubted. The Ives-Stilwell experiment, as it is now called, became therefore besides the MM experiment and KT experiment one of the three fundamental tests of special relativity theory. Its positive result strengthened almost collectively the conviction, that the relativistic description of the Lorentz symmetry is true. Consequently, any anisotropic part or aspect of light is *a priori* denied. That's the second reason, why the second face of c remained hidden until today.

But the assumption of an anisotropic blueprint like the square does *by no means* contradict the Lorentz symmetry. If the effect of time dilation is read within the geometrical context of the MA_0-Blueprint, then the relationship between the vector of the square and the vector of the quarter circle implies a formalism, which is also distinguished by a strict Lorentz symmetry: it leads to the same Gamma factors γ as predicted by special relativity. This prediction is not limited to the discussed case of $v = 0.5$ c, it concerns actually all velocities from the velocity of $v = 0$ to the velocity of $v =$ c, which can already be perceived by pure pattern recognition. (see: Fig. 3)

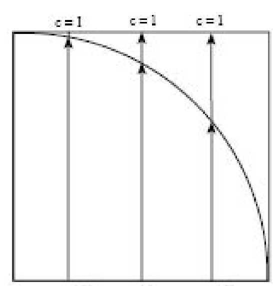

Fig. 7. The Lorentz symmetry of the MA_0-Blueprint (*Magnitude*)

The isotropy of light may still be taken for granted, but it could be a great delusion: If the MA_0-blueprint portrays correctly, how the Lorentz symmetry is codified within our universe, then special relativity is a highly incomplete theory about the universe, because it has omitted a complete blueprint of the universe (i.e. the square).

But at the same time we can understand, why it is so difficult, to expose Einstein's theory as wrong. With respect to KT experiment we even have to admit, that there is no possibility to unmask special relativity as wrong, because both geometrical patterns – the relativistic one as well as the MA_0-Blueprint - are making exactly the same predictions.

However, if the Lorentz symmetry is codified in the here proposed way, then we are confronted with far-reaching changes of our physics. Only one of these changes shall be sketched. The dual parameterization of *c* suggests *that the speed of light c, as well as Lorentz symmetry, is intrinsically of quantum mechanical origin.*

4. Is QED an Artificial Theory?

The easiest approach to this suggestion is the following table. It gives a clue, in what respect the dual parameterization of *c* provided by the MA0-Blueprint suggests a quantum mechanical interpretation.

If we read the two geometrical blueprints of the quarter circle and the square in the presented way*, connecting them with the wave-like and the particle-like aspect of light*, then it is near at hand, to interpret their entangled structure (i.e. the MA_0-Blue-print) as the geometrical expression of the wave-particle-duality. Only the quantum mechanical concept of the wave-particle-duality gives us, physically speaking, this option.

The main message of quantum mechanics was the unexpected discovery that the wave-like picture and the particle-like picture of light did not contradict each other *as asserted by classical physics*. It offered instead the astonishing insight, that light could be both a particle as well as a wave. The physicist Niels Bohr called this idea of wave and particle being two possible facets of light as complementarity. From this point of view it is quite natural to conclude that the fundamental constant of c is in fact given twice – in two different geometrical modes that fit to the quantum mechanical concept of the wave-particle-duality.

If this conclusion is true, then Einstein has perceived the fundamental constant of c quite insufficiently. This would have far-reaching consequences for our understanding of the Lorentz symmetry, which is a fundamental symmetry of modern physics.

In special relativity this symmetry is derived from the geometrical blueprint of the quarter circle only. But if the Lorentz symmetry is codified by the MA_0-Blueprint, then a very restricted and perhaps misleading version of it was incorporated into the body of modern physics.

The quantum mechanics was the first theory made relativistically Lorentz invariant. The result of this incorporation is known as *Quantum Electrodynamics* (QED). It is striking, to state, that the development of this theory was endangered a long time because it appeared that a fundamental incompatibility existed between quantum mechanics and special relativity.

This incompatibility became visible by the appearance of a series of infinities, i.e. an infinite mass of the electron that emerged if the electromagnetic field was quantized. After some struggles the physicists found a way to get rid of these infinities by dividing one infinity by another. But this mathematical procedure now called renormalization was considered as a trick to make QED fit our observations of the universe.

Many physicists are therefore still dissatisfied with this solution. The root of this "feeling" could be the relativistic version of the Lorentz symmetry. As we know it had to be added to quantum mechanics from outside *via special relativity* because it was not yet contained in it at that time. But theorists are in general suspicious if important conditions have to be imposed on a theory instead of being a natural part of it. When Einstein i.e. searched for his unified field theory he hoped that Mach's principle would be contained within his general theory of relativity, but it wasn't. It has to be added explicitly as an extra hypothesis. In the end as the result of this artificial character of Mach's principle Einstein refused it as futile [18].

If the Lorentz symmetry is codified in the proposed dual way and if this codification is - as hypothetically supposed - of quantum mechanical nature, than a new way may open up to establish QED in a physically more satisfactory and natural manner.

This new perspective could be highly important, because *all* relativistic quantum field theories including the Standard Model are modelled by QED. Hence, the most fundamental problem of modern physics – the incompatibility of general relativity and quantum mechanics – could possibly be solved by the proposed new understanding of the Lorentz symmetry.

References

[1] Harry Hamlin Ricker is one of these scientists. He is an electrical engineer, who began an intensive investigation of the special theory of relativity around 1995. He is one of the very rare examples who has investigated the meaning of the KT experiment critically. In a series of 13 papers (Herbert Dingle Was Correct) he investigated the refutation of special relativity by physicist Herbert Dingle. In some of these paper, especially in paper XII, he gives a critical examination of the KT experiment. All papers are documented at http://www.worldsci.org/people/Harry_Ricker.

[2] Helmut Hansen, "About the Dual Parameterization of c", *Proceedings of the NPA* **8**: 186-198 (2010).

[3] J. D. Barrow, "Enigma Variations", *New Scientist*, p 32 (7. Sep 2002).

[4] Caroll Lewis Epstein, **Relativity Visualized** (Insight Press, 1981).

[5] Epstein, ib. pp. 63-67.

[6] John D. Norton, "Einstein's Investigations of Galilean Covariant Electrodynamics prior to 1905", *Archive for History of Exact Sciences.* **59**: 45-105 (2004). In the introduction of this paper he wrote: "Einstein regarded the MM experiment as evidence for the principle of relativity, whereas later writers almost universally use it as support for the light postulate of special relativity."

[7] Richard Feynman, **The Character of Physical Law**, p. 91 (1961).

[8] J. Stachel, "Einstein and Michelson – The Context of Discovery and the Context of Justification", *Astron. Nachr.* **303**: 48 (1982).

[9] Stachel, ib. p. 49

[10] Einstein's 1912 Unpublished Manuscript on the Special Theory of Relativity: A Facsimile, English translation of the manuscript from The Collected Papers of Albert Einstein, Vol. IV, The Swiss Years: Writings 1912 – 1914, Princeton University Press 1995, p. 76 (Manuscript page 18)

[11] H. P. Kennedy, E. M. Thorndike, "Experimental Establishment of the Relativity of Time", *Rev. Mod. Phys.* **42**: 400–418 (1932).

[12] Epstein, ib. pp. 62-64.

[13] David Wittman, "Special relativity: time dilation and length contraction", http://www.youtube.com/user/drdwittman#p/u/5/rek7881OGRY, describes a friendly approach to special relativity.

[14] Epstein; ib. pp. 64-67

{ 15] The other key effect of relativity, that is, the length contrac-tion, can also be derived from the MA0-Blueprint consistently. If we investigate the relationship between the vector of the square and the vector of quarter circle in different directions, then we get the same Gamma factor γ as predicted by special relativity – at least within a specific area of applicability. This area is limited by the velocity of $1/\sqrt{2}$ c (~ 0.707.. c). Beyond this area there are some differences, that might be testable. For the sake of simpli-city this aspect of the Lorentz symmetry was not discussed here. More information; see: Footnote no. 2 of this paper.

[16] The MA0-Blueprint is only part of a more extended geome-trical structure, which looks very much like a Mandala; a struc-ture that is of great simplicity and symmetry. This symmetry and simplicity is the reason why I personally believe that nature follows the MA0-Blueprint. To quote Einstein: This is so simple God could not have passed it up. Further details about the extended structure, see [2].

[17] Domenico Giulini, **Special Relativity**, p. 127, (Oxford University Press, 2005).

[18] A. Einstein. In a letter to Felix Pirani (1954) Einstein declared that one should no longer speak of Mach's principle at all.