Relativity Theory: what is Reality?*

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Abstract

In classical Newtonian physics there was a clear understanding of 'what reality is'. Indeed in this classical view, reality at a certain time is the collection of all what is actual at this time, and this is contained in 'the present'. Often it is stated that three dimensional space and one dimensional time have been substituted by four dimensional space-time in relativity theory, and as a consequence the classical concept of reality, as that what is 'present', cannot be retained. Is reality then the four dimensional manifold of relativity theory? And if so, what is then the meaning of 'change in time'? This problematic confronts a geometric view (as the Einsteinian interpretation of relativity theory) with a process view (where reality changes constantly in time). In this paper we investigate this problem, taking into account our insight in the nature of reality as it came by analyzing the problems of quantum mechanics. We show that with an Einsteinian interpretation of relativity theory, reality is indeed four dimensional, but there is no contradiction with the process view, where this reality changes in time.

1 Introduction

Many textbooks on relativity theory give the impression that the theory is conceptually very well defined, contrary to textbooks on quantum mechanics, where it is usually openly admitted that many aspects of quantum theory are not understood at all. We think that it is actually possible to claim that also relativity theory, although seemingly very clearly put forward by Einstein himself [1, 2], is not understood in many important aspects. More concretely, it is not at all clear 'what reality is' taking into account relativity theory.

In a world imagined to be modeled by classical mechanics there is no problem concerning the question 'what is reality?'. Indeed, in this classical world, reality at a certain instant of time t, is all that exists at this instant of time t. Expressed

*Published as: Aerts, D., 1996, "Relativity theory: what is reality?", *Found. Phys.*, **26**, 1627-1644.

in ordinary language, reality is all that exists 'at present'. It is accepted that the 'past' does not exist anymore (it has been real in the past), while the 'future' does not yet exists (it is a potentiality for possible realities to come). Now that relativity theory is considered to describe the world the concept of 'present' is not an unambiguous concept anymore. In this paper we will analyze this situation in detail and arrive at a rather amazing conclusion.

2 Being and Becoming

Albert Einstein writes on page 2 of his little booklet on relativity theory [2]: "The only justification for our concepts and system of concepts is that they serve to represent the complex of our experiences; beyond this they have no legitimacy. I am convinced that the philosophers have had a harmful effect upon the progress of scientific thinking in removing certain fundamental concepts from the domain of empiricism, where they are under our control, to the intangible heights of the *a priori*. For even if it would appear that the universe of ideas cannot be deduced from experience by logical means, but is, in a sense, a creation of the human mind, without which no science is possible, nevertheless this universe of ideas is just as little independent of the nature of our experiences as clothes are of the form of our human body. This is particularly true of our concepts of time and space, which physicists have been obliged by the facts to bring down from the Olympos of the *a priori* in order to adjust them and put them in a serviceable condition."

I think that Einstein's introduction of special relativity theory and its consequence for our conception of time and space is one of the examples of a deep philosophical reasoning that has changed physics forever in a very concrete and determinate way. We will not repeat here all the subtle steps that make Einstein proceed to introduce the special theory of relativity (they can be found in [1]) but just expose shortly some of the main results.

Suppose that we consider two coordinate systems K_1 and K_2, where K_2 moves with constant velocity v in the direction x_1 of coordinate system K_1. An event α can be coordinated in both coordinate systems, respectively in K_1 by four numbers (x_1, y_1, z_1, t_1) and in K_2 by four numbers (x_2, y_2, z_2, t_2). Then the relation between these two ways of coordinating the same event is given by the Lorentz transformations:

$$x_2 = \frac{x_1 - v \cdot t_1}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{1}$$

$$y_2 = y_1 \tag{2}$$

$$z_2 = z_1 \tag{3}$$

$$t_2 = \frac{t_1 - \frac{v}{c^2} \cdot x_1}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{4}$$

From this it is easy to calculate how the behavior of clocks depend on the velocity. Let us consider two clocks C_1 and C_2 that are permanently situated in the origins of the coordinate systems K_1 and K_2 respectively. Let us consider two events α and β, coordinated in K_2 by $(0,0,0,0)$ and $(0,0,0,1)$. This means that the events α and β mark respectively the beginning and the end of one tick of the clock C_2, and hence a lapse of time of one second in coordinate system K_2. These events will be coordinated in K_1 respectively by $(0,0,0,0)$ and $(0,0,0,1/\sqrt{1-\frac{v^2}{c^2}})$, which shows that the laps of time measured in the coordinate system K_1, where the clock C_2 is not at rest but moving with a velocity v, is not one second, but $1/\sqrt{1-\frac{v^2}{c^2}}$ second, i.e. a somewhat larger time depending on the velocity v. This relativistic effect is the well knows effect of time dilatation: time goes slower in a moving coordinate system. From Einsteins general theory of relativity follows that there is also an effect of gravity on the measuring of time by clocks: a clock in a gravitational field slows down more and more with increasing strength of the field.

Mostly this effect of time dilatation makes it not easy to retain the classical view on reality, were, as we mentioned already, there is a present, which is the collection of all events that happen at the present time, and a past, the collection of all events that have happened, and a future, open for the events that still have to happen. Einstein made a detailed analysis of how the concept of simultaneously happening events depends on the coordinate system where these events are considered (see [1]). This shows that we certainly cannot consider the present as being defined by all the events that happen simultaneously. In the classical worldview reality is in fact considered to be this 'classical present'. The past and the future are not real. Although we know from Einsteins analysis of the concept of simultaneity that we cannot retain the classical view on reality, as being the collection of all simultaneously happening events, there has not been proposed a real relativistic equivalence for reality in a serious way. It is important to remark in this respect that the effect of time dilatation is not interpreted as a physical effect on the functioning of the clocks itself. If this would be the case, if we would interpret the effect of time dilatation as a physical effect on the clocks itself, the classical view can be retained. This is exactly what the Aether theory interpretations of relativity theory propose. Lets not consider this possibility for this moment, we'll come back to it later on, and definitely interpret the time dilatation effect as indicating that a moving reference frame not only moves in space but also moves in time. With this Einsteinian interpretation we want to investigate the question :"What is reality?".

Einstein has presented always his theory as a geometrization of time (in the special theory of relativity) and gravity (in the general theory of relativity). This means that time becomes a fourth geometrical dimension, behaving differently as to the metric involved but existing on the same level as the three geometrical dimensions of space, and the 'real' scenery of reality is then the space-time continuum. There is however a stupendous but immediate result of this interpretation: if the scenery of reality is the four dimensional space-time continuum, then there is no change. Everything, future, present and past, are

fixed once ad for all. This conclusion seems to contradict in a very profound way our daily immediate experience. Often this contradiction is put forward as a contradiction between a process view on reality, where there is a being and a becoming, and a geometrical view, where there is only a being and no becoming. We shall show in this paper that this contradiction is only due to a incorrect view on what reality is. To make this clear we first have to introduce some new concepts, and give, completely along the lines of Einsteins introduction of relativity theory, an operational definition of reality. Once we have done this we shall prove that reality is four dimensional but that at the same time it is changing and that our intuitive process view is also correct and not in contradiction with the geometrical view.

3 Where Has Reality Gone To?

In [3] we have presented a very formal operational analysis of reality, completely in agreement with Einstein's idea that the construction of reality has to be related intrinsically with our experiences. The analysis that we have presented in [3] is inspired by the problem of the nature of reality as it appears in relation with the problems of quantum mechanics (see [4] and [5]). We shall apply in this article the analysis of the construction of reality as presented in [3] to the situation of relativity theory. In a more formal way than we will do here, we have analyzed some aspects of this problem already in [6] and [7].

We first start with an example that we have used already in [8] to see clear in what reality is in quantum mechanics. We consider a 'piece of wood'. We have in mind the property of 'burning well'. A test for this property consists of taking the piece of wood and setting it on fire. If we perform this test on a dry piece of wood, the piece of wood will in general be destroyed by the test. So the property of 'burning well' is a property that the piece of wood has independently of the fact that we make the test or not. Of course it is after having done a number of tests with certain type of pieces of wood and having always discovered the answer to be yes, we decide that this one new piece of wood of this type, whereon we never performed the test, has actually the property of burning well. What is important to remark, and what can clearly be seen in the example that we gave here, is that the connection of 'elements of reality' or 'properties' with the 'experiments to test these properties' is in some sense a subtle one. A property 'is real', or e.g. a specific piece of wood 'has' the property of burning well, now, September 30, 3 pm exactly, if, when we would have decided to test this property, hence if we would have set on fire the piece of wood, the test would have succeeded, the piece of wood would have burned. It is very important for our analysis of reality and relativity theory to understand deeply this subtle 'empirist' analysis of the concept of reality. Let us illustrate it further by some more detailed situation. I would like to consider another property of a piece of wood, namely the property that 'the piece of wood floats on water', and the test in relation with this property consists of putting the piece of wood on water and

seeing whether it floats[1]. We all agree that a specific piece of wood can very well have the two properties 'at once', it 'floats' on water and 'it burns well'. Clearly however it is not possible in general to test both properties at once, or even not one after the other. Indeed if we would first test whether the piece of wood floats on water and afterwards whether it burns well, then this would not be a good test for the two properties. Making float the piece of wood changes to much the state of the piece of wood, such that the test to see whether it burns well becomes irrelevant. The same is true if we first test whether the piece of wood burns well. At first sight we would be inclined to conclude that from an empirist point of view it makes no sense to attribute these two properties at once to a piece of wood. But, and now we come to the essential point that we want to make here, this intuitive conclusion does not take into account the subtle way in which the tests of properties are connected to the state of reality of these properties. Indeed, if we repeat, and say that the piece of wood 'has' (now, September 30, 3 pm exactly) the property of burning well if, when we would have decided to test this property, the test would have come out positive, and the piece of wood 'has'(now, September 30, 3 pm exactly) the property of floating on water if, when we would have decided to test this property, the test would have come out positive, then it is easy to understand that to attribute 'two' properties at once to an entity, it is not at all necessary that we are able to perform the two tests connected to these two properties at once. Indeed, the piece of wood has both properties, burning well and floating on water, if, whenever we would perform one of them, making it burn 'or' making it float, we will get a positive outcome. This is the way that we attribute properties. Before coming to the subject of this paper, relativity theory and reality, because of the subtlety of the foregoing remark, we introduce a more general scheme in which we can analyze carefully this subtle empirist remark.

3.1 Experiences

Remembering Einsteins remark in the introduction we want to present a framework in which 'reality' is empirically reconstructed. The basic concept of our framework is that of an experience. An experience is the interaction between a participator[2] and a piece of the world. When the participator lives such an experience, we will say that this experience is *present*, and we will call it the *present experience* of the participator. When we consider a measurement then we conceive this situation as the experimentator and his experimental apparatus together being the participator, and the physical entity under study to be the piece of the world that interacts with the participator. The experiment is the experience.

Let us give some examples of experiences. We consider the following situation: I am inside my house in Brussels. It is night, the windows are shut. I sit in a chair, reading a novel. I have a basket filled with walnuts at my side, and

[1] There exists some sort of African wood 'wenge' that does not float on water

[2] We consciously use here the word 'participator' instead of the word 'observer' to indicate that we consider the cognitive receiver to participate creatively in his cognitive act.

from time to time I take one of them, crack it and eat it. My son is in bed and already asleep. New York exists and is busy.

Let us enumerate the experiences that are considered in such a situation:
(1) E_1(I read a novel)
(2) E_2(I experience the inside of my house in Brussels)
(3) E_3(I experience that it is night)
(4) E_4(I take a walnut, crack it and eat it)
(5) E_5(I see that my son is in bed and asleep)
(6) E_6(I experience that New York is busy)

The first important remark, referring again to the example of the piece of wood of the foregoing section, is that obviously I do not experience all these experiences at once. On the contrary, in principle, I only experience one experience at once, namely my present experience. Let us suppose that my present experience is E_1(I read a novel). Then a lot of other things happen while I am living this present experience. These things happen in my present reality. While 'I am reading the novel' some of the happenings that happen are the following: H_1(the novel exists), H_2(the inside of my house in Brussels exists), H_3(it is night), H_4(the basket and the walnuts exist, and are at my side), H_5(my son is in bed and is sleeping), H_6(New York exists and is busy). All the happenings, and much more, happen while I live the present experience E_1(I read a novel).

Certainly it is not because I experience also these other happenings. My only *present* experience is the experience of reading the novel. But, and this is the reason for this type of construction, I could have chosen to live an experience including one of the other happenings *in replacement* of my present experience. Let me put down the list of these experiences that I could have chosen to experience in replacement of my present experience: E_2(I observe that I am inside my house in Brussels), E_3(I see that it is night), E_4(I take a walnut, crack it and eat it), E_5(I go and look in the bedroom to see that my son is asleep), E_6(I go to New York and see that it is busy).

This example indicates how we have started to construct reality. First of all we have tried to identify two main aspects of an experience. The aspect that is controlled and created by me, and the aspect that just happens to me and can only be known by me. Let us introduce this important distinction in a formal way.

3.2 Creations and Happenings

To see what I mean, let us consider the experience E_4(I take a walnut, crack it and eat it). In this experience, there is an aspect that is an action of me, the taking and the cracking, and the eating. There is also an aspect that is an observation of me, the walnut and the basket. By studying how our senses work, I can indeed say that it is the light reflected on the walnut, and on the basket, that gives me the experience of walnut and the experience of basket. This is an explanation that only now can be given; it is, however, not what was known in earlier days when the first world-models of humanity were constructed. But without knowing the explanation delivered now by a detailed analysis, we could

see very easily that an experience contains always two aspects, a *creation*-aspect, and an *observation*-aspect, simply because our will can only control part of the experience. This is the creation-aspect.

For example, in E_1(I read a novel) the reading is created by me, but the novel is not created by me. In general we can indicate for an experience the aspect that is created by me and the aspect that is not created by me. The aspect not created by me lends itself to my creation. We can reformulate an experience in the following way: E_4(I take a walnut, crack it and eat it) becomes E_4(The walnut is taken by me, and lends itself to my cracking and eating) and E_1(I read a novel) becomes E_1(The novel lends itself to my reading).

The taking, cracking, eating, and reading will be called *creations* or actions and will be denoted by C_4(I take, crack and eat) and C_1(I read). The walnut and the novel will be called *happenings* and will be denoted by H_4(The walnut) and H_7(The novel).

A creation is that aspect of an experience created, controlled, and acted upon by me, and a happening is that aspect of an experience lending itself to my creation, control and action.

An experience is determined by the creation and the happening. Creations are often expressed by verbs: to take, to crack, to eat, and to read, are the verbs that describe my creations in the examples. The walnut and the novel are happenings that have the additional property of being objects, which means happening with a great stability. Often happenings are expressed by a substantive.

Every one of my experiences E consists of one of my creations C and one of my happenings H, so we can write $E = (C, H)$.

3.3 The Empirical Reconstruction of Reality, Present, Past and Future

Let us again consider the collection of experiences: E_1(I read a novel), E_2(I observe that I am inside my house in Brussels), E_3(I see that it is night), E_4(I take a walnut, crack it and eat it), E_5(I go and look in the bedroom to see that my son is asleep) and E_6(I go to New York and see that it is busy). Let us now represent the 'reconstruction of reality' that is made out of this small collection of experiences.

E_1(I read a novel) is my present experience. In my past I could, however, at several moments have chosen to do something else and this choice would have led me to have another present experience than E_1(I read a novel). For example:

One minute ago I could have decided to stop reading and observe that I am inside the house. Then E_2(I observe that I am inside my house in Brussels) would have been my present experience.

Two minutes ago I could have decided to stop reading and open the windows and see that it is night. Then E_3(I see that it is night) would have been my present experience.

Three minutes ago I could have decided to stop reading, take a walnut from the basket, crack it, and eat it. Then E_4(I take a walnut, crack it and eat it) would have been my present experience.

Ten minutes ago I could have decided to go and see in the bedroom whether my son is asleep. Then E_5(I go and look in the bedroom to see that my son is asleep) would have been my present experience.

Ten hours ago I could have decided to take the plane and fly to New York and see how busy it was. then E_6(I go to New York and see that it is busy) would have been my present experience.

Even when they are not the happening aspect of my present experience, happenings 'happen' at present if they are the happening aspect of an experience that I could have lived in replacement of my present experience, if I would have decided so in my past.

The fact that a certain experience E consisting of a creation C and an happening H is for me a possible present experience depends on two factors:

(1) I have to be able to perform the creation.

(2) The happening has to be available.

For example, the experience E_2(I observe that I am inside my house in Brussels) is a possible experience for me, if:

(1) I can perform the creation that consists in observing the inside of my house in Brussels. In other words, if this creation is in my personal power.

(2) The happening 'the inside of my house in Brussels' has to be available to me. In other words, this happening has to be contained in my personal reality.

The collection of all creations that I can perform at the present I will call my present personal power.

The collection of all happenings that are available to me at the present I will call my present personal reality.

I define as my present personal reality the collection of these happenings, the collection of happenings that are available to one of my creations if I would have used my personal power in such a way that at the present I fuse one of these creations with one of these happenings.

My present personal reality consists of all happenings that are available to me at present. My past reality consists of all happenings that were available to me in the past. My future reality consists of all happenings that shall be available to me in the future.

My present personal power consists of all creations that I can perform at present. My past personal power consists of all the creations that I could perform in the

past. My future personal power consists of all creations I shall be able to perform in the future.

Happenings can happen at once, because to happen, a happening does not have to be part of my present experience. It is sufficient that it is available, and things can be available at once. Therefore, although my present experience is only one, my present personal reality consists of an enormous amount of happenings all happening at once.

4 The Reconstruction of Reality and Relativity Theory

We will concentrate now on the question 'what is reality in relativity theory?'. Since we have an operational definition of reality in our framework, we can investigate this problem in a rigorous way.

Let us suppose that I am here and now in my house in Brussels, and it is September 21, 1996, 3 pm exactly. I want to find out 'what is reality for me now?'. Let us use the definition of reality given in the foregoing section and consider a place in New York, for example at the entrance of the Empire state building, and let us denote, the center of this place by (x_1, y_1, z_1). I also choose now a certain time, for example September 21, 1996, 3 pm exactly, and let me denote this time by t_1. I denote the happening that corresponds with the spot (x_1, y_1, z_1) located at the entrance of the Empire State building, at time t_1 by m. I can now try to investigate whether this happening m is part of my personal reality. The question I have to answer is, can I find a creation of localization l, in this case this creation is just the observation of the spot (x_1, y_1, z_1) at the entrance of the Empire State building, at time t_1, that can be fused with this happening m. The answer to this question can only be investigated if we take into account the fact that I, who want to try to fuse a creation of localization to this happening, am bound to my body, which is also a material entity. I must specify the question introducing the time coordinate that I coordinate by my watch. So suppose that I coordinate my body by the four numbers (x_2, y_2, z_2, t_2), where t_2 is my time, and (y_1, y_2, y_3) is the center of mass of my body. We apply now our operational definition of reality. A this moment, September 21, 1996 at 3 pm exactly, my body is in my house in Brussels, which means that (t_2, x_2, y_2, z_2) is a point such that t_2 equals September 21, 1996, 3 pm, and (x_1, y_1, z_1) is a point, the center of mass of my body, somewhere in my house in Brussels. This shows that (x_1, y_1, z_1, t_1) is different from (x_2, y_2, z_2, t_2), in the sense that (x_1, y_1, z_1) is different form (x_2, y_2, z_2) while $t_1 = t_2$.

The question is now whether (t_1, x_1, y_1, z_1) is a point of my reality, hence whether it makes sense to me to claim that now, September 21, 1996, 3 pm, the entrance of the Empire State building 'exists'. If our theoretical framework corresponds in some way to our pre-scientific construction of reality, the answer to the foregoing question should be affirmative. Indeed, we all believe that 'now' the entrance of the Empire State building exists. Let us try to investigate in

a rigorous way this question in our framework. We have to verify whether it was possible for me to decide somewhere in my past, hence before September 21, 1996, 3 pm, to change some of my plans of action, such that I would decide to travel to New York, and arrive exactly at September 21, 1996, 3 pm at the entrance of the Empire State building, and observe the spot (x_1, y_1, z_1). We could give many concrete ways to realize this experiment, and we will not give here one in detail, because we shall come back to the tricky parts of the realization of this experiment in the following example. But hence the answer is indeed affirmative: I could have experienced the spot (x_1, y_1, z_1) at September 21, 1996, 3 pm, if I would have decided to travel to New York somewhere in my past. Hence (t_1, x_1, x_2, x_3) is part of my reality. It is sound to claim that the entrance of the Empire State building exists right now. And we remark that this does not mean that I have to be able to experience this spot at the entrance of the Empire State building now, September 21, 1996, 3 pm, while I am inside my house of Brussels. I repeat again, reality is a construction about the possible happenings that I could have fused with my actual creation. And since I could have decided so in my past, I could have been at the entrance of the Empire State building, now, September 21, 1996, 3 pm.

Until this moment one could think that our framework only will confirm our intuitive notion of reality but our next example shows that this is certainly not the case. Indeed, let me consider the same problem, but now consider another point of space-time. I consider the point (x_3, y_3, z_3, t_3), where $(x_3, y_3, z_3) = (x_1, y_1, z_1)$, hence the spot we envisage is again the entrance of the Empire State building, and t_3 is September 22, 1996, 3 pm exactly, hence the time that we consider is, tomorrow 3 pm. If I ask now first, before checking rigorously by means of our operational definition of reality, whether this point (x_3, y_3, z_3, t_3) is part of my present reality, the intuitive answer here would be 'no'. Indeed, tomorrow at the same time, 3 pm, is in the future and not in the present, and hence it is not real, and hence no part of my present reality (this is the intuitive reasoning). If we go now to the formal reasoning in our framework, then we can see that the answer to this question depends on the interpretation of relativity theory that we put forward. Indeed, let us first analyze the question in a Newtonian conception of the world to make things clear. Remark that in a Newtonian conception of the world (which has been proved experimentally wrong, so here we are just considering it for the sake of clarity), my present reality just falls together with 'the present', namely all the points of space that have the same time coordinate September 21, 1996, 3 pm. This means that the entrance of the Empire State building tomorrow 'is not part of my present reality'. The answer is clear here and in this Newtonian conception, my present personal reality is just the collection of all (x, y, z, t) where $t = t_2$ and (x, y, z) are arbitrary. The world is not Newtonian, this we know meanwhile experimentally, but also if we put forward an Aether theory interpretation of relativity theory (let us refer to such an interpretation as a Lorentz interpretation) the answer remains the same. In a Lorentz interpretation, my present personal reality coincides with the present reality of the Aether, namely all arbitrary points of the Aether that are at time y_0, September 21, 1996 3 pm, and again tomorrow

the entrance of the Empire State building is not part of my present reality.

For an Einsteinian interpretation of relativity theory the answer is different. To investigate this I have to ask again the question of whether it would have been possible for me to decide in my past such that I would have been able to make coincide (x_2, y_2, z_2, t_2) with (x_3, y_3, z_3, t_3). The answer here is that this is very easy to do, because of the well known, and experimentally verified, effect of 'time dilatation'. Indeed, it would for example be sufficient that I go back some weeks in my past, let us say the beginning of September 1996 and then decide to step inside a space ship that can move with almost the velocity of the speed of light, such that the time when I am inside this space ship slows down in such a way, that when I return with the space ship to planet earth, still flying with a speed near the velocity of light, I arrive in New York at the entrance of the Empire State building while my personal watch indicates September 21, 1996 3 pm, and the watch that remained at the entrance of the Empire State building indicates September 22, 1996 3 pm. Hence in this way I make coincide (x_2, y_2, z_2, t_2) with (x_3, y_3, z_3, t_3), which proves that (x_3, y_3, z_3, t_3) is part of my present reality. First I have to remark that in practice it is not yet possible to make such a flight with a space ship. But this is not a crucial point for our reasoning. It is sufficient that we can do it in principle[3].

4.1 Einstein versus Lorentz: Has Reality Four Dimensions?

We can come now to one of the points that we want to make in this paper, and that clarifies the paradox of time that makes the difference between an Aether interpretation of relativity (Lorentz) and an Einsteinian interpretation of relativity. Why would we come to a different result concerning the foregoing question, depending on whether we advocate an Einsteinian interpretation of relativity theory or an Aether interpretation. To see clear in this we have to come back to the essential aspect of the reconstruction of reality of our framework, which is the difference between a creation and a happening. We have to give first another example to be able to make clear what we mean.

Suppose that I am a painter and I consider again my present reality, at September 21, 1996, 3 pm, as indicated on my personal watch. I am in my house in Brussels and let us specify: the room where I am is my workshop, surrounded by paintings, of which some are finished and others I am still working on. Clearly all these paintings exist in my presents reality, September 21, 1996, 3 pm. Some weeks ago, when I was still working on a painting that now is

[3]We have not yet made this explicit remark, but obviously if we have introduced in our framework an operational definition for reality, then we do not have to interpret such an operational definition in the sense that only operations are allowed that actually, taking into account the present technical possibilities of humanity, can be performed. If we would advocate such a narrow interpretation, then even in a Newtonian conception of the world, the star Sirius would not exist, because we cannot yet travel to it. What we mean with operational is much wider. It must be possible, taking into account the actual physical knowledge of the world, to conceive of a creation that can be fused with the happening in question, and then this happening pertains to our personal reality

finished, I could certainly have decided to start to work on another painting, a completely different one, that now does not exist. Even if I could have decided this some weeks ago, all of you will agree that this other painting, that I never started to work on, does not exist now, September 21, 1996, 3 pm. The reason for this conclusion is that the making of a painting is a 'creation' and not a happening. It is not so that there is some 'hidden' space of possible paintings such that my choice of some weeks ago to realize this other painting would have made me to detect it. If this would be the situation with paintings, then indeed also this painting would exist now, in this hidden space. But with paintings this is not the case. Paintings that are not realized by the painter are potential paintings, but they do not exist.

With this example of the paintings we can explain very well the difference between Lorentz and Einstein. For an Aether interpretation of relativity the fact that my watch is slowing down while I decide to fly with the space ship nearly at the speed of light and return at the entrance of the Empire State building while my watch is indicating September 21, 1996, 3 pm and the watch that remained at the Empire State building indicates September 22, 1996, 3 pm, is interpreted as a 'creation'. It is seen as if there is a real physical effect of creation on the material functioning of my watch while I travel with the space ship, and this effect of creation is generated by the movement of the space ship through the Aether. Hence the fact that I could observe the entrance of the Empire State building tomorrow September 22, 1996 3 pm, when I would have decided some weeks ago to start traveling with the space ship, only proves that the entrance of the Empire State building tomorrow is a potentiality. Just like the fact that this painting that I never started to paint could have been here in my workshop in Brussels is a potentiality. This means that as a consequence the spot at the entrance of the Empire State building tomorrow is not part of my present reality, just as the possible painting that I did not start to paint is not part of my present reality. If we however put forward an Einsteinian interpretation of relativity, then the effect on my watch during the space ship travel is interpreted in a completely different way. There is no physical effect on the material functioning of the watch[4], but the flight at the velocity nearly the speed of light 'moves' my space ship in the space-time continuum such that time coordinates and space coordinates get mixed. This means that the effect of the space ship travel is an effect of a voyage through the space-time continuum, which brings me at my personal time of September 21, 1996, 3 pm at the entrance of the Empire State building, where the time is September 22, 1996, 3 pm. And hence the entrance of the Empire State building is a happening, an actuality and not just a potentiality, and it can be fused with my present creation. This means that the happening (x_3, y_3, z_3, t_3) of September 22, 1996, 3 pm, entrance of the Empire State building, is an happening that can be fused with my creation of observation of the spot around me at September 21, 1996, 3 pm. Hence it is part of my present reality. The entrance of the Empire State

[4]Certainly if we take into account that most of the time dilatation takes place not during the accelerations that the space ship undergoes during the trip, but during the long periods of flight with constant velocity nearly at the speed of light

building at September 22, 1996, 3 pm exists for me today, September 21, 1996 3 pm.

If we advocate an Einsteinian interpretation of relativity theory we have to conclude from the foregoing section that reality is four dimensional. This conclusion will perhaps not amaze those who always have considered the space-time continuum of relativity representing the new reality. Now that we have however defined very clearly what is the meaning of this, we can start investigating the seemingly paradoxical conclusions that often are brought forward in relation with this insight.

4.2 The Process View Confronted with the Geometric View

The paradoxical situation that we can try to solve now is the confrontation of the process view of reality with the geometric view. Often it is claimed that an interpretation where reality is considered to be related to the four dimensional space-time continuum contradicts another view of reality, namely the one where it is considered to be of a process like nature. By means of our framework we can now understand exactly these two views and see that there is no contradiction. Let us repeat now what is the meaning in our framework of the conclusion that reality is four dimensional. It means that, at a certain specific moment, that I call my 'present', the collection of places that exist, and that I could have observed when I would have decided to do so in my past, has a four dimensional structure, well represented mathematically by the four dimensional space-time continuum. This is indeed my present reality. This does not imply however that this reality is not constantly changing. Indeed it is constantly changing. New entities are created in it and other entities disappear, while others are very stable and remain into existence. This is as much the case in all of the four dimensions of this reality. Again I have to give an example to explain what I mean. We came to the conclusion that now, at September 21, 1996, 3 pm the entrance of the Empire State building exists for me while I am in my house in Brussels. Then this is not a statement of derterministic certainty. Indeed, it is very well possible that by some extraordinary chain of events, without me knowing about these events, the Empire State building had been destroyed, such that my statement about the existence of the entrance of the Empire State building 'now', although almost certainly true, is not deterministically certain. The reason is again the same, namely that reality is what I would have been able to experience, if I would have decided differently in my past. The knowledge that I have about this reality is complex and depends on the changes that go on continuously in it. What I know from experience is that there do exist material objects, and the Empire State building is one of them, that are rather stable, which means that they are into existence without changing to much. To these stable objects, material objects but also energetic fields, I can attach the places where I could observe them. The set of these places has the structure of a four dimensional continuum. At the same time all these objects are continuously changing and moving in this four dimensional scenery. Most of the objects

that I used to shape my intuitive model of reality are the material objects that surround us here on the surface of the earth. They are all very fixed in the fourth dimension (the dimension indicated by the t variable, and we should not call it the time dimension) while they move easily in the other three dimensions (those indicated by the x, y, and z variables). Other objects, for example the electromagnetic fields, have a completely different way of being and changing in this four dimensional scenery. This means that in our framework there is no contradiction between the four dimensionality of the set of places and the process like nature of the world. If we came to the conclusion that the entrance of the Empire State building, tomorrow, September 22, 1996, 3 pm exists also for me now, then our intuition reacts more strongly to this statement, because intuitively we think that this would mean that the future exists also and hence is determined and hence no change is possible. This is a wrong conclusion which comes from the fact that during a long period of time we have had an intuitive image of a Newtonian present, that would be determined completely. We have to be aware of the fact that it is the present, even in the newtonian sense, which is not determined at all. We can only say that the more stable entities in my present reality are more determined to be there, while the places where they can be, because these places are stable with certainty, are always there.

4.3 The Singularity of the Reality Reconstruction

We want to come back to the reconstruction of reality in our framework that we have confronted here with the Einsteinian interpretation of relativity theory. Instead of wondering about the existence of the entrance of the Empire State building tomorrow, September 22, 1996, 3 pm, I can also question the existence of my own house at the same place of the space-time continuum. Clearly I can make an analogous reason and come then to the conclusion that my own house, and the chair where I am sitting while reading the novel, and the novel itself, and the basket of wall nuts beside me, etc..., all exist in my present reality at September 22, 1996 3 pm, hence tomorrow. If we put it like that, we get confronted even more with a counter-intuitive aspect of the Einsteinian interpretation of relativity theory. But it is a correct statement in our framework. We have to add however that all these objects that are very close to me now September 21, 1996, 3 pm, they indeed also exist in my present reality at September 22, 1996, 3 pm, but the place in reality where I could have observed them is of course much further away for me. Indeed, to be able to get there, I have to fly away with a space ship at nearly the velocity of light. We now come to a very peculiar question that will confront us with the singularity of our reality construction. Where do I myself exist? Do I also exist tomorrow September 22, 1996, 3 pm? If the answer to this question would be affirmative, we would be confronted with a very paradoxical situation. Because indeed, I myself, and this counts for all of you also, cannot imagine me to exist at different places of time. But indeed our framework clarifies this question very easily. It is impossible for me to make some action in my past such that I would be able to observe myself tomorrow September 22, 1996 3 pm. Indeed, if I would have chosen to fly away and come

back with the space ship such that I observe now, September 21, 1996, 3 pm on my personal watch, the inside of my house tomorrow September 22, 1996, 3 pm, then I can do this, and as we remarked already, it proves that this inside of my house tomorrow is part of my present personal reality. But I will not find myself in it. Because to be able to observe my house tomorrow September 22, 1996 3 pm, I have had to move out of it. Hence, in this situation I will enter my house, for myself being still at September 21, 1996, 3 pm, but my house and all things in it, being at September 22, 1996, 3 pm. This shows that there is no paradox.

5 Introducing an Additional Time Parameter?

There is an approach to relativity theory that could be interpreted conceptually as we put forward in this paper. It has been developed by Stueckelberg, Horwitz and Piron [9, 10, 11, 12, 13, 14, 15]. One introduces explicitly a parameter τ that would correspond to the time of the processes and changes going on in reality. The variable t is interpreted as being a geometrical variable. In this mathematical model, recently technically more and more developed by Horwitz and his collaborators [14, 15], it would be very interesting to see how the conceptual framework that we put forward here, with a very definite interpretation of 'what reality is' could be elaborated. It is one of the aims of the author to work on such a conceptual elaboration in the near future.

6 Acknowledgments

This work was supported by the Federale Diensten voor Wetenschappelijke, Technische en Culturele Aangelegenheden; IUAP-III n∘9. The author is a Senior Research Associate of the Fund for Scientific Research.

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