TIME AND SPACE IN SPECIAL RELATIVITY

A critique of the realist interpretation

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Preface and acknowledgements

Some five or six years ago I opened Einstein's *Relativity, the Special and General Theory*, for the first time. For the life of me I was unable to understand what is meant by "time" and "space" in this groundbreaking work and a strong feeling of inadequacy temporarily toppled my enthusiasm. It was therefore with the greatest relief I read Johan Arnt Myrstad and Thor Sandmel's *Einstein, Kant og fysikkens metafysiske basis*,[1] where Myrstad/Sandmel describe the exact emotion I experienced in trying to understand Relativity theory:

When he (the reader of popular presentations of SRT) has studied thoroughly for some time and still finds himself unable to deceive himself into the belief that he has understood it, he eventually gives up convinced that there is something wrong with him, not the theory.[2]
(Myrstad/Sandmel: p.14).

The work of Myrstad/Sandmel has been a great inspiration for me more as a guide into the topic of philosophical evaluation of Relativity than as a final answer. This is simply because elements of their work are beyond my current scientific knowledge, a fact that I hope to change as soon as possible. However, for one that has an interest in Relativity, but can come to no understanding of it, there is great inspiration in seeing well-renowned scholars dedicated to what the majority deems a dead topic. The confidence derived from such inspiration has led to this thesis.

I would like to thank Johan Arnt Myrstad for his patience and guidance, and the will to make things as easy as possible for a student who has rarely been in the same country as him. Through countless emails he has made a study in philosophy possible and enjoyable. I would also like to thank Viggo Rossvær for his humanity and openness in dealing with me as a student.

I would further like to thank my biological and extended family, especially my brother and Ivar Erling, for the emotional and academic support you have given. For the value of this, there are no words.

Finally I would like to give the greatest thanks to my wife Elena for the love, support, guidance

[1] In English translation: "Einstein, Kant and the metaphysical basis of physics".
[2] Loosely translated from Norwegian.

and patience that is needed when living with someone who finds waking up at two in the morning to "just read some Kant" within the frame of normal behavior. Thank you for accepting and promoting the weirdness that is our life.

Fredrik Andersen.

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Abbreviations of frequently cited sources

Critique:	*Critique of pure Reason*	(Kant)
Apologia:	*Apologia pro Tychone contra Ursum*	(Kepler)
Relativity:	*Relativity, the Special and General Theory*	(Einstein)

1.0. Introduction

We must accept that time is not completely separate from and independent of space, but is combined with it to form an object called space-time. (Hawking: 26)

In the 20th century two physical theories arose that would change the basic ideas of physics: The theory of relativity and quantum physics. The most remarkable common feature of these theories is that they both stem from the pen of Albert Einstein. When Max Planck introduced quanta of energy (the idea that energy travels in "packs" rather than as continuous streams), it was intended as a mathematical principle.[3] Einstein adopted a realist view of this principle and claimed that not only can we treat energy as travelling in quanta mathematically, but we must also see energy as something that really does behave in this way! When faced with the theory of relativity and the application of the Lorentz transformations, Einstein adopts the same view. Not only do the Lorentz transformations show us that time and space can be treated mathematically as if they are changing, but they must be seen as really changing.

The idea of relative time and space brings problems for Kantian philosophers who view time and space as pure intuitions. Therefore the idea has arisen that Kantian metaphysics is somehow obsolete. In the beginning of the 21st century we see a slight dint in the absolute authority of relativity and ironically the problems stem from Einstein's other brainchild quantum physics. Examples of this are the *Scientific American* articles "A quantum threat to special relativity" (*Scientific American1*) and "Splitting time from space – New quantum theory topples Einstein's space-time" (*Scientific American2*). We shall not discuss the internal difficulties in the attempted joining together of relativity and quantum physics in this thesis, but we shall recognize that there are such difficulties and that they do not unequivocally speak in favour of relativity theory.

We shall see that the theory of relativity, in the form of special relativity, is a theory of a particular kind as it is not purely a physical theory. Time and space cannot, as we shall see, be treated as the common everyday or scientific object, in the way Hawking describes, without

[3] In order to mathematically discuss the problem of black body radiation, Planck proposed a formal change in the treatment of energy transfer where there are upper and lower limits for transfer (Planck's constant). This was intended as a calculation-device where energy is transferred in packs and not in the continuous stream as usually understood. Einstein understood Planck's constant as a real explanation of the phenomena, i.e. that energy is really transferred in distinct quanta, an understanding that is seen as the birth of quantum physics.

untangling some of the classical problems of metaphysics and philosophy of science in general. Our situation is therefore one in which the philosophical speculations around scientific theory is needed. In order to reveal the inherent difficulties of the metaphysical aspects of physical theories, I have chosen to glance back in time to the philosophical claims of one of the greatest thinkers of the scientific revolution, Johannes Kepler.

Traditionally we see the scientific revolution as a movement from the Aristotelian principles of science to those of Galileo and Newton (Hawking hardly mentions Kepler in his bestselling *A brief history of time*) as following from the Copernican revolution of the heliocentric world system. Fairly recent studies of Kepler's work, however, have shown that not only was Kepler a brilliant astronomer, but he also had much of value to say about the underlying philosophical principles of science. I have chosen Kepler as a proponent for a sound philosophy of science for a number of reasons, but the main utility of Kepler's studies in astronomy for the purpose of this thesis is the similarity of his situation to ours. Kepler is faced with mathematically equivalent portrayals of the world system having completely different underlying physical assumptions. The systems were equally observationally defendable and there was apparently no way of preferring one over the other. Kepler therefore sought the probable causes of the apparent movements of the planets and ended up with the description of the world system, as we know it today through his famous three laws.

What is missing in Kepler is a foundation for his metaphysical assumptions that the world must behave according to simple rules that are universally valid. Such a justification can be found in Kantian metaphysics and we shall present Kant's metaphysical arguments for the simplicity and predictability of the external world accordingly. Through the first part of this thesis we shall see that Kant and Kepler laid a foundation for scientific realism. We can thereby evaluate the theory of relativity on the ground laid in the first part. The theory of relativity will, for the most part, be evaluated on the basis of Einstein's explanatory work *Relativity, the special and general theory*, with an exclusive focus on the special theory (hereafter noted as "SRT").

SRT can be seen as two different theories according to which way one chooses to interpret the results. There is in other words an ambiguity included when simply dealing with SRT as a closed theoretical framework. We shall resolve this ambiguity by noting the two main interpretations as the principle and the realist interpretation. Common to the two interpretations is the mathematical and observational results of SRT. The understanding of these results is not so. The realist interpretation (which is the standard interpretation within contemporary physics) interprets time and space as really changing objects that depend on each other as in the Hawking-quote previously given. The principle interpretation views time and space as absolute in the sense of non-changeable and therefore sees the measuring results of SRT as dependent on the behaviour of matter rather than time and space. The principle interpretation will be defended in this thesis on the grounds laid by Kepler and Kant, while the realist interpretation will be shown as lacking in rational justification. The immodest claim of this thesis is therefore that the bulk of contemporary physicists are working with a misguided theory of time and space, and that there is now, as always, a need for philosophy within science.

1.1. Limitations

In dealing with the principle interpretation of SRT one is forced to confront the principle of an ether. In this thesis, however, I have chosen to focus on rejecting the realist interpretation and therefore I have been left with neither time nor space to treat the possible explanations of a principle interpretation sufficiently. What I have chosen to do is to simply join arms with Henri Poincaré and treat the ether as dynamical and unobservable. In this way I have been able to leave the vast area of ether theory out of my discussions at the cost of a positive result. Now, there are other possibilities of understanding ether theory and one can assume that the Kantian understanding of ether as a metaphysical principle in a form somewhat similar to time and space is one that needs thorough investigation. But for now I have chosen to neglect these possibilities, showing that independent of the possible observation or non-observation of ether, there is still justification for a "prior rest system" on which the principle interpretation rests. The question of how one is to explain the surprising results of the Lorentz transformations is therefore left untreated in this thesis, apart from the claim that it must be explained from a principle interpretation of the theory where time and space are not relative.

2.0. What a Scientific Theory Is

In order to properly discuss the philosophical and scientific implications of the Special Theory of Relativity, we need first to take a general look into what a scientific theory is as well as some points connecting natural science and philosophy. As a founder of modern scientific thinking, and also a key writer on the philosophy of science, the German astronomer Johannes Kepler seems to be a natural starting point. In his *Apologia pro Tychone contra Ursum*, Kepler chooses not only to defend Tycho Brahe's claim to originality (which had been disputed by Ursus) but also, more importantly, to defend the status of astronomical hypotheses in general. This defense has proved to be an indispensable insight into the nature of scientific discovery as well as a basis of arguments for modern scientific realism. The *Apologia* is written as a counterargument against the skeptic Ursus, who claims that astronomical hypotheses cannot yield any certainty in respect to the nature of celestial motion, but must rather be seen as intrinsically untrue statements though they can be used as basis for forming methods of calculation of celestial positions of stars and planets. Kepler's defense against this skeptical claim is a description of the true nature of hypotheses and thereby a new conception of what scientific theory must be. We will discuss some key elements of this book in order to build a conception of what scientific theory is, and must be.[4]

Altogether there are three things in astronomy: geometrical hypotheses; astronomical hypotheses; and the apparent motions of the stars themselves. (Apologia: 154)

The astronomical hypotheses are hypotheses on physical and metaphysical grounds portraying the world-system. The geometrical hypotheses are the mathematical formalisms constructed to order the observations in accordance with the astronomical hypotheses. If an astronomical theory contains all these areas in a coherent way, the theory is deemed sound. It is vital to notice here that all three areas are necessary; standing alone they are insufficient. The common notion that a physical theory can never be proved but only verified, borrows support from this insight. Proof in its absolute sense is given exclusively in mathematics. The fact that a given formula corresponds to observational data does not prove anything outside what is stated (that the mathematics is fitting the observational data as a formal representation), while the highest goal of science

[4] In the *Apologia* Kepler argues about the nature of astronomical hypotheses specifically. Following Hanson, Maxwell, Kleiner and others I will take this argument as relevant for natural science in general.

according to the popular notion and Kepler is to provide explanations of the observational data. This presumes more than mathematics and observation. First of all the observations themselves need theoretical justification. We observe the world around us from a certain perspective and there is no justification to the statement that "the world is exactly as it appears to us". On the contrary! There is overwhelming evidence that the objective picture of the world is in some sense shaped by us in observation:

For where, walking through the fields, he encounters hedges and things near to his path, he would believe, on the testimony of the sense of sight, that distant mountains are really following him. (Apologia*:* 155)

As the mountains appear to follow us, but we understand that they obviously cannot perform such an action we must justify our observations through theoretical explanation. We must also be aware that the reasons we have for judging our observations as sometimes obviously false, is a commitment to, and acceptance of, some basic claims of coherence in the physical world. The mountain cannot follow me because if the mountain follows everyone it will have to move in several directions at the same time, while still maintaining its shape. This contradicts our most basic understanding of matter and space and we thereby see the need of a theoretical investigation.

All in all the three aspects of scientific theory are means to achieve the end of science: the understanding of how our universe works. "Understanding" is itself a difficult concept and I see the need here to discuss it briefly. In order to say that something is understood it is requested that we are able to provide an explanation for it. The main task at hand for science is therefore to provide explanations. In general we can say that an explanation is the ordering of something that at first appears to be disordered. It is to reveal harmony through structure. In everyday life we seek explanations mainly when things are not "as they should". (In the current economical crisis we even *demand* such explanations.) Science, on the other hand, is the pursuit of explanations also when things "are as they should". In general we seem to expect of an explanation that it should render the phenomena understandable by subsuming the specific under the general. In the natural sciences this means subsuming the objects that are part of the phenomena, under a general genus that is portrayed as behaving in a certain way according to a natural law.

The natural law itself is not explained but rather accepted as being "just the way things are". This process of explanation is made possible by, among other things, the reference to causality and causal chains. A phenomena *P* is explained by the reference to genus *G*, where all things *G* show behavior *B* under conditions *C* according to natural law *L*. For example: *The glass falls to the ground when I drop it because glass and ground fall under the genus "material things", and material things attract each other as long as they are not impeded, according to the Law of Gravity*. From this formula of explanations we get references to forces in nature or general tendencies as theoretical explanations of observed phenomena. The difference between these two types of explanation is the possibility or reality of reference to causal chains. A tendency-explanation, as "any given closed system tends toward chaos", leaves the causal explanation open. We do not know why there are such tendencies but they seem resistant to objection and the goal of further insight is to relate them to other general tendencies and a causal explanation. Tendency-laws are not seen as complete explanations, but are nevertheless accepted as temporary end-of-the-line explanations.

A reference to forces is, on the other hand, seen as a complete explanation. Our gravity-example shows a typical scientific explanation. The difference between this and the tendency-explanation is that in the former the chain of causality is explicit. *Matter M and matter M1 act on each other through force F and the resulting phenomena is approach*. If we start asking "why *F*?" and bring the demands to explanation further, we simply have no answers apart from "that's just the way it is" or "that's how things have to be". The chain of questions ends in the limit of possible observation, when related to forces, while there still exist the possibility of further "whys" in a tendency-explanation. When related to one of these forms of end-of-the-line explanations we judge the phenomena as explained and understood. This is of course a very general portrayal, but it shows how we accept something as understood and explained by referring it to a major system of explanations and thereby revealing order where earlier we could not see it. The process of revealing such an order through a rationally justified method is what we call "Science". In other words, *science is the pursuit of explanation of our apparent surroundings, expressed in logical argument and mathematical formalisms.* This pursuit of explanations is corrected through a set of rules that define what is sufficient as evidence for a given theory.

2.1 The Internal Coherence of a Theory

We thereby designate a certain totality of the views of some notable practitioner, from which totality he demonstrates the entire basis of the heavenly motions. All the premises, both physical and geometrical, that are adopted in the entire work undertaken by that astronomer, are included in that totality. (Apologia*:* 139)

A theoretical system, or in modern terms; a scientific theory, must be seen as a coherent whole, free of contradiction. This is the minimum claim of every argument in any scientific field. There are two distinct, but connected issues to deal with here. The most obvious one is that any theory must be coherent in the sense that it does not yield logical absurdities and contradictions. The basic axiom of logic, the principle of contradiction, states that *No object can be P and Not-P* at the same time. When Ursus claims in his *Tractatus* that it is the nature of hypotheses to be untrue, he commits a violation of this rule. Kepler points out that in claiming all hypotheses to be untrue, Ursus is claiming that the earth both does not move, and is not at rest. With a restatement of one of the terms in this argument (”not moves” can be stated as “is at rest”) we see that Ursus’ claim about the necessary untruth of hypotheses yields a logical absurdity in the form of a contradiction.

Contradictions can be solved in different ways, the more obvious being the introduction of a time-line. The contradictory claim “my car is blue and not-blue” can be solved by a reference to change on a time-line. The restatement “my car was blue at time *T1*, and is Not-blue now at time *T2*” is logically unproblematic. If the restatement is embellished by references to the course of events (for example that the car was painted at some point in time intermediate between *T1* and *T2*) we deem the statement as explained and thereby justified. Another way of resolving a contradiction is the separation of the object into parts. This means that a statement about an object can be specified as relevant only to a part of that object. ”My car has a blue hood and a Not-blue right front door” is also logically unproblematic.

I focus on these banalities in order to present the tools Kepler provides us with through his arguments against Ursus. We will see the utility of these tools later in the treatment of SRT. The underlying similarity between the two solutions to contradictions that are stated is the need for what we will call “conservation of reference” in the given terms. By conservation of reference I mean that a given term must, throughout the theory, refer to the same objects in the world, or the same concepts in language. If by “my car” in the above statements I sometimes refer to my old car, and sometimes to my new car, the statements give ambiguous references. In the *Apologia*, Kepler shows that Ursus violates this principle and thereby commits a paralogism.[5] The first and most important confusion of Ursus is treating astronomical and geometrical (and kinematical) hypotheses as equivalent and referring to them both simply by the term “hypothesis”. In the *Tractatus* Ursus shows that there is more than one hypothesis able to “save the phenomena” and therefore there can be no rational basis for choosing one over the other even though only one of them can be true. Kepler responds to this by showing that the multiplicity of hypotheses referred to are geometrical (and kinematical) rather than astronomical hypotheses. Given this distinction there is no problem to admit that there is more than one way of geometrically constructing the movement of the planets, given a set of observations. It is not therefore given that the same claim can be made about astronomical hypotheses.

This is a vitally important point to the Keplerian philosophy of science. Astronomical hypotheses are not purely geometrical (and kinematical) constructs, but physical explanations. In giving the explanation of the planetary movements, i.e. the causes of them, there can only be one true theory. This point is a way for us to see the difference of what is meant by “truth” in science and in pure mathematics. Among geometrical figures one is not truer than the other. A square is, in itself not truer than a circle. If, therefore, we can propose a plurality of geometrical (and kinematical) constructions that “save the phenomena”, in conformity with observation, we have no problem. The problem arises when we want to connect these geometrical (and kinematical) constructions to physical explanations and thereby practice astronomy. Since, in physics, we deal with material objects and not simply mathematical constructs, there are extra demands due to the fundamental difference in nature of the two disciplines. It is on these grounds Kepler demonstrates Ursus’ claim as faulty, and also later, in *Astronomia Nova* or *New Astronomy*, he shows the geometrical equivalence of all the three existing portrayals of the world system. By showing them to be erroneous on physical rather than geometrical grounds Kepler utilizes the distinction to its fullest. The distinction between mathematics and physics will be emphasized in this paper, but for now we will be content with acknowledging that although modern science, just

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[5] Although the term ”paralogism” is usually connected to Kant, the term was used several times by Kepler in *Astronomia Nova* in the sense indicated above.

like classical science, is communicated largely through mathematical formalisms (as $E=MC^2$), the two are not the same. We must therefore distinguish clearly between them so that we do not commit the paralogisms noted above.

2.2. External Coherence

They (the hypotheses in a theory) *are included if the practitioner has for his convenience borrowed them from elsewhere. And they are likewise included if he has already demonstrated them from observations…* (Apologia: 139)

Typically, a scientific theory lies between metaphysics and "raw data" in the sense that it is an explanation of previous, and prediction of future data inside a metaphysical framework. The data or observations are usually treated explicitly in the theory, as the theory's justification, while the metaphysical framework is either assumed understood or not consciously treated by the scientific practitioner. In addition to these higher and lower levels of a specific theory, the theory also relates to previously discovered and generally accepted same-level theories. In Kepler's treatment of the history of hypotheses he draws the line from geometry to natural science with an emphasis on the method of building theorems upon generally accepted axioms. This method is an integrated part of classical and modern natural scientific practice and we will take a short look at what this means for a theory's external relations, i.e. its relation to accepted scientific dogma.[6] In any scientific field there exists a set of generally accepted explanations of phenomena. The better verified these are, the more problematic it is to contradict them in a new theory. Naturally the dogma changes in the light of new insights, but these insights need scientific justification in the sense that they either show the existing dogma to be obsolete, or they can redress the dogma and include it as an integral part of the new theory. If I state in a physical theory that the movement of particles must be understood as "larger than C" I will have to justify this claim by showing that the dogma of C (the speed of light) being the maximum obtainable velocity, as stated by SRT (and indeed any theory that utilizes the Lorentz-transformations for movement) is either erroneous, or that it must be modified and included in a new dogma. A scientific theory does not stand alone! It is an integrated part of a larger theoretical framework and must therefore comply

[6] The term "dogma" in this sense refers to already justified and verified insights, not to religious or habitual rules without proper justification.

with the rules of coherence also in its non-internal but still relevant parts. In frontier science there are naturally fewer dogmas than in the more established sciences, but there are dogmas nonetheless (also in frontier science like quantum physics the Euclidean axiom: "the whole is larger than the part" directs our thoughts and observations, although without us treating it explicitly). These must be seen as relevant parts of any theory in any specific part of the scientific project. If a new theory unjustifiably contradicts the scientific dogma, it must be revised or rejected.

2.3. The Possibility of Causal Explanation

One who predicts as accurately as possible the movements and positions of the stars perform the task of the astronomer well. But one who, in addition to this, also employs true opinions about the form of the universe, performs it better and is held worthy of greater praise. The former draws conclusions that are true as far as what is observed is concerned; the latter not only does justice in his conclusions to what is seen, but also, as was explained above, in drawing conclusions embraces the inmost form of nature. (Apologia: 145)

Kepler accepts, as we can see, that the primary task of astronomy is the prediction and description of the movement of the stars and planets. But he also emphasizes that this is not the end of science. The true end is the embracing of the inmost form of nature, or the explanation of everything. This does in no way mean that only a "theory of everything" can be a scientific theory in the proper sense, but rather we must accept that a proper scientific theory must leave the possibility of end-of-the-line explanations open. If a theory renders the very essence of such an explanation (causality) impossible, there must be justification of this impossibility, and at the same time there must be openings for new understanding of what an explanation is. In other words: *if a theory in effect blocks the possibility of further investigation it must contain the end-of-the-line explanation in itself*. If the explanation given contradicts other scientific theories, we must justify this in accordance with the rules of external coherence.

What is traditionally seen as the main event in the birth of classical science, the Copernican revolution, is an act of seeking explanations to the observations rather than an act of conforming theory to the observations.[7] Kepler points out that there is no observational gain to be drawn from

[7] The emphasis on The Copernican revolution as the birth of science seems, in light of Kepler's history of hypotheses, to be somewhat misguided (the heliocentric world-system appears to be accepted by the

the Copernican hypothesis, compared to the Ptolemaic one. The only rationale for Copernicus´ heliocentric system is that it seems to Copernicus to be more in conformity with how things really are (*Apologia*: 145). The search for end-of-the-line explanation (as reference to how things really are through causal chains) is thereby shown to be an intrinsic part of the research performed by the learned practitioner.

And if she is unable to complete the task, she must leave the possibility of completion open. A theoretical system that blocks the possibility of further investigation and explanation is a dogmatic system that can only be based on belief. We have seen earlier that causality is an integral part of any scientifically acceptable explanation. Things happen for a reason, the explication of that reason, be it a singular reason or a set of reasons, is what we understand by the term "explanation". A more thorough discussion of causality will be presented later but for now we will constrain ourselves to the very basic ideas of causality. Causality is the idea that something happens because something else already happened. This, of course, presumes a time in which things happen. The very idea of something happening is an idea of change i.e. the idea that at some point in time there was a state S and at another point of time there is a state S´. Any theory that deems time, causality, or change as simply illusory (as Parmenides does) must justify this claim properly in accordance with the rules of internal and external coherence. One can hold that knowledge of the world is fundamentally impossible and therefore reject any explanation whatsoever, but this is in direct contrast to the very idea of scientific research and must be seen as a position outside of science. If we are inside the scientific sphere and thereby assume that explanation is possible, the rejection of the very essence of explanation is a contradictory position.

So far we have looked at the parts of Kepler's philosophy of science that are more or less accepted by the general scientific community. But the idea that physical hypotheses include metaphysical hypotheses is a more controversial one, to say the least. For Kepler this is a commonsensical assumption and therefore one that needs little justification. But in modern science the idea that metaphysics has *anything* to do with science is rather seen as an absurdity.

Pythagoreans about 2000 years before Copernicus). Indeed, Norwood Russell Hanson argues in *The Copernican disturbance and the Keplerian revolution*, that it is Kepler's ideas that are the true beginnings of what we call modern science.

We shall demonstrate the idea of metaphysics as an integral part of science is not only a justifiable one, it is an absolute necessity!

2.3. Metaphysics in Science

One of the supposed victories of modern science is that it has been able to rid itself of the unempirical, and therefore unscientific, weight of metaphysics. This is simply a misunderstanding of the issue and one that has no justification. We have seen that contradictions and absurdities can be hidden through paralogisms in the sense that a term is taken in two meanings, while treated according only to one of them. In the modern idea of science without metaphysics something of the sort is going on. Metaphysics is the part of philosophy dealing with topics of a pre-physical nature. This means that metaphysics, in relation to science, deals with the parts of science that has no possibility of direct physical evidence. Let us take a classical example: *On a pool-table ball* A *moves toward ball* B*, hits ball* B*, and looses its momentum; ball* B *on the other hand gains momentum and moves in a direction depending on the point of impact from ball* A. In physics this event is described through the law of reciprocity. In other words: Ball *B* moves *because* ball *A* hits it and thereby transfers energy to it; ball *A* stops *because* it hits ball *B* which is impeding its movement. What is needed for this explanation to be accepted? Firstly, in order for locomotive change to happen, there must be time and space (of some sort or other) for the event to happen in. Secondly, there must be justifiable reasons to say that something can happen because of something else (causality).

But how can we assume causality as something real? It cannot be observed. There is no visible particle of causality flying around. What is happening is that we introduce causality into the event. A standard objection to this is to claim that 'causality' is not in itself a metaphysical concept, but rather a physical explanation-theory. This, naturally, is not valid. Firstly, causality cannot be a physical theory, since it has no empirical justification. Secondly, the very idea of explanation in science is explanation with reference to causality. The argument is circular and nonsensical. The possibility of introducing causality into any scientific theory must be justified by metaphysical argumentation. This goes also for concepts such as 'change', 'movement', 'rest', and not the least – 'time' and 'space'. These concepts make physical science possible and are therefore *meta*physical. The fact that they are not treated explicitly thus does not mean that they are not there.

A plausible reason for the lack of explicit treatment of metaphysical aspects of modern scientific theories is that the main metaphysical elements are agreed upon. They are therefore working as axioms within science, axioms that are assumed proven. The major metaphysical hypothesis of Kepler seems also to be the main metaphysical hypothesis of science in general. The hypothesis is that *the world is harmonic and simple*. It can thereby be expressed in general formalisms. Other elements, like an object's conservation of identity, are consensus-hypotheses in science. In principle the situation of a silent consensus is not necessarily a crisis-situation. But when the consensus-metaphysics is rejected, as it is in the realist interpretation of SRT, we must be aware that such a rejection has taken place. We cannot accept both the new and the old pretending that nothing has happened. The reconstruction and objectification of time and space, cannot take place within science while the old ideas of time and space are at the same time silently accepted. SRT is not a theory that rids science of metaphysics. There can be no such theory. As long as we introduce metaphysical concepts like causality and identity into the observed phenomena, we are accepting metaphysical hypotheses. If we reject the inclusion of these concepts, we reject our general view of what an explanation is; we thereby reject the scientific project. Metaphysics, it appears, is here to stay.

3.0. General Aspects of Kantian Metaphysics

In everyday life we consider science to be the authority on explaining the world. We separate science from religion and opinionators, because in our understanding of it, science gives objective answers. Since metaphysics is a necessary, although often untreated, part of science we must demand of it the same objectivity. A scientific method based on arbitrary metaphysics will be an arbitrary method giving arbitrary results. We can sometimes save the phenomena with such a method (as indeed Ptolemy did) but the rational certainty of such results will be lost. In this chapter we shall look at what objectivity is and can be as we unfold the basic ideas of Kantian metaphysics. The most profound aspect of Kantian metaphysics is the claim that we perform *synthetic a priori* judgments. This will be the main idea in the following.

Kant enters the field of philosophy in the midst of a separation between the two major opposing ideas about human understanding. The empiricist school claims that knowledge about the world can only be derived from empirical facts, and we must therefore investigate the world and draw conclusions from what we find. This has the benefit of creating new knowledge, but at the same time we must admit that a collection of facts from the changing world must be contingent. There can be no necessity or absolute certainty in such knowledge as it must finally rest on inductive arguments. On the other side the rationalists claim that certainty and necessity is the very core of knowledge and that knowledge must therefore stem from purely rational arguments rather than empirical facts. This guarantees certainty and necessity, but by simply analyzing our concepts we cannot say anything new about the world. Kant joins the two together and claims that we can say new things about the world that are necessary and certain and that indeed we do so all the time!

We have claimed earlier that mathematics is a field in which proof can be posited. But why is mathematics so special? What is there in a mathematical judgment that gives it certainty and necessity? In order to investigate this we must look at judgment itself and the three basic types of judgments that can be performed.

Analytic judgments are judgments where the given predicate is already contained in the subject concept. The classical example of an analytic judgment is “a bachelor is not married”. Since the term “bachelor” is defined as “not married” this judgment tells us *nothing new* about the world. A *synthetic* judgment on the other hand tells us something new. All synthetic judgments have one or more references outside the given concept. An example: "My friend Tommy has a beard". There is nothing in the concept of "my friend Tommy" that tells us whether or not he has a beard. There must therefore be an external reference to this judgment. The external reference we can give in this example is an empirical one. We have gone to look at the object to which the term "my friend Tommy" refers, and by that we have been able to see that he has a beard. If he does, the judgment is true, if he does not the judgment is false. Judgments that need empirical evidence are *a posteriori* (after the experience). Judgments that do not rest on empirical experience are *a priori* (prior to experience). Until Kant's *Critique* it had been generally accepted that there are only two meaningful types of judgment: *a priori analytic* and *synthetic a posteriori*. Kant shows the existence of a third possibility. For the exposition of this third possibility we must return to mathematics. Kant uses two examples to prove his point and we shall briefly look at both of them.

<u>Arithmetic</u>: "5+7=12" (*Critique*: B 15).

How can we be sure that the sum of 5 and 7 equals 12? There is nothing in the concept of 5 or 7 justifying their union being 12. That they shall be added and that there will be a sum is given by the plus-sign, but the necessity of it being 12 is not thereby given. Why can it not be 11? In order to answer this we must look into what goes on in our mind when we do arithmetic. The adding of numbers is performed through counting. We take the number 5 and add the unit 1 to it 7 times. In this process the initial number increases by one for every one we add. We are in other words adding successively. The very possibility of succession, i.e. the idea of something following *after* something else, is *prima facie* time. It is thereby clear that we refer to time in performing arithmetic. Since time is not included in the concept of either 5 or 7, it is an external reference. Arithmetic is therefore *synthetic* in its nature. We have seen that the common view has been that all synthetic judgments are *a posteriori* and we should expect the arithmetic ones to be so too. But is 'time' an empirical concept? This is the question that will be answered in paragraph 3.2: *Time is not an empirical concept.* For now we shall leave it open and go on to analyse the second mathematical example that Kant uses.

<u>Geometry:</u> "A straight line between two points is the shortest" (*Critique*: B 16).

Since the concept of a straight line is a qualitative concept that does not deal with the size of that line, there is nothing in the initial concept that contains the conclusion (*Critique*: B 16). What is needed is therefore an external reference. In arithmetic the reference is time, but in geometry we must refer to space. Only spatial reference can help us make the conclusion that the straight line is *shorter*. In the same way we need space in order to know that *any three intersecting straight lines, where all intersect each other and in more than one point, create a triangle.* There is nothing in 'line' or 'intersection' or 'the number 3' that contains the concept of a triangle. But through reference to space we can deem the conclusion to be correct. We have thereby seen that some mathematical judgments are *synthetic*.[8] The question is thereby whether the judgments are *a priori* or *a posteriori.* If Kant can show that synthetic a priori judgments are not only possible, but are already prerequisites to our most certain knowledge, mathematics, he has found an indication to what we must look for in order to say something new and certain about the world. But the type of argument that secures the certainty of mathematical judgment is not exclusive to mathematics.

So when further proof of the *synthetic a priori* character of mathematical judgment is given, we are at the same time arguing for the validity of other insights that depend on the pure intuition of time and space. When dealing with the categories in the next chapter, we shall see that the categories themselves are directly dependent (for their objective reality) on pure intuition and that therefore the synthetic a priori character of judgments that are grounded in the categories are also grounded on time and space as pure intuition. Therefore the categories themselves are *synthetic a priori* and the general concepts contained in them, as for example causality, are justified in their

[8] The idea that mathematics is *synthetic a priori* is often criticized in variations of the same basic theme. The theme appears as follows: Non-Euclidean geometry proves mathematics to be either *a posteriori* (argument 1) or *analytic* (argument 2). As for argument 1) there is a simple refutation of this objection. If mathematics is to be *a posteriori* it must rely on empirical statements or facts. However, the very nature of mathematics lies in its independence of such empirical realities, as it is a formal system of statements. Any statement that is true in a mathematical system is true by necessity. There is no need (or indeed possibility) of testing empirically whether '1+1=2' is a true statement. This independence from empirical issues is what makes mathematics *a priori.* For argument 2) one can see that the appearance of non-Euclidean and Euclidean geometry shows that mathematics is not analytic as any statement that is not directly derivable from the initial subject is either *synthetic* or contradictory. 'A bachelor is married' is a contradictory statement since the subject concept 'bachelor' contains the sub-concept 'not married' which contradicts the predicate concept 'married'. Thus: If Euclidean geometry is to be analytic, there can be no possibility of alternative geometries. What seems to be ignored in the objections toward Kant's view on mathematics as *synthetic a priori* is that Kant shows that mathematical judgments are inherently spatiotemporal and that time and space must be non-empirical horizons for sensation. Since space and time are not included in the terms of an equation, but utilized for the performance of mathematical judgments, mathematics is *synthetic a priori*. For a more elaborate discussion on this topic, see Thor Sandmel's: *Matematikkens indre arkitektonikk*.

use in the same way and by the same argument as mathematical judgments. The description of mathematical certainty is therefore an exemplar of the more general fact that human beings perform *synthetic a priori* judgments and that through this we can guarantee the necessity of scientific judgments. This is a major metaphysical support for scientific realism as we can thereby transcend the rationalist/empiricist separation. The question we need to ask is therefore: Are Time and Space empirical concepts, thereby making mathematics (and science in general) a purely empirical and uncertain science, or are they non-empirical, keeping mathematics free of the contingent empirical facts?

3.1. Space is not an Empirical Concept

The important question at this point is whether space can be conceived of as an empirical concept. If space is empirical, (or if this is even a possibility) we cannot retain our conception of mathematics as being certain and synthetic.[9]

If space is to be an empirical concept it must be wholly arrived at through empirical observation. If space is arrived at through empirical observation, we must imagine ourselves as not already having spatial relations in our minds in which to organize our observations in a spatial manner. This means that all concepts of figure, size, position and other spatial relations to other objects must be removed from our minds. If then, in this non-spatial state, I am to observe something outside me, what do I observe? The simple answer is nothing. It is impossible to observe something as outside of me, without already assuming that I am in a different position from that something in space. It is also impossible for me to observe something (other than me) that has no size or figure. How are we supposed to arrive at the concept of space from these non-spatial observations? It is obvious that this is impossible. My only possibility for observing spatial relations is that I have spatial organization at the outset. In other words: *Space cannot be an empirical concept arrived at through observation*. Space must be an organizing aspect of my

[9] If space is empirical, and therefore spatial judgments are *a posteriori*, mathematics – which utilizes intuitions of space and time – would be contingent (as there is no certainty contained in *a posteriori* judgments). In order to retain the necessity of mathematical judgment and at the same time consider space to be empirical, one must assume mathematics to be independent of space, which we have shown not to be the case. There is, in other words, no way to coherently retain the *synthetic a priori* character of mathematics and an empirical concept of space at the same time.

mind! In order for me to observe something external I must therefore already have the concept of space *a priori.* This simple argument shows space to be non-empirical and so far we can see that at least in relation to geometry mathematics can be certain due to its *a priori* character. We shall now see that the same argument is valid for time.

3.2. Time is not an Empirical Concept

In just the same way as with space, we must empty ourselves of the given temporal relations in our minds and see if it is possible to arrive at the concept of time without it already being there at the outset. An observation would thereby have no succession. All change and endurance must thereby be removed from our observation (internal or external), and we see very clearly that without time already existing in us as an organization, we can have no experience whatsoever. Time can, in other words, not be an empirical concept. It is unthinkable that we should have non-temporal experiences from which we should derive the concept of time. Time is thereby necessarily an *a priori* organization of our minds and the whole of mathematics is *a priori.* We have arrived at a third form of judgment which is *synthetic a priori* judgment, and this form of judgment is certain due to it being deprived of contingent empirical data (a priori) and it gives us new information due to its synthetic character (external reference). Before we keep on with the synthetic a priori judgments and what they mean for both metaphysics and natural science, we shall look at what space and time must be since they are not empirical concepts.

3.3. What Space Is

By means of the external sense (a property of the mind), we represent to ourselves objects as without us, and these all in space. Herein alone are their shapes, dimensions, and relations to each other determined or determinable. (Critique: B 37)

Space is the *form* of the external sense that Kant is referring to. There is nothing material to space itself but space is rather a prerequisite for all external observation, and thereby the prerequisite of all appearances of objects. In other words space is the *way* we perceive, rather than any singular perception itself. Space must therefore reach indefinitely in all directions, and a closed space or segment of space is simply a limitation within Space itself. In opposition to concepts, space is not limited by borders and does not have a possibility of non-application. As it is forcibly present in all perception but is not perception itself, Kant denotes it as pure intuition (”reine Anschauung”). The other part of pure intuition is Time, which we shall look at presently.

3.4. What Time Is

Time is a necessary representation, lying at the foundation of all our intuitions. With regard to phenomena in general, we cannot think away time from them, and represent them to ourselves as out of and unconnected with time, but we can quite well represent to ourselves time void of phenomena. (Critique: A 31)

In opposition to space (which is pure intuition of external phenomena), time is pure intuition of *all* phenomena. We have seen that there can be no phenomena without time and there can therefore be no intuitions of phenomena without time (as form without matter is empty). Axioms of what time must be can be built from this insight:

<u>Direction:</u> Time has one (primary) direction (“forward-looking”, from the past through the present now towards the future). Since succession is one thing following (after) another time cannot move backward, as this would mean that the object that moves backward in time is doing this at a point in time after the time it moves backward to. In other words: moving backward in time means moving backward and forward at the same time, which is absurd. Also we can say that any point in time comes after another point in time and is not simultaneous to that point. *Time is an indefinitely long succession*. Just as with space, any segment of time or “moment” is a limitation within time itself and as the other part of pure intuition. Time is thereby boundless and forcibly present in all intuition.

<u>Prerequisite for change:</u>

Time is a prerequisite for change and not, as is sometimes argued, the other way around. One might claim that the knowledge and consciousness of time is possible only through observed change, but we must then remember that change itself is not possible without time. The origin of our awareness of something is not equivalent to the origin of the thing as biodiversity is the origin of our awareness of evolution, but not the origin of the evolutionary process itself.

Time does not exist in itself or as a quality of objects:

Time is not an observable concept that has boundaries and possibilities of non-existence. Under the Newtonian concept of absolute time as a self-existing entity one must accept time as a non-physical object that is a prerequisite for the existence of all other objects. This is an insufficient description ultimately demanding the understanding of time as an empirical concept. (We showed the impossibility of this in 3.2.) If time is to be a quality of the objects themselves, it must ultimately be its own prerequisite, which is absurd (*Critique*: B 49). Time is only conceivable as pure intuition and as a condition for experience of objects, not for the objects in themselves. Time is therefore only valid as the pure intuition prerequisite for empirical observation and does not exist in any other way.

3.4.1. The Visualization of Time

Since time is not purely external and relates to the inner as much as to the outer life of a person, it cannot itself be intuited. As a representation of time, therefore, we are in the habit of drawing a line. This has led to some confusion that we shall try to clear up at this point. The main root of the confusion is that a time-line is often confused with any and all geometrical lines and thereby given characteristics that do not belong to it. A geometrical line can be moved about, but this cannot happen with time. Time is in all places equal to itself (i.e. in all places at the same time) and it is not bendable or movable. We have seen that the possibility of movement itself is only given through time (since movement is a contradiction without time) and therefore time itself cannot move. *Time stands still, we move!*

If we draw a line to represent time, we must also imagine all things moving along that line in the same direction at the speed of one second per second. It is vitally important that we remember this separation between the actual thing we discuss and describe, and the mathematical representation of it. Otherwise we shall fall into the classical ditch of claiming that everything is mathematics. At best, that credo must be restated as *a lot of things can be represented by mathematics*. Time is obviously not a line even though it can be represented by it. The misconception that time moves is also present in our everyday language: Time runs, time is slow, time is flying and so on. Even though these descriptions of the movement of time are perfectly acceptable in everyday language, we cannot introduce them into our understanding of what time is or does. Time obviously does nothing. For time to do something there would have to be a more fundamental time for it to do that something in. We must therefore remember that it is the objects that appear to us that move, not time. Time is a formal prerequisite for that movement to occur.

3.5. What We Can Know

That all our knowledge begins with experience there can be no doubt. For how is it possible that the faculty of cognition should be awakened into exercise otherwise than by means of objects which affect our senses, and partly of themselves produce representations, partly rouse our powers of understanding into activity, to compare, to connect, or to separate these, and so to convert the raw material of our sensuous impressions into a knowledge of objects, which is called experience? In respect of time, therefore, no knowledge of ours is antecedent to experience, but begins with it. But, though all our knowledge begins with experience, it by no means follows that all arises out of experience. (Critique*:* A 1).

This extraction from the introduction to Kant's *Critique of Pure Reason* shows his ambition to unite the empirical and rationalist schools of thought into one that gives us new and certain knowledge about the world. The question we shall now try to answer is *what can we mean by the world?* The world that appears to us is a world of phenomena that, as we have seen, are compounded by the formal aspects of our minds (the pure intuitions of time and space) and the appearances within these horizons. The actual objects in themselves that create these apparent phenomena, though, are not. Unless we make the unfounded claim that if humans disappear, the whole universe disappears; we must accept that there is a world that influences us through our senses.

The main aspect of Kantian philosophy that opponents reject is the idea that we can know nothing about this world-in-itself. The world-in-itself as the world without us observing it cannot, they claim, be completely unknown to us because that would mean that there is no objective knowledge. If knowledge about the world without our observation is deemed the only knowledge there is to value, we must simply agree with the opposition. There is, however, no such knowledge. How could we conceivably know anything about something we cannot have any experience of? What we can know though, is that there is a world apart from our observation of it, because something must affect our senses in such a way that we have experiences. But to describe that world and give predicates to it is tantamount to describing what God looks like (if there is such a thing). It is outside the scope of our *possible* experiences, and since we all agree that experience is the very thing that we have knowledge of, it is outside the scope of possible knowledge.

What we can know about is the world in which we live, the world of phenomena. By accepting that all our experience in one specific sense is and must be subjective (someone needs to have the experience), we see that all objective knowledge stems from subjective experience, in this sense. In science we have accepted a definition of objective that perfectly conforms to this: Objectivity as the possibility of reproduction. Any verification of a physical theory must be reproducible through language, mathematics and observation. If it is, the theory is objectively valid. It is, in other words, valid for all human beings.

If another species had different pure intuitions (not time and space) we cannot guarantee that they would observe what we observe, or that they observe what we do not observe. We must simply accept that human knowledge about the world is limited to possible human observation. Thus: the argument that we cannot know anything about the world is false. We can know how we observe it (through time and space), and we can learn from these observations how the world will appear to us. For scientific purposes this does not really make a radical change. Natural science has been limited to human observation all along; this does not change because we are now aware of it. What changed is that we can see the limit of human knowledge about the world as being time and space. About non-spatial non-temporal things-in-themselves we can know nothing! Claiming to know how things are in them selves is simply self-flattery; for where could such knowledge be found? How should we observe without observing as humans? Kant argues for the lack of proof that time and space can be taken as things-in-themselves independent of our experience. Rather than restating those arguments we shall move quickly through them and spend our time on some more recent objections.

Time and space cannot be proven to exist outside human experience since they are the very formal aspects of that experience. The world-in-itself cannot be experienced and thereby not known. This does not mean that time and space are unreal or simply illusory. Time and space are real; they are the real intuitions that enable us to have experience and are thereby absolutely valid in all empirical knowledge (*Critique:* A 37).

Time and space are, therefore, two sources of knowledge, from which, a priori, various synthetical cognitions can be drawn. Of this we find a striking example in the cognitions of space and its relations, which form the foundation of pure mathematics. They are the two pure forms of all intuitions, and thereby make synthetical propositions a priori possible. But these sources of knowledge being merely conditions of our sensibility, do therefore, and as such, strictly determine their own range and purpose, in that they do not and cannot present objects as things in themselves, but are applicable to them solely in so far as they are considered as sensuous phenomena. (Critique*:* B 55-56)

Newer objectors try to avoid the need of human experience by letting machines have the experience for them. The argument runs as follows: *Since a machine is not human, it will observe objectively only what is there. Not what we put into it.*

This argument is common but groundless in that it is simply a misunderstanding of what technology can do for us. Let us take the example of a mercury thermometer. This contraption is simple enough: a glass cylinder contains a given amount of liquid mercury. Liquid mercury is known to expand with heat at temperatures where glass is relatively stable. When the room containing the thermometer gets warm, heat transfers first to the glass and then to the mercury and as the temperature increases, the mercury expands and shows us by size how warm it is. The underlying physical principle is the thermodynamic principle of thermal expansion and everything is objective and nice.

So doesn't this show that heat exists apart from our experience, and machines avoid the limits of Kantian dualism? No, it does not! We need only to ask some simple questions to see that this is not what happens. Firstly, why do we use glass and mercury? The answer is obviously that we have experienced that when we perceive heat (subjectively) we also observe the expansion of mercury. Our subjective heat-experience is a prerequisite for the connection between heat-increase and mercury expansion. This connection is what makes mercury thermometers useful.

The second question is: what would we do if we observed no expansion when the room got warmer? We would simply consider mercury a poor indicator of heat. If we already knew mercury to be a good heat indicator we would conclude that there must be something wrong with the contraption (in the same way as with the moving mountain, or the mathematical error). This will be true for any and all machines we construct to do our observations for us. We made them and they are ultimately used and understood, based on our subjective experiences. Subjective experience is the only experience there is! Through it we can create standards that are the same for all *human* observers and thereby render our knowledge objective.

What can be gained from Kantian dualism is that we can find, in the structure of our minds, the very thing that makes pure mathematics possible: *synthetic a priori judgment* through the reference to pure intuition (time and space). We can thereby claim with absolute certainty that *all human experience will be spatial and temporal* and refute Parmenides´ claim that change and time are illusory. Time is not an illusion! It is the formal aspect needed for all human experience internal and external. This means that all objects and relations between objects must be spatiotemporal when observed by us. This again, leads us to the possibility of knowledge of objects and relations between objects prior to the actual experience of them. The general relations that objects must have to each other are, of course, what we seek to find when we do science and provide scientific explanations and therefore the explanations we give must conform to the general rules of spatiotemporal relations. Kant gives an exegesis of the totality of these in his description of the categories of understanding. We thereby have a formal *synthetic a priori* knowledge on which science can be based.

4.0. Presentation of The Categories

Our knowledge springs from two main sources in the mind, first of which is the faculty or power of receiving representations (receptivity for impressions); the second is the power of cognizing by means of these representations (spontaneity in the production of conceptions). Through the first an object is given to us; through the second, it is, in relation to the representation (which is a mere determination of the mind), thought. Intuition and conceptions constitute, therefore, the elements of all our knowledge, so that neither conceptions without an intuition in some way corresponding to them, nor intuition without conceptions, can afford us a cognition. (Critique: B 74)

In the previous chapter we looked at the faculty of receptivity for impressions, or intuitions. In this one we shall look at the spontaneity of the understanding, or the act of thinking as the ability to judge. Judgment is an ability to subsume particular instances under general concepts. In other words, *thinking is the ordering of our impressions through concepts.* In modern philosophy of science we are careful not to separate the act of thinking and the act of receiving impressions too strongly as these cannot meaningfully exist as totally separated. Also Kant sees the thinking aspect of seeing as an internal, not purely external one to seeing, but we anyway need to separate the two in order to understand what is going on. When I see something I, as we have shown, place that something in time and space. This is done, not as an effect or interpretation of the impression, but rather as the having of an impression is having it in space and time. But there is more to seeing than just space and time. Norwood Russell Hanson focuses on the *seeing as* and *seeing that* in his classical book *Patterns of discovery* where he shows that when I see for example a glass held over a stone, I see the glass *as* a glass (i.e. as a thing with certain functions) and I see also *that* it might break if I drop it on the stone. There is, in Hanson's words, "*more to seeing than meets the eyeball"* (*Patterns of Discovery*, Chapter 1: "Observation", p. 7). The *more* in seeing is - in the Kantian terminology - a spontaneous representation of impressions through concepts. Since concepts are general and all impressions on our mind are singular, a concept is a representation of the impression. In other words: thinking is *representation of representations*, the production of general concepts in the experience of particular phenomena. The spontaneous act of producing concepts in our minds, or rather the act of calling out concepts that are already in our minds when observing something, is not itself an act of the receptive or intuitive faculty. It is the performance of an action that (even though it appears simultaneously as the passive receiving of information) does not stem from the impression. It stems from the faculty of understanding and must therefore be treated as separate from the faculty of reception.

4.1. The Faculty of Understanding

Kant treats the faculty of understanding (thinking) as cognition and imagination, where cognition is intrinsic to an experience, and imagination is a productive ability to produce possible intuitions in the absence of the actuality of those intuitions. When we imagine something we bring together concepts in a unity and thereby create a synthesis that is not only limited by general logic in the sense that it is impossible for us to clearly imagine something that cannot be synthesized. The lack of possible synthesis can be due to internal contradiction or to the lack of spatiotemporal coherence.[10] Through this synthesis we can, and often do, arrive at ideas that we cannot possible have experience of. There is, for example, no contradiction or spatiotemporal incoherence in the idea of God creating the universe. But there is no possible experience of such a thing. For us, experience is limited to space and time, but these limits do not pertain to a god in the Christian sense. Since science and possible experience is the topic here we must limit the imagination to these horizons. Thinking in general must thereby be limited by time and space in the same manner as our intuition is. The fundamental structure of thinking is as we have said the ordering of particular objects (things or events) under general concepts, and there can be no finite number of concepts as there can be no finite number of possible experiences. If we are to understand the processes of the understanding, we are therefore forced to look for something more fundamental than single concepts. What we must look for is a set of higher-level functions that can reveal some general aspects of all concepts. A set of functions of this kind can be found in general logic.

4.1.1. The Transcendental Logic

General logic deals with the pure form and relation between concepts through a limited set of functions. Through this set we can uncover the structure of any statement and check if there is a formal problem with it (i.e. a contradiction). General logic is therefore a powerful tool when it comes to structuring any argument whatsoever, but in order for us to limit those arguments to possible experience (which is the prerequisite for saying anything about our perception of the world) we must alter the functions a little. The alteration follows from Kant's architectonic view of General Logic. In this view General Logic is not simply a collection of functions that we

[10] A standard example of spatiotemporal incoherence is M. C. Escher's "Ascending and descending" (Escher 1) where at first sight the object of the image appears imaginable, but when related to time and space it reveals itself as impossible.

perform, but rather this collection is a completion of the initial idea of a totality or whole. The completeness of a system of logical functions is thereby not evaluated on the lack of other functions, as this could in theory change over time. The completeness is the fulfilment of a demand that there can not possibly be a need for more functions as the functions described constitute a totality to which nothing can be added (*Critique*: B 89). Kant differentiates his ideas of logic and categories from Aristotle's on this basis (*Critique*: B 106 – 108). When, therefore, Kant seeks to uncover the totality of our underlying basic judgments, he must consider the birthplace of these judgments. Kant calls this altered logic *Transcendental Logic* as it is a logic that, based purely on a priori judgments, allows us to transcend the faculty of understanding and unite it with the receptive faculty. In order for it to be transcendental (i.e. a synthetic a priori prerequisite for any experience) it must cover the whole range of possible experiences. In General Logic a singular term can be treated as a universal term since a singular term refers to the entire content of that term. Any judgment about that term will therefore be valid for the entire term and not only for parts of it (as in a particular). In Transcendental Logic, on the other hand, we must distinguish between these, as they are obviously different in character when we consider the content. In General Logic the truth of the initial premises are completely disregarded and only the purely formal aspect of an argument is considered. In the Transcendental Logic this cannot, as we have seen, be the case. Transcendental Logic must consider the content of any statement (as possible experience) and is therefore connected to the representations of empirical data in a way that cannot be justified for General Logic. The basic set of functions in Kant's Transcendental Logic is named "the categories" (after the Aristotelian categories) and we can see the whole system as a synthesis in which we categorize our experience. We must remember, though, that this is not purely an act of categorizing after the experience. The categories must be there at the outset in order for experience to be possible and thereby they constitute the formal synthetic unity of all our experience!

4.1.2. Presentation of The Categories

In General Logic we consider the fundamental unifying functions that underlie all our concepts, but as derived from material content. This means that General Logic, although it represents the unifying functions, does not and cannot be directly applied to the world per se. The world as we experience it is a combination of the formal and material content and we must therefore, at some point, consider the senses when used for describing the world. So even though General Logic satisfies the criterion of completeness of functions, it does not satisfy the needs of a Transcendental Logic that must consider the material content. But, as we have seen, the material content needs not be empirically derived but can be *a priori* uncovered through the fundamental functions that guide experience. It is with a logic of this kind that Kant seeks to overcome the gap between the empirical nature of our experience and the formal logical nature of our understanding of it. So the Transcendental Logic is thereby a totality of the fundamental unifying functions by which we arrive at concepts through which we experience the world.[11] Kant presents the totality of logical functions of the understanding as follows:

Table of the totality of logical functions of judgments in the faculty of understanding

1. Quality of judgment
Universal
Particular
Singular

2. Quality
Affirmative
Negative
Infinite

3. Relation
Categorical
Hypothetical
Disjunctive

4. Modality
Problematic
Assertoric
Apodictic

Table 1

As the Transcendental Logic is to contain the totality of functions, Kant has introduced, for example, the distinction between totality and singularity that did not exist in General Logic.

[11] The need for unity is given by the guiding principle of completeness without which there will be no possible Transcendental Logic as one can only fill the gap if it is filled completely. We see here the connection also to Kepler's postulate of the harmony and simplicity in nature, as the totality of descriptions of that nature is the very same as the totality of fundamental unifying functions. Only when the totality of possible relations between phenomena is described do we have a complete understanding of them, and only when the totality of functions is fulfilled do we have a bridge over the gap between the material and formal aspects of concepts.

Indeed there is no need for such a distinction in General Logic as it relates purely to the relations between the given concepts. In Transcendental Logic however, where we must also consider the relations of concepts to possible experience, such a distinction is of formidable importance. With the given functions we can perform an act of reason that surpasses the possibilities of General Logic as we can now bring the syntheses themselves on concepts and not only the formal relations of concepts to each other. We can therefore find the fundamental concepts of the understanding and thereby the *a priori* foundation of our experiences. Kant collects these fundamental concepts in a table of categories:

Table of the categories of the pure understanding

1.Of Quantity
Unity
Plurality
Totality

2.Of Quality
Reality
Negation
Limitation

3.Of Relation
Of Inherence and Subsistence
(*substantia et accidens*)
Of Causality and Dependence
(cause and effect)
Of Community
(reciprocity between agent and patient)

4.Of Modality
Possibility - Impossibility
Existence - Non-existence
Necessity - Contingency

Table 2

In Table 2 we see the total amount of categories for the understanding. They are ordered under four main classes and we shall see that there is also a further order as Classes 1 and 2 (quantity and quality) relate to the objects as given in intuition while Classes 3 and 4 (relation and modality) relate to the existence of these objects. We shall briefly look at the first classes before investigating the latter two more thoroughly.

4.1.3. The Schemata of The Constitutive Categories

Any experience is necessarily an experience of a manifold. There is no such thing as an impression totally deprived of relation to other impressions and to other aspects of that same experience. The synthesis of this multitude of impressions into an experience is performed through the schemata of the categories. What appears to us is, in an abstract sense, as a disconnected plurality of impressions is, through the faculty of understanding, represented as a synthesis, or an experience. In the same way, when we think about previous experiences, we synthesize the variety of impressions through the rules of our understanding, and when those rules are broken we are unable fully to understand and accept the synthesis as an experience. For example: When we dream, we sometimes connect people and things that cannot have existed at the same time. If we remember that dream we can sometimes be sure that the dream was a product of creative imagination and not of memory or recollection, as it does not comply with the possibility of synthesis according to the rules given by the schemata of the categories. So we do, even though this is usually done without our conscious knowledge of it, apply a set of functions by which we decide whether the events of the dream were possible or impossible. Through the schemata of the classes of categories we apply the rules of synthesis to the dream as we do in any experience.

1 Quantity:

For the external sense the pure image of all quantities (quantorum) is space; the pure image of all objects of sense in general, is time. But the pure schema of quantity (quantitatis) as a conception of the understanding, is number, a representation which comprehends the successive addition of one to one (homogeneous quantities). Thus, number is nothing else than the unity of the synthesis of the manifold in a homogeneous intuition, by means of my generating time itself in my apprehension of the intuition. (Critique: B 182)

Let us imagine seeing four identical drops of water. In order to see them as four (and not one) we must place them in four different places in the same space. Since they are identical in their construction (and could therefore all be represented by the same geometrical figure) they *must* be placed in space to appear as four, i.e. as a number, (in the image that is). When discussing pure intuition (time and space) we saw that mathematics is in need of intuition in order to make synthetic a priori judgments; now we see that these mathematical judgments are included in our perception - in this case as the common foundation of arithmetic and experience is the achievement of *number* through counting - through pure intuition. Any quantitative experience (i.e. any experience what so ever) has the temporal horizon as a constitutive necessary condition and any external experience is also within the spatial horizon. In the example above, the raindrops are placed next to each other as to ensure their plurality. That plurality is counted, under the schemata of number, as we have seen earlier, in time. Any concept applicable to experience is therefore quantitative in the manner that its objects fall under the schema of number.

2 Quality:

Reality, in the pure conception of the understanding, is that which corresponds to a sensation in general; that, consequently, the conception of which indicates a being (in time). Negation is that the conception of which represents a not-being (in time). (Critique: B 182)

In everyday language the term “is” refers to the reality of something at a given point in time or at all times. For something to be real it must therefore have a degree of existence in time. But between existence of a given degree and non-existence there is an infinity of degrees and therefore we must consider the schemata of quality as an intensity of that reality. If, for example, we experience pain or love, there are degrees of intensity of these sensations where an infinite number of degrees can be found between any given degree of sensation and its absence. We have shown that the appearance of something must be universal (unity), plural and singular (totality), i.e. that any appearance falls under the schemata of number. We have also seen that the reality of that thing is a continuum in which any degree of existence is possible between a given reality and negation. But any reality for our intuition is necessarily also relational. The existence of something is only cognisable as in a relation to all other things, and in particular to the one having the intuition (the observing subject).[12] We have thereby been able to say what is needed for something to be described as existing (a quantity and a non-zero reality at some point in time), but now we need to look at the hows and whys of existence.

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[12] *The formal (aspect) of nature in this narrower sense is therefore the conformity to law of all the objects of experience, and so far as it is cognised a priori, their necessary conformity. But it has just been shown that the laws of nature can never be cognised a priori in objects so far as they are considered not in reference to possible experience, but as things in themselves. And our inquiry here extends not to things themselves (the properties of which we pass by), but to things as objects of possible experience, and the complex of these is what we designate as nature.* (Prolegomena § 17)

The reality of a thing is thereby possible only within the framework of ”nature” as the complex of all things, which means that reality designates community and there are no unrelated objects.

4.1.4. The Schemata of The Dynamic Categories

3 <u>Relation</u>

The relational categories consider the synthesis of objects qua their relations to each other in time. In the three modes of time (persistence, succession and simultaneity) we find three different ways in which objects relate to the understanding (substance, causality, reciprocity). It is these three ways of existence we shall now look into closer.

3.1 <u>Substance</u>

The schema of substance is the persistence of the real in time, i.e., the representation of the real as a substratum of empirical time-determination in general, which therefore endures while everything else change. (Critique: A 144)

We have seen earlier that time itself cannot be thought of as something that moves, but must rather be seen as a continuous unmoving horizon in which movement can occur. A substance, i.e. something that cannot exist as a predicate of something else, shares that quality. If we consider energy in physics, we have an example of a substantial existence. In all change there is some or other transfer of energy or change of energy. Pressure can turn into heat, heat into motion etc. When we consider energy in this way, we always assume that energy exists as a substance. The transfer of energy from one object to another or from one form to the other is always seen as a change in the accidence of energy, i.e. as the way that energy happens to exist at some point in time. What we do not think is that energy is created and disappears. Energy in this sense is considered to be a substance, a reality that exists at all times and that cannot enter or exit the world. We must not understand this as if there are unchanging entities, but rather that change itself is not the coming-to-be or ceasing-to-be of substances. Change concerns the coming or ceasing to be of accidents (predicates) of substances and it is a change in the way substances exist, i.e. the *how* of existence. So we have already a description of an object's quality and that quality's mode of existence through which we may see the connection between an object's representation as a quantum (a totality) and the reality of that object as a degree (as intensity) in which it is presented to us in the senses.

Hence there is a relation and connection between, or rather a transition from reality to negation, that makes every reality representable as a quantum, and the schema of reality, as the quantity of something insofar as it fills time, is just this continuous and uniform generation of that quantity *in time, as one descends in time from the sensation that has a certain degree to its disappearance or gradually ascends from negation to its magnitude*. (Critique: A 143)

The reality of an object is thereby constituted by the intensity of a given quality. So when an object is moving away from us we consider it a stable quantum that gradually disappears and looses its reality in respect to its representation in our senses, but even if the quantum (which must be understood as a mode of existence of substance) is destroyed, the substance that constitutes that quantum (i.e. energy) remains, but in a different form of existence.

3.2 Causality

The schema of the cause or of causality of a thing in general is the real upon which, whenever it is posited, something else always follows. It therefore consists in the succession of the manifold insofar as it is subject to a rule. (Critique: A 144)

In the previous section we said that change concerns the accidents of substances. Causality concerns the underlying rules of that change and as we have seen in chapter 3, when something happens in the world it is only understood properly when those rules are revealed. We can consider two scenarios in order to see more clearly why there is a necessity of a specific order in certain experiences. Let us first consider a non-causal scenario: I see a house with a man on top of it. In this scenario there is no necessary rule stating that my seeing the man on top of the house must be prior to my seeing the wall of the house. There is in other words no causal chain in my perception. If in the next scenario I see the man at an intermediate point in the air halfway between the roof and the ground, and then later splashed about the ground itself, there is such a necessary succession. I can not conceive of the man first being in the air, then on the ground, and finally on the top of the house because the horizontal and continuous character of time and space forces me to see the man as moving through all the intermediate points in space and time from being alive at the top of the house, alive in all the intermediate points in the air, and finally dead on the ground. This experience is in other words only thinkable for me in a causal way, i.e. as a succession of appearances in time according to a rule.

A common counterargument to Kant's description of causality is that I have no reason to believe that even though it appears to me as if there is a necessary connection here, there must really be one in the external world. We will deal with this objection later, as it is but a misunderstanding of

Kant's point, but we shall look closer at the given example here in order to hammer the basic idea home. The example shows that the three instances must be connected in a way that allows for time and space to remain continuous. We must therefore consider the man as passing through space in a continuous manner and he cannot appear and disappear at different arbitrary points in an arbitrary order. If I am to draw a line between two points from A to B it must be done in the same manner.

A B

There is of course the possibility of drawing the line from B to A instead (as the man can jump to the roof from the ground), but this must also be done in a particular way (as a continuation through all the intermediate points where one point closer to the end must necessarily come later than a point close to the beginning). For external change space and time must remain continuous, and the rule that ensures this continuity is a causal law.[13]

3.3 Community

The schema of community (reciprocity), or of the reciprocal causality of substances with regard to their accidents, is the simultaneity of the determinations of the one with those of the other, in accordance with a general rule. (Critique: A 144 - 145)

Consider the first scenario we presented above (A man on the roof of a house). In this scenario my perception of the house and the man can have any order in time. In other words it is arbitrary whether I consider the man or the house first. For this arbitrariness in succession to be possible, the house and the man must exist simultaneously.[14] If we imagine two playing-cards leaning on each other (as in a house of cards), we immediately understand that they are mutually dependent on each other for the possibility of existing in the way they do. The push in a horizontal direction

[13] There are naturally causal laws that are not necessary for the preservation of the continuous character of time and space per se. The causal laws of empirical science must rather insure that time and space remains while at the same time appearances must correspond to empirical fact. It is therefore a negative prerequisite for any explanation that we preserve the continuous character of space and time. Before we can give particular laws [that the man must fall down (gravity), and that he must be alive before he is dead and cannot go from dead to alive (general laws of biology)] we must investigate the world around us. What we are considering here is the form or schema of causality, not particular causal laws in empirical science.

[14] We can also consider the perimeter, centre and area of a circle. Without a perimeter there can be no centre or area, without area there can be no perimeter or centre and without a center there can be no perimeter or area of a circle. The three aspects of a circle are therefore necessarily simultaneous as the one cannot exist without the other two existing simultaneously. This consideration is somewhat misleading, though, as it does not deal with substances. But it works as a clarifying example of how we can recognize reciprocal existence.

that is given by both to both is the effect of the reciprocal forces keeping the cards erect rather than falling down. For such a reciprocal relation to occur the objects must necessarily exist simultaneously.

The three relational categories and their schemata correspond directly to the three modes of time: substance (persistence), causation (succession) and community (simultaneity). Therefore they can only be related to human experience of things as phenomena and not to the things in themselves (for which time has no rationale). The relational categories are therefore functions through which we order the manifold of any experience in accordance with the modes of pure intuition. In other words: The ability to order objects in a temporal way.

4 <u>The categories of modality</u>

The categories of modality concern the mode of existence of any thinkable object or relation. If I imagine an event I can describe it through the three previous classes, but if I wonder about the reality of the event as an actual experience there remain three further questions:

1) Is it possible that this happened?
2) Did it actually happen?
3) Would it be possible for this not to have happened?

The following considerations deal with these questions.

4.1 <u>Possibility</u>

The schema of possibility is the agreement of the synthesis of various representations with the conditions of time in general (e.g., since opposites cannot exist in one thing at the same time, they can only exist one after another), thus the determination of the representation of a thing to some time. (Critique: B 184)

Through the principle of contradiction we can exclude an infinite amount of syntheses of the manifold that can be presented by imagination. This is simply excluding the contradictory, which means that there cannot be a universal law of gravity and a universal law of non-gravity valid for the same things, that my car cannot be blue and not-blue at the same time, and that an object cannot be in two places at the same time. In other words, the possible experiences (syntheses of impressions) are those that can be brought together without an internal contradiction and at the same time without the external contradiction of disrupting the continuity of pure intuition. These relations can, however, also be deemed impossible through General Logic.

When we are dealing with Transcendental Logic we must also consider for example the possibility of spatiotemporal coherence as referred to earlier, as well as the dynamical principles which underlie our understanding of the world. We must therefore consider what is possible, not only through what is logically possible (in the sense of non-contradictory), but also what is impossible on the grounds of coherence of concepts. One can, for example, exclude the possibility of a man jumping to the moon on the basis of fundamental dynamical principles of energy-exchange and so on. From this we see the relation of the categories of modality to the categories of relation as the possible existences are naturally "pushed" into different relations according to their possibility of existence.

4.2. Actuality

The schema of actuality is existence at a determinate time. (Critique: A 145)

The appearance of something at a particular time is the actuality of that thing. Traditionally philosophers have discussed the potentiality of a thing as a contrary mode of existence to its actuality in order to avoid the idea of creation (new substances coming into existence). For Kant there is no need of such a distinction as any change or appearance must be a coming and ceasing to be of accidents, not of substances. "An existence" is therefore the existence of accidence, or of a particular form of existence of the substance. The actual presentation of a particular accidence (i.e. in a substance as object) at a point in time is the actuality of it. This must, however, be contrasted with necessity (which contains the idea of the impossibility of the non-existence of something) in that actuality can always be formally rejected. By this I mean that one must find the actual object in perception, as it is neither necessary nor impossible.

4.3 Necessity

The schema of necessity is existence of an object at all times. (Critique: A 145)

The understanding of an object as necessary is the understanding of the lack of possibility of that object not existing at any given time. Causal laws are fundamentally connected to necessity, as their expression is an expression of necessity (i.e. succession according to a rule). We have also seen that substances necessarily exist at all times as their non-existence at any point in time would lead to the idea of creation.

4.2. Thinking Through Categories

This chapter has been dealing with the categories of the understanding by which we form a synthesis from the manifold of impressions in an actual experience and in the thoughts about previous and possible future experiences. To a large extent it is simply a summary of Kant's view and I have found no reason for objecting to it. In philosophy in general there are also few objections to this description of the functions by which we think, as it is coherent and in agreement with general logic. The main question and objection has been whether we can justify that the categories are valid for anything more than our thinking. In other words: *Does our thinking about objects tell us anything about the objects*, or must we simply deem the categories to be of psychological interest only and thereby as something to overcome in natural science? This question will be dealt with in the following chapter where we shall also see that the answer to that question is at the same time the answer to whether we can justify the Keplerian assumption that the universe is uniformly coherent and simple. What we know so far is that the way we think about experience and the way we experience is reducible to a set of functions that we can call categories. We also know that these categories are fundamentally connected to the pure intuitions, as they are an organizing of concepts of space and time.[15]

[15] Although a fuller exposition of this system is generally important in order to understand Kantian metaphysics, it would require an amount of space and technicalities beyond the purpose and ambition of this thesis. In my treatment of the categories I have primarily focused on the temporal aspect intrinsic to the system of categories. We have seen that all the categories are bound to a uniform understanding of time, since the occurrences of identical phenomena are only conceivable through the schemata of number (*quantity*), understood only through the temporal process of counting. The degrees of these phenomena as intensive quantities (*quality*) are conceivable only through the gradual change of an occurrence from a given degree of existence to its negation in time (or vice versa). The relations of any given phenomenon to all other phenomena (*relation*) are conceivable only as infinite (*substance*), following according to a rule (*causality*), or simultaneously (*community*). The modalities of the phenomena depend on their possible existence in time (*possibility - impossibility*), their actual existence in time (*existence – non-existence*), and the contradictions or non-conformity to the uniform nature of space and time of their non-existence (*necessity – contingency*). The uniform nature of time – which is our primary concern – is thereby considered to be a central aspect of the whole system of categories.

5.0. Justification of The Categories for Empirical Understanding

As we have presented the categories as abstractions of the synthesis of the manifold of experience into a unity in the understanding, we must ask ourselves whether this actually solves the problem of knowledge about the world. In order to answer that question we must ask some further questions about understanding and experience in general. Rene Descartes posed a problematic idealism where only the light of God could justify claims about the world, and without God's help there would just be rationality on one side and perception on the other without any possible unity. But what Descartes does not answer to a satisfactory degree is what the "I" of the Cogito-argument is. For Kant, on the other hand, this is a fundamental question. First of all the "I" is the unity that has experience. This means that when we receive impressions from the outer world there is something having those impressions. This is the "I" of "I think". But reception of impressions requires something to be received and therefore there has to be more than me in the world. If I am to think about impressions (spontaneity), I must receive impressions (receptivity), and if I receive impressions there must be something that influences me. In other words there must be some external world that makes thinking possible. We can thereby transform *I think therefore I am* into including *I think therefore there are things*.[16] So we have the guaranteed existence of an "I" and of things that influence that "I". These two aspects of any thought will be the topic of this chapter.

5.1. No Knowledge of The Objects in Themselves

Any human experience is, as we have seen, an experience through categories and pure intuition. An imagined experience that cannot comply with these fundamental aspects of understanding and intuition is deemed, well... imaginary. This means that the subject having any experience forms that experience in some fundamental ways. The thing in itself without the influence of the human mind is therefore impossible for any human being because in every observation there is perspective. A completely unbiased experience of the things in themselves, is an experience that cannot be had or understood by any human being no matter how much technology we put

[16] Under the title "*Refutation of Idealism*", Kant argues against the material idealism by showing that awareness of time is only possible if the internal change of consciousness (experience) has a correlating non-change. Change, as relational, is change between one stable state and one altering state. If there is to be consciousness of this change there must be some correlating reality that is unchanging. The unchanging nature of externally existing substances (as *a priori* conditions for the determination of time) is therefore necessary for the internal sense. Proof of temporal consciousness is therefore also proof of the existence of external things (*Critique*: B 274 – 279).

between ourselves and the object. Absolute objectivity qua unbiased experience appears simply to be a product of a misguided imagination, and can therefore not be a goal for scientific research. What must be the goal is objectivity in the sense we mentioned earlier, as the possibility of reproduction in thought or test. In that way we can ensure objectivity in the sense of common for all human beings and any scientific realism must rest on this definition of objectivity. We must accept that our impressions are not things in themselves but human representations of those things, i.e. phenomena, and that our thoughts are representations of those representations. We can no more know the world outside our possible experience than we can know about the afterlife. Knowledge of the things in themselves and the way they relate to each other (or indeed if they even do relate) is, in a word, impossible! For how should such knowledge be justified? Where should experience come from? Rather than dwelling on these questions, which in my view cannot be answered, we shall look at the having of experiences. From this we shall be able to finally justify the validity of the categories for all phenomena.

5.2. The Apperception

Any impression or thought is had by someone. Someone needs to receive the impression and someone needs to have the thought, which means that there must be some continuously existent "I" which is uniform in experience. This I must be constant and therefore substantial to any experience, since any observed phenomena is a moderation of consciousness of the observer. The subject is therefore, *qua observer*, a substance as he/she experiences this moderation. The moderation, as it is connected in a temporal manner to previous experiences had by the observer, must be a moderation of something constant that binds the experiences together into a uniform temporal flow. When we think about previous experience we see a time-line of events that are united in us. If we consider experience without this unity, we see that appearances must be independent impressions with no possible connection. As they are obviously connected we realize that the connecting feature of all experience is what we refer to as our self, the haver (sic!) of experience. We can also realize that the having of experience is itself the uniting of the manifold in a synthesis (which is formed by the categories). So the "I" is simply the persistence of a unifying principle that we cannot understand more clearly than any other phenomena. It is the possible connection of any impression to "I think", which means I organize these impressions in such a way.

The apperception must be thoroughly separated from the persona or product that we often refer to as ourselves. The self in that sense is not the corresponding "I" in all experience, but rather the product of it. To believe that introspection is a higher form of knowledge of the apperception, because we have direct connection to our selves in a way that can never be had about objects, is a vast misunderstanding of the actual situation. When we investigate ourselves, we consider ourselves as objects, i.e. as phenomena and products of experience, not as the subjective havers (sic!) of those experiences. It is that particular meaning that the apperception or the realization of the possible connection of "I think" is supposedly investigated through introspection. But the apperception is an ability not an object and it can therefore not be understood properly by treating it as an object.

5.3. The Mind and The World

We started our exegesis of Kant's philosophy by saying that Kant claimed to find a way to transcend the old dichotomy of empiricism and idealism, a claim that we can now finally justify. The initial assumption that led to the dichotomy was the idea that rational thought and empirical fact were fundamentally different and that there could be no justification for imposing one on the other. By asking what thinking and experience is, Kant shows us that this is a false assumption. The set of rules that governs our thoughts and the set of rules that govern the world around us are one and the same. This we can say since we have shown the absurdity of assuming empirical data to be independent of the human mind, and thereby data concerning the things in themselves.

All empirical data are simply representations of the things in themselves, i.e. they are the way in which we represent to us things as phenomena. The *way* to which we refer is governed by the rules of a synthesis of the manifold through the categories. So if all empirical data are governed by a set of rules, and that same set of rules governs our understanding or thought about the phenomena, we are fully justified in making claims about the world *a priori*. We can, in other words, make true claims about external affairs that are certain and cover possible future experiences. We are also justified in assuming that the world is uniform, understandable and simple as it conforms to our way of thinking. When Kepler claims that the world must be harmonious he is not making a wild guess based on wants and wishes. He is making a justifiable claim about how the world must necessarily appear to us since the harmony of the world is nothing but the conformity between the world and our way of thinking. It seems therefore that the fundamental thoughts of natural science, imbedded in it by its earliest prominent thinker, have been fully justifiable all along.

5.4. About Particular Instances

We have been able, so far, to justify the use of the categories on human perception and thereby on the world as it appears to us. This is the scope and necessary boundary of possible human knowledge. But we can also see that the categories of the understanding are purely formal functions needing material instances in order to tell us anything about the world. The justification of particular causal laws is the most common problem to be dealt with in this case and we shall stick to it. So: if I see an apple falling to the ground a number of times, how do I justify the necessity of the fall?

The answer to this is found in a multiple step procedure of converse abduction:[17] We have justified the use of causality in general as a necessary ordering of phenomena according to the succession of time. When we empirically perceive a single instance (as actual and not merely possible) we must find out whether the non-existence of the fall is possible, i.e. if the fall is necessary. This can only be done through the analysis of the objects involved in the event according to the categories. The fall of the apple is not a constant and necessary form of existence of the apple; it is subsumable as accidence and not as a substance and therefore it is prone to change. The form of that change can be dependent or independent. If it is independent it could occur without any given previous event. As we can test the previous events we can check if the apple still falls under any and all conditions. If it does not, there must be some condition or conditions outside the apple that is necessary for the fall to occur. If we investigate further we can see that all material things fall under those same conditions, i.e. as being close to another material

[17] "Converse Abduction: *The credibility of an explanandum, whether or not observed, is enhanced by its being explained at a deeper explanatory level"* (Kleiner 2003: 518). The main ideas of both Darwin and Kepler are shown respectively in Kleiner 2003 and Myrstad 2004 to be examples of converse abductive reasoning.

thing and as not being impeded by anything. The true genus of our investigation is therefore not apples, but material things. By looking at magnetism, as Kepler did, we can see an analogy for all material things. We can thereby posit the hypotheses that all material things attract each other through magnetic species.[18] When we have formed such a hypothesis, we can ask whether it is possible that the data we collect can be organized and understood in any other way than through the hypothesis of a magnetic force (gravity).[19] When we find that they cannot, we are fully justified in saying that apples necessarily fall, and will always fall toward the ground, due to the force of gravity. What we have done here is to constantly check the appearances with the categorical classes of quantity (the move from one apple to all material things), the fall from tree to ground (the events thinkable being in time), the fall as a closed event in time (as a succession, i.e. as a change of accidence according to a rule), and modality (as the necessary existence of this relationship at all times). In addition to this we have ensured the uniform and horizontal character of pure intuition (time and space). The single instance is in other words generalised, conceptualised and treated according to all the categories of understanding. The steps from general causality to particular natural law, to the testing of that particular law by the synthesis of the understanding, are the steps needed to justify a particular natural law as certain, and as an example of the *Synthetic a priori* in natural science.

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[18] I use "Species" in the sense of "subgroup" where the Genus "material things" are investigated qua magnetism. This seems justified, since the image of terrestrial magnetism used on the heavenly bodies is a part of the interconnection through laws that govern both celestial and terrestrial objects. Donahue describes Kepler's use of the term "species" as somewhat untranslatable in his introduction to *New Astronomy* (NA: 23-24).

[19] In General Relativity the explanation given is not by magnetic force but by the bending of space. This obviously does not count as a possibility in our description as it breaks with the conservation of the uniform character of space.

6.0. The Special Theory of Relativity

In 1905 Albert Einstein introduced the theory of Special Relativity, which was later to be enhanced by the theory of General Relativity, where the law of gravitational force was to be reformed. In this chapter, and in this thesis as a whole, the discussion is restricted to the Special Theory as it is in the justification for this theory we find the introduction of its most controversial aspect, the relativity of time and space. The relativity of time and space is intrinsic also to the General theory, but since we need to introduce a rather large amount of physics in order to treat General Relativity properly, we shall in the following discussion exclude it from our treatment.

6.1. Presentation of the Theory of Special Relativity (SRT)

As a vast simplification of what SRT is we can state it as an attempt to conserve two basic principles of physics: The principle of relativity and the light-principle. These principles had traditionally been considered commensurable, but Einstein shows us that this is not intuitively obvious. In order to save the two principles we must, according to Einstein, introduce the electromagnetic insights of Lorentz and Maxwell as not only valid for electromagnetic phenomena, but as generally valid for all moving bodies. The theories of electrodynamics can thus be reconciled with Newtonian mechanics. The cost of such a theory is first of all that Newtonian mechanics must be reformed in order to save the phenomena in a satisfactory way. A general misconception of SRT is that it is a completely new theory of mechanics that rejects Newton altogether. We shall avoid this misconception by simply noting that since SRT is a reform of Newtonian physics, SRT would make no sense without it. In other words: *Newtonian physics is a prerequisite for the Theory of Special Relativity.* In the same way, as we shall see, Einstein's concepts of time and space have more in common with the Newtonian concepts than generally assumed. In order to make sense out of the previous presentation we shall look at the relevant principles in SRT and Einstein's justification for them.

6.1.1. The Light-principle

The light-principle is generally accepted in physics, not only by relativity, as it has shown itself remarkably resistant to rejection. The principle simply states that *light moves at a constant velocity C, in vacuo, independent of the movement of its source.* This means that no matter how fast I am travelling in any direction, a light-beam emitted from me will travel at the same velocity. The speed of light is currently accepted as 299,792,458 metres per second, and most commonly noted as an approximation to 300 000 Km/second.[20]

6.1.2. The Principle of Relativity

The principle of relativity (in the restricted sense) is not introduced in SRT, but is explicitly stated by, among others, Galileo and Newton. We shall, however, present it in the words of Einstein: (Einstein 1: 15)

If, relative to K, K′ is a uniformly moving co-ordinate system devoid of rotation, then natural phenomena run their course with respect to K′ according to exactly the same general laws as with respect to K′.

What has been said here? First of all, *K* is any co-ordinate system and *K′* any co-ordinate system uniformly moving (i.e. moving at constant speed in one direction) in relation to *K*. So if I consider an event from my room while an aeroplane is passing over me, then a passenger on that aeroplane and I should be able to describe that event in exactly the same way (if the aeroplane is travelling at a uniform velocity relative to me). It thereby appears that events in the world are describable in the same way, independent of how we observe them. This principle seems intuitively reasonable as it retains the simplicity and uniformity of events in the world. Our identification of a phenomenon as being the same seen from different perspectives is inherent in the principle of relativity as the phenomenon would adhere to the same basic laws independent of it’s relation to the observer. If there was no such understanding of the laws of nature we would be hard pressed to identify a phenomenon, as seen from different perspectives, as one and the same. There is therefore a necessity, and implied understanding, that the laws of nature must be

[20] Source: *Oxford Concise Dictionary of Mathematics 2009.*

formulated in such a way that they are valid from every perspective. But we shall see that the combination of the light-principle and the principle of relativity (in the restricted sense) is not obviously coherent.

6.1.3. Light and Translation

Einstein asks us to consider a co-ordinate system, *K*, rigidly attached to a railway embankment. In addition to this we are prompted to consider a co-ordinate system *K´* attached to a train passing the embankment at velocity *v*. If there is a light-beam moving uniformly to *K*, it will move uniformly also to *K´* and it should be possible to express the light's movement relative to *K´* through the co-ordinates of system *K* (we should be able to translate the event-description in *K´* to the event-description of *K*). If we attempt to perform this translation we see that the light-principle cannot immediately be retained. Through Cartesian co-ordinates we describe the movement of the light relative to *K* (the embankment) as *c*, and the velocity of the train as *v*. A simple addition or subtraction of speeds thereby gives us the speed of light relative to the train as *c-v* or *c+v*, depending on the direction of the light-beam relative to the motion of the train. It therefore seems as if light does not travel at the same speed relative to all co-ordinate systems. The two most obvious solutions to this problem, rejecting the principle of relativity or rejecting the light-principle, are not satisfactory for Einstein and he sets out to find a third alternative.

6.1.4. On The Relativity of Simultaneity

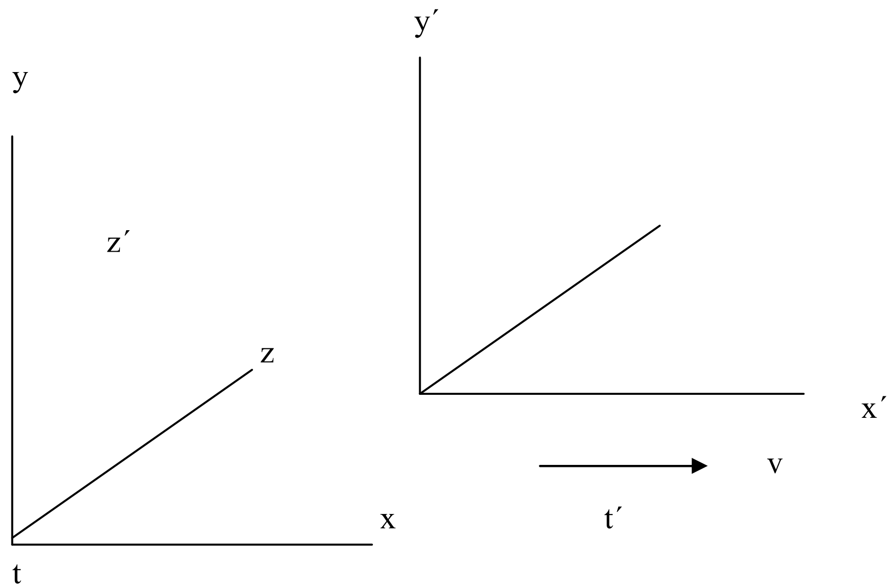
In our previous treatment of simultaneity, we dealt with its connection to reciprocal processes and the idea that one can move one's attention from one aspect of an experience to another. Einstein, on the other hand, wants to attain an operational definition of this concept, as is standard procedure in physics. This operational definition is given through a procedure for the measurement of simultaneity. The question we are facing is therefore no longer "what is simultaneity?" but how it can be measured. This distinction will be vital in the later treatment of relative time. So: In order to measure simultaneity we are prompted to consider an observer at the midpoint between two mirrors set in a position so that a light-beam from a lightning that strikes the mirror will travel a distance *D* and then meet with another mirror that reflects the light-beam toward the observer. If lightning strikes at two points perpendicular to the initial mirrors in such a way that the observer will experience them at the same time, the two instances of lightning are simultaneous.

We assume in this operational definition that the light-principle is valid and therefore that any light-beam travelling the distance *D* will spend an equal amount of time on that trip. We are then prompted to consider the same devise viewed from a train uniformly moving at velocity *v* in direction from *A* to *B*. In that case the simultaneous events in the sky will not be simultaneous to the observer, as the distance from the observer to the point *A* (of the mirror) will increase slightly, and the distance to *B* will decrease slightly in the intermediate time between the event of the light-beam from the lightning hitting the mirror and the event of the light-beam reaching the observer. The greater the speed of the train is the greater the difference. So it appears that universal simultaneity cannot be taken for granted, or in other words: *The measurement of simultaneous events appears to be relative to the movement of the observer.*

This indicates a rejection of the idea of simultaneity, and thereby time, as absolute. If simultaneity is relative to the observer's movement it can be argued that time and space (that are the fundaments of this operational definition of simultaneity) also depend on the observer's movement. Before we make that statement we need to look at how, in SRT, the rejection of temporal and spatial absoluteness is presented as a solution to our present problem.

6.1.5. The Lorentz Transformations

In order to reconcile the two principles Einstein makes use of the Lorentz-transformations and rejects the classical translations of Galileo. In the Galileo-transformations any event in a co-ordinate system *K (x′, y′, z′, t′)* can be translated into the system *K* in the following fashion:



$x' = x - vt$

$y' = y$

$z' = z$

$t' = t.$

If we use the Lorentz-transformations on the other hand, the translation must be performed in a slightly different manner:

$x' = (x - vt) / [\sqrt{(1 - v^2/c^2)}]$

$y' = y$

$z' = z$

$t' = t - ((v/c^2)\, x) / [\sqrt{(1 - v^2/c^2)}]$

A quick look at the Lorentz-transformations shows that they are superior in containing the uniformity and universality of scientific laws. If we are to express the event measured in *K’* through the system *K*, only the Lorentz-transformations allow for the simultaneous existence of the principle of relativity and the light-principle. Through numerous physical experiments it has been shown that the Lorentz-transformations are indeed valid as descriptions of actual phenomena. The significant parts of the transformations are found where they differ from the Galilean transformations, i.e. in the contraction in the direction of movement (*x´*), and the slowing down of measured time (*t'*). We shall deal with the possible interpretations of these parts later, and at this point simply accept that the Lorentz-transformations are superior to the Galileo-transformations in predicting phenomena in very high velocities.

6.1.6. Understanding The Lorentz-transformations

When we look at the calculations above, we see that measured time and measured space, when treated mathematically, appear to respectively slow down and contract at high velocity. This fact forces us to consider the fundamental ideas of physics, time, space and matter in a new way. For if matter is rigid and preserves its shape at high velocities, there must be some explanation as to why it appears to contract. Einstein finds the solution to this problem by rejecting what he calls *"two unjustifiable hypotheses from classical mechanics"*: (Einstein 1: 32).

(1) The time-interval (time) between two events is independent of the condition of motion of the body of reference.
(2) The space-interval (distance) between two points of a rigid body is independent of the condition of motion of the body of reference.

By rejecting these two hypotheses, Einstein is claiming that the time and distance between two events is not given. They differ depending on the movement of the observer. We have thereby seen that in SRT the determinations of time and space are relative to the observer's movement. This is a possible interpretation of the Lorentz-transformations and at first sight it seems coherent. In the next chapter we shall first look at some of the assumptions in SRT that led to the conclusion of relativity of time and space. By analysing these assumptions we shall see that first, there are other possibilities of explanation, and second that the alternative explanations are fit to fulfil the demands set on scientific explanations in the previous chapters of this thesis.

7.0. The Roots and Contemporary Understanding of Relativity

We said in the former chapter that there are two major interpretations of SRT and that Einstein can be seen, at different points in time, as a proponent for both of them. In this chapter we shall justify that statement and take a brief look at the alternatives to the standard interpretation. The reason for doing this is to show that at the time of presentation of SRT there was, as there still is, other interpretations presented that had a major role to play for the development of physics.

7.1. A Short History of SRT

The time leading up to the end of the 19th century was a time of open questions or frontier science. This means that at the time, some of the fundamental principles of classical physics were being questioned. The major reason for this was the introduction of Lorentz and Maxwell's theories of electrodynamics. The classical principle of relativity (which we, following Einstein, have called "the principle of relativity (in the restricted sense)") seemed incommensurable with the well-confirmed new theory of electrodynamics. The principle of relativity (in the restricted sense) states that it is impossible from experiments to deduce whether a system is moving. As the principle of relativity (in the restricted sense) is vital to the understanding of symmetry in natural science, it is not one that can simply be brushed off. The effect of the principle is that a device will behave in exactly the same way in all systems independently of their position in space or time, assuming that the external forces working on the system are equal (i.e. as long as the system can be regarded as "closed"). Lorentz presented a solution to the discrepancy by introducing what was soon to be called "the Lorentz transformations". It is the meaning of these transformations that is at the core of the rift between the two interpretations of SRT. Since the ether, as a stationary ever-present base for matter, appeared to be impossible to prove real by experiment, Einstein set out to find a different solution that could exclude the ether-theory altogether. Einstein had good reasons for doing this, as the ether was now apparently a supposed existence introduced to "save the phenomena". Throughout the history of science, scientists have tried (sometimes successfully) to remove non-provable existences, and since the ether was also seen as a non-detectable universal force the justified removal of it would apparently be beneficial for the simplicity of scientific explanation. Einstein therefore set out to understand the Lorentz-transformations as excluding the ether-theory while holding on to the principle of relativity (in the restricted sense) and the light-principle. This is done through a generalization of principles of electrodynamics as valid for all of mechanics. In order to do this, Einstein considered it a necessity to exclude the priority of a system "at rest", as this was commonly understood as "at rest in the ether". Later on we shall see that the idea of a system "at rest" does not need the ether-theory for its use. The importance of these principles for Einstein's thoughts is most clearly shown by Einstein himself in the introductory part of his famous 1905 article "*On the Electrodynamics of Moving Bodies*".

7.1.1. "On the electrodynamics of moving bodies"

It is well known that Maxwell's electrodynamics - as usually understood at present - when applied to moving bodies, leads to asymmetries that do not seem to be inherent in the phenomena. Take, for example, the electrodynamic interaction between a magnet and a conductor. The observable phenomenon here depends only on the relative motion of conductor and magnet, whereas the customary view draws a sharp distinction between the two cases, in which either the one or the other of the two bodies is in motion. For if the magnet is in motion and the conductor is at rest, an electric field with a definite energy value results in the vicinity of the magnet that produces a current wherever parts of the conductor are located. But if the magnet is at rest while the conductor is moving, no electric field results in the vicinity of the magnet, but rather an electromotive force in the conductor, to which no energy per se corresponds, but which, assuming an equality of relative motion in the two cases, gives rise to electric currents of the same magnitude and the same course as those produced by the electric forces in the former case. Examples of this sort, together with the unsuccessful attempts to detect a motion of the earth relative to the 'light medium', lead to the conjecture that not only the phenomena of mechanics but also those of electrodynamics have no properties that corresponds to the concept of absolute rest. Rather the same laws of electrodynamics and optics will be valid for all coordinate systems in which the equations of mechanics hold, as has already been shown for quantities of the first order.
(Einstein 2: 124)

The main argument is, as we can see, that the idea of the conductor or the magnet being "at rest" in a fundamental way gives different results. Since we have been unable to establish an experimental foundation for describing which is at rest, we are forced to arbitrarily choose between the one result and the other. This choice cannot be *inherent in the phenomena* and it appears that the assumption of absolute rest is one of unreasonable priority rather than reality. Since "absolute rest" refers to the non-movement relative to the ether, Einstein opts to remove the idea of ether all together. The removal of ether seemed a reasonable one at the time although we cannot thereby reject all possible ether-theories in the future. Einstein goes on from this to discuss simultaneity, length and time of events and it is important to note that the terminology utilized in this groundbreaking article differs slightly from the standard interpretation that Einstein later supported. On the non-absoluteness of simultaneity he concludes: (Einstein 2: 130)

Thus we see that we cannot ascribe absolute meaning to the concept of simultaneity; instead, two events that are simultaneous when observed from some particular coordinate system can no longer be considered simultaneous when observed from a system that is moving relative to that system.

We shall see later that the rejection of simultaneity is not properly defendable, but for now we shall simply note the focus Einstein puts on events being simultaneous for observers in different systems, rather than the events actually being simultaneous altogether. Since we saw earlier that Einstein argued against the conductor or magnet being at rest because the results differ, not because of the phenomena, but from how they are measured, we must transfer his understanding to simultaneity and assume that the non-absoluteness of simultaneity is meant as a non-absoluteness of *measuring simultaneity*. This non-absoluteness follows from the rejection of the idea of something being "at rest". When dealing with what would later turn into "space contraction" and "time dilation" Einstein's language is remarkably modest, and he does not introduce any explanation for what is treated as the contraction of measuring-rods and the slowing down of clocks. He simply states that the effect of the Lorentz-transformations is that these things occur. In this article there are a couple of important features that we shall need to emphasize:

1) The traditionally mechanical principle of relativity (in the restricted sense) is generalized and made valid for all physical phenomena.

2) The Lorentz transformations are generalized and deemed valid not only for electromagnetics but also for classical mechanics. This means that classical mechanics are somewhat modified.

3) Einstein's examples show that by utilizing the principle of relativity (in the restricted sense), the light-principle, the lack of a prior "rest system" and the Lorentz transformations, there

is no measurement of absolute simultaneity, and measuring-rods contract and clocks run at different rates in different systems in uniform translatory motion.

From the more specifically electrodynamic investigations of “The electrodynamics of moving bodies” Einstein concluded in “Does the Inertia of a Body Depend on its Energy Content” that mass can be a measure of energy, which the arguably most famous single formula in the history of science ($E=MC^2$) expresses.[21] These two articles transformed Einstein from a patent office clerk to the very manifestation of modern physics and natural science, a transformation that sometimes appears to have given Einstein’s authority a function of veto in the next hundred years of relativity physics.

7.1.2. Einstein on SRT as a Principle Theory and as Explanation

As said earlier, we may see Einstein, at certain points in time, as a proponent for the principle theory interpretation of SRT. This means simply that at some point Einstein considered special relativity not so much as a theory, but more as a heuristic principle (Stachel: 117).[22] Considering the background confusion over basic physical laws, this approach seems intuitively attractive as it avoids unfounded and possibly unjustifiable assumptions about the nature of nature. Einstein describes the kinematic aspects of SRT (with which we are primarily concerned) at this point as “*a heuristic principle, which considered by itself alone only contains assertions about rigid bodies, clocks, and light signals*” (Einstein, as cited in Stachel: 117). In a 1919 “Times” article Einstein distinguished this type of theory from *constructive* theories that provide an understanding of the phenomena through an interpretation of the results (Myrstad/Sandmel: 11-13). At this point we are in other words supposed to see the contraction of measuring rods, the slowing down of clocks and the non-ability to measure simultaneity as empirical facts that are not yet understood. In the same year Einstein made a somewhat different claim in a “New York Times” interview: (Einstein 4)

[21] Einstein 3.

[22] In other words the theory is not so much a theory as it is a limiting set-up of proposed valid principles from which a secure ground can be laid for further understanding.

Till now it was believed that time and space existed by themselves, even if there was nothing else - no sun, no earth, no stars - while now we know that time and space are not the vessel for the universe, but could not exist at all if there were no contents, namely no sun, earth and other celestial bodies.

This latter claim is one of explanation of the contractions of rods and slowing down of clocks. It seems therefore that at some points in time Einstein confused the possible valid understandings of his theory. If the theory is a principle theory there can be no explanation in it. This does not mean that conclusions cannot be drawn from it, but rather that any conclusion or explanation needs further justification. In this case the needed justification is one of transferring the results of measurements of clocks and measuring-rods to time and space determinations. We shall see later that this is not obviously justifiable.

7.1.3. The Realist Interpretation of SRT

The latter quote of the previous paragraph shows Einstein as a proponent of realist SRT. This interpretation concludes that if all materials are measured to contract and all clocks to slow down in moving systems, the explanation must be that time and space themselves slow down and contract. This interpretation is the standard interpretation of SRT in contemporary physics and it has led to the claims that Absolute Space and Time must be rejected. This latter claim can, to a certain extent, turn out to be a fruitful one, understood as identical to Kant's negative claim about Newtonian absolute time and space. For Kant the Newtonian absolute time and space are empirical non-existing existences that have absolute reality in the sense of things in themselves or noumena. This, as we have seen, makes absolutely no sense under the Kantian metaphysics. For Einstein on the other hand it is absoluteness as the "everywhere and at all times" of time and space that are to be rejected. The realist interpretation therefore sees the measured slowing down of "time" in a system as an *actual slowing down of time*. This implies that there are many "times" that do not "act" the same way and the idea of absolute time as an all-pervasive horizon is thereby rejected. This interpretation also instructs us to understand contractions and slowdowns as somewhat unreal or confused observations, as the actual phenomena are not that rods contract and that clocks slow down, but rather that the space and time of their systems contract and slow down. This means that contraction of material objects and slowing down of material clocks *relative to the time and space of the system* never occurs! If it did we would be forced to re-write the Lorentz-transformations, since they would be invalid for observed phenomena. If there is space contraction and time dilation there can be no object contraction and clock dilation, as we would then be forced to implement the Lorentz transformation two times. The mathematics of it would then simply not add up.[23]

7.1.4. The Principle Interpretation of SRT

The principle interpretation of SRT treats SRT as a heuristic principle in the sense that it is a mathematical model based on physical principles, allowing us to formulate secure, but not understood observations. The question of why measuring rods appear to contract and clocks appear to slow down is thereby considered as an open one.[24] Traditionally this interpretation of SRT has been glued to ether theory and therefore rejected on principal grounds by physics in general. This is at least the case with its major proponents Poincaré and Lorentz. The reason for this connection is that in order to see contraction and dilation as material actualities, we must see them from a "rest system". Otherwise it all depends on the observer's movement relative to the system of measurement, and that system must be arbitrarily chosen if there is no "rest system". From inside the "moving system" the rods and clocks will behave as normal as proclaimed by the principle of relativity (in the restricted sense). We shall therefore immediately ask ourselves the main question at hand: Is there an argument for treating a system as "at rest" and not all others? The positive answer to that question can be found not only in ether theory but also in Einstein's own thought experiments. Before we can properly answer the question we must take a closer look at what is implied in realist SRT.

[23] The Hafele-Keating experiment on cesium beam clocks sent around the world is an example of how the use of the Lorentz transformations on "time" and "clocks" is problematic. Their result is that the travelling clocks actually slowed down relative to the stationary clock (Hafele & Keating: 1972). If this is an expression of "time dilation" there should be no way of deciding which of the clocks were "really" moving and it should be possible, from the system of the "travelling" clocks to view the "stationary clock" as dilated, contrary to the results of the Hafele-Keating experiment. If, however, the result is viewed as "clock dilation" we meet the double-application-of-transformation problem. Understood as an experimental 'confirmation' of General relativity, it paradoxically appears to be not conformable to Special relativity.

[24] Hans Reichenbach also notes in his classic *The Philosophy of Time and Space* that "*we can speak of an explanation by Einstein's theory as little as we can speak of an explanation by Lorentz's theory*". However, Reichenbach still sees Einstein's theory as superior in "*the recognition of the epistemological legitimacy of his procedure"* (Reichenbach: 201-202). The legitimacy of Einstein's procedure will be discussed in the following chapter.

8.0. A Critique of Realist SRT

In this chapter we shall look at some aspects of the realist interpretation of SRT that shows this interpretation to be unsatisfactory as a scientific explanation according to the rules set up in chapter 2. Our main focus shall be the apparent inconsistencies in the realist SRT's use of the terms "time" and "space" and the contradictions that follow from this use. We shall first look at the internal contradictions in realist SRT, and then look at the more basic misunderstandings that appear to underlie the idea of clocks and rods as time and space measurers.

8.1. Utilizing Both Absolute and Non-absolute Concepts of Time and Space

In Einstein's thought experiment (as relating to simultaneity) we are prompted to consider two co-ordinate systems, S and S´ that are in relative motion to each other. A quick look at the term "motion" reminds us that in order to have motion there must be an underlying time and space in which that motion occurs. This underlying time and space must be common for the two systems.[25] As we saw in our treatment of Kantian metaphysics, a prerequisite conception of time and space as underlying all spatial and temporal relations (i.e. all possible experience) must imply *a priori* concepts of time and space as pure intuitions. Time and space as pure intuitions do not (as we have also seen) move and are therefore absolute in the sense of non-changing. In other words universal time and space are implied in the very foundations of the framework for Einstein's thought experiment. When proponents of realist SRT claim that time slows down due to the system's movement, there is an implied "tempo" of time from which the movement causes a "slowing down". We have seen that universal time can have no such tempo and that therefore there can be no slowing down from it. The conceptual basis for the idea that time slows down seems to be on shaky grounds since the dilation of time contradicts absolute time. The new relative time of SRT is indeed seen as new and revolutionary because of this aspect, but one seems to miss the simple observation that universal time is implied in the very framework for the experiment. What we are dealing with here is therefore not the old theory of absolute time and space, contradicted by the new theory of relative time and space. We are dealing with a theory that utilizes both absolute and non-absolute time and space notions at the very same time. Since

[25] In order for the two systems to be in a spatial relation, they must occupy different points in the same space. A reference to the "different spaces" of realist SRT only moves the problem one step further as these "different spaces" must be in a spatial relation to each other, and thereby in the same space.

we have seen that there is a contradiction involved between the two sets of concepts, we must realise that there is an internal contradiction in the way that realist SRT describes time and space. This contradiction is not one that can be removed by further investigation or experiment, as it is a fundamental contradiction in the very conceptual basis of the theory. A theory that states that time and space are not absolutes cannot coherently utilize absolute concepts of time and space, as it is done in the theoretical framework of relatively moving coordinate systems in SRT. There is, however, no way to set up the thought experiment without already assuming absolute time and space, so the conclusion seems principally impossible! The principle of internal coherence as dealt with in chapter 2 seems therefore not to be satisfied in realist SRT, since realist SRT breaks the rule of "conservation of meaning" in relation to the use of the terms "time" and "space".

8.2. Relative Concepts of Time and Space are Self-Contradictory

If, for the sake of argument, we propose that the only concepts of time and space in realist SRT are relative ones, we will still be caught in a contradiction. This contradiction follows from the methodical principles set up by Einstein in his thought experiment on simultaneity (See Einstein 1: 23 – 29). Einstein rejects any possible simultaneity measurement on the basis that according to his operational definition the phenomena will present themselves as simultaneous in one system and not in the other. This means that Einstein gives *equal value to the two measuring systems at the same time*. Now if we hold on to this method when considering time dilation and space contraction, we see that for an observer in system S, the space and time of system S′ is contracting and dilating while those of system S are not, and for an observer in system S′ the space and time of system S are contracting and dilating while those of system S′ are not. By holding on to both measurements at the same time we find that space and time of systems S and S′ are contracting and not contracting, and dilating and not dilating in the same instance! We are thereby presented with clearly contradictory results if we follow Einstein's method of measurement. We must therefore ask ourselves what is wrong with the presuppositions of realist SRT in order to see if we can find either an alternative interpretation or an internal solution to these contradictions.

8.3. Mathematics as Phenomena

In chapter 2 we saw that Kepler defended the truth-claims of astronomy by rejecting Ursus' equation of geometrical and physical hypotheses. This distinction appears to be neglected also in the realist interpretation of SRT as the mathematical treatment of time and space as relative variables functions as an argument for the actual dilation and contraction of time and space. We are thereby confronted with the use of geometrical models acting as physical proof. The mathematical expressions of the slowing down of clocks and contraction of measuring rods are equivalent for the realist and the principle interpretations of SRT and can therefore not be used as an argument for one or the other interpretation. SRT in the realist and the principle interpretations are equally able to save the phenomena in a systematic way due to their mathematical equivalence.

There is also no satisfactory explanation of the phenomena in either of the interpretations as we are here temporarily neglecting ether-theory as a solution. If we consider the above contradictions of the realist interpretation of SRT, we see that as a theory it fails in the physical (here also including the metaphysical) sphere. In the remaining treatment of the realist interpretation of SRT we shall look at the underlying paralogisms that lead to the realist interpretation and how they can be resolved through a principle interpretation of the theory. Through this we shall see that the realist interpretation of SRT relies on an unfounded understanding of time and space as empirical concepts.

9.0. Universal Simultaneity

The realist SRT proponents see the apparent lack of universal simultaneity that follows from Einstein's thought-experiment of the mirror-contraption, when understood as an operational definition of simultaneity, as an argument for the relativity of simultaneity. We shall now take a closer look at what is going on in that experiment and we shall see that there are some problems with Einstein's conclusion (Einstein 1: 23 – 29).

9.1.1. Relativity of Measurement of Simultaneity

Einstein is only able to show that there is no way of measuring the simultaneity of events at a distance through his operational definition.[26] In his example we are prompted to accept that a meteorologist has claimed that two lightning strokes occur simultaneously. He then sets up an operational definition that will enable us to test the validity of this claim. This means that the actual simultaneity of the events is assumed true until proven invalid. In other words the claim "the two lightning strokes occur simultaneously" play the role of supposition in the argument. The mirror-contraption is deemed valid on the basis of the light-principle in combination with the constancy of distance between the events and the observer. There is no other way by which we would accept the definition. With this I mean that the distance from light beam of lightning *A* of mirror *A* to the observer takes light *x* amount of seconds to traverse, and that the time (*x*) of this travel is equal to the time it takes light from lightning *B* of mirror *B* to reach the observer. This is the function of the "middle point". It intuitively makes sense for us since the constant distances are assumed. When Einstein moves the observer to the train, however, this assumption is no longer valid. From this we must conclude that there is something missing in the operational definition of simultaneity. Our initial proposition was that there is simultaneity of two events. When it turns out that the measurements controlling the truth of that proposition are depending on the velocity of the observer relative to the measuring-devices, and we assume that there is no way of knowing if you are moving or not (as the principle of relativity states), we can only conclude that we do not have a secure method of measurement of simultaneity at a distance. What we cannot conclude is that the events are not simultaneous, as this would be stretching the

[26] In "*Light signals on Moving Bodies as Measured by Transported Rods and Clocks"* H.E. Ives emphasizes the difference between indeterminacy (as with Einstein's definition) and nonexistence (Einstein's interpretation), as well as showing a possible method for measuring simultaneity at a distance (Ives: 1937).

conclusion far beyond the information given in the premises. The reason that the device does not work is that we cannot know, under these circumstances, whether or not we are at the middle point at the time of observation. The fact that we presume ourselves to be at the middle-point at the time of the events is irrelevant as the events are real to us only when their effects reach our senses. To make the point clear, we can assume that we are at the middle point of some pair of events on Monday morning when the events occur in space. If the event-effects take two days to travel to earth we cannot justifiably assume that we are still at the middle point without knowing our movement (we could in principle have travelled to the moon in that time). This uncertainty is exactly what makes Einstein's operational definition of simultaneity unsatisfactory. But therefore to state that there is no simultaneity is simply bad judgement in this case. We could claim with equal justification that there is simultaneity, but that we are unable to measure it. According to the guiding principles of scientific thinking we shall do exactly that. We shall accept that *under the precept of the principle of relativity in Einstein's application of it there is no possible measurement of the simultaneity of events at a distance*. This of course does not mean that there is no simultaneity. That claim is equivalent to claiming that since we cannot observe God, we are justified in concluding that there is no god. We must conclude that we have no way of knowing!

9.2. The Relativity of Measurements of Time and Space

Now if all moving clocks run slower, if no way of measuring time gives anything but a slower rate, we shall just have to say, in a certain sense, that time itself appears to be slower on a space ship. (Feynman: 61)[27]

In this passage Feynman reveals a fundamental error of realist SRT, the identification of clock measurements and time. Through a somewhat closer look at what time and space measurements actually are we shall see that the identification of time and clock modifications is highly problematic.

9.2.1. Measuring time and space

When we want to measure time and space we must consider the special role that time and space plays in our experiences. We might otherwise fall victim to what Kant calls the "transcendental

[27] The space ship in Feynman's example plays the role of the train in Einstein's example, i.e. as a moving co-ordinate system.

illusion" where objects, concepts and principles are all treated in the same way (i.e. organizing features of different parts of the human mind are taken to be of the exact same kind and treated in a united logical system). We saw in chapter 2 that the distinctions between observational data, geometrical hypotheses and physical hypotheses also play a major part in Kepler's philosophy of science and his methodical treatment of the apparently observationally equivalent hypotheses of Tycho, Copernicus and Ptolemy. The main reason for this distinction is the distinctive nature of each topic. In physical hypotheses we are to understand the phenomena, while in geometrical and kinematical hypotheses we are to present them in mathematical formalisms. Both the physical and the geometrical and kinematical hypotheses need to "save the phenomena" in the sense that the theories must conform to theoretically justified observations. However, if we treat these different aspects as members of one logical group, we might end up committing ourselves to paralogistic judgments. We shall look at how this is done in the realist interpretation of SRT, but first we need to consider the general relation between measurements and phenomena.

When we set out to measure something we do this with some sort of physical device (wave-train, atomic decay, barometers etc.), which imply what we call an *operational definition*. That physical device will *always* be a possible victim to influences from what it is supposed to measure and from outer influences that modify the phenomena and the device. A presupposition for trusting the ability of the device to measure what we want is that we can control these influences. We shall call this "the criterion of control". More than this we need an actual object to measure. If we want to measure processes or forces we need to substitute the object for other objects that can reasonably be said to show the action of the force. An example of this is measuring gravity. Since gravity cannot be observed directly, we must observe it indirectly through the relationship between material objects. A method we shall call *analogue measurement*.

The validity of using analogue measurements depends on the satisfaction of the criterion of control. Since the main task of measuring is to standardize the phenomena and thereby order them, we also need a unit of measurement (meters, seconds, bars, moles etc.), attached to some imagined or real object of reference. The *measuring result* must be expressed in a unit of this sort. So: When we measure something we need units and objects (as phenomena or representations of the rules behind the phenomena). These must be organized in a *system* that we treat as a *closed system* when we have excluded the influences on the measuring devices from either external factors or internal factors outside our area of measurement. When we want to express results from different systems in one system, we must transform the data according to some procedure. This is the role of the Lorentz-transformations in SRT.

9.2.2. The Criterion of Control

When we want to investigate the level of control we have over the influences on our operational definition, we take counter-measures. Counter-measures may take the form of either changing the material of our device, or manipulating the variables of our experiment. We know for example that all materials contract or expand as a function of heat, and that this expansion/contraction is different for different materials. It is because of this that we define the meter as an object of a certain material under certain heat-conditions. If we can find no change when we manipulate the device we usually assume that the device is not influenced. If it does change, we usually specify our device further until we reach a stable non-change set of variables (as with the meter).

9.2.3. Operational Definitions

The devices we use for measuring are based on operational definitions. The operational definition is therefore not the actual device, but the standard on which the use of the device for measurement is based. We do not go to Paris to measure how tall we are, but we measure it with a device that is based on the Paris-meter. When we want to measure processes, forces etc. we use objects that have properties that are presumably relevant for what we want to measure. If, for example, we want to measure temperature, we can use the principle of thermal expansion and the relevant relations between thermal expansions of different materials in order to perform a standard measurement for temperature. This approach is based on the operational definition of temperature for a given scale (as shown earlier). With most phenomena, we can meaningfully construct operational definitions and base physical devices on them, and finally measure an instance of the phenomena. We can take counter-measures to ensure the level of control, and thereby we can feel confident that what we measure is what we are actually looking for. But when we deal with time and space (which are the prerequisites for the existence and determinability of the phenomena and not phenomena themselves), there can be no counter-measures, as all experience is made possible through time and space. We seem therefore to be in some difficulty. We do, however, have some sort of solution to this difficulty in that we measure time-intervals and distances with clocks and measuring-rods. We shall look now at how this is done and what kind of results follow from these measurements.

9.2.4. Measuring Time and Space

There is no direct observation of space and time and therefore there can be no treatment of space and time as material objects. But in order to measure velocity, force and objects we need some kind of standard for space and time determinations. The solution we have found is to standardize *duration and distance*. The meter is the distance from end to end on a material object kept in a special place in Paris, and duration is measured by regularly repeating processes. We cannot, however, go from measurements of duration and distance to determinations of time and space themselves. We saw in our treatment of time and space in chapter three that the pure intuition of space and time must be prior to relations between objects. This means that space and time must be prior to distance and duration. If we try to go the other way and add durations and distances to each other and by this arriving at determinations of time and space, we see that this addition can only be performed by placing the durations and distances after and next to each other. In other words, the addition of measurements of duration and distance requires a pre-existing understanding of time and space. We must therefore conclude that duration and distance-measurements are not measurements of time and space. Rather, time and space are the prerequisites of the possibility of duration and distance-measurements. For the further discussion of this topic we shall set the following statement as true: *There is no measure possible of time and space themselves.*

Distance and duration are measured analogously through operational definitions represented by objects. We have already dealt with the meter as a unit based on a material object under certain conditions, and we shall see that duration-measurements require an operational definition of the same kind. Duration is measured by clocks. A clock can be anything material (wave-patterns, planetary movement, atomic decay etc.) that shows change at a regular rate. Change at a regular rate means that the object shows a type of change that can be treated as identical on every occasion, and that the duration of that change is always the same. The frequency or regularity of change of the clock can only be judged in relation to other objects of regular change. From these regular processes we can create a unit, for example second, which is represented by an operational definition (atomic halftime etc.). Measurements of duration are therefore measurements of the regular change of one object in relation to the regular change of another object. The true "speed of change" of something as an absolute non-relative predicate, is a nonsensical notion. We can no more know the absolute speed of something, than we can know the absolute speed of time. Moments in time and durations of processes are only meaningfully explained as relations between events (the year 2010 is 2010 revolutions of the earth around the sun after the birth of Jesus).

9.2.5. The Criterion of Control in Duration and Distance-measurements

The criterion of control in measurement is an estimate of the degree to which we can guarantee that the measuring results reflect the actual behaviour of the object we are measuring. We have seen that in distance and duration-measurements a conventional standard (unit) must represent duration and distance, as in clocks or measuring-rods. Since these representations are necessarily material, we are always faced with the possibility that our measuring results follow from a change in the behaviour of the clocks and measuring-rods rather than from a change of duration or length of the measured object. We thereby need counter-measurements to ensure that our results reflect the properties of the phenomena themselves. If we change the materials and the results stay the same, we always have three logically possible explanations: 1) the results follow from the *actual behaviour of the phenomena*; 2) the results follow from a *change in the materials used in measuring*, and 3) *both.* If we assume that the results follow from a change in the materials and that change appears to be universal – not depending on the type of material - we are faced with the possibility of a more fundamental aspect that governs these changes. This more fundamental aspect – in the case of distance and duration measurements - can be the realist SRT supposition of time and space change, or the principle interpretation of SRT assuming that the change must be due to a fundamental character of matter itself. However, if we assume that the change is due to a fundamental aspect of matter itself, we must also assume some sort of universal force that works on all matter. Since we want, for the conservation of the simplicity of scientific explanations, to avoid the introduction of universal forces that cannot be observed or tested, we usually reject the second option. In duration and distance measurements the case is not so simple. This is because the alternative interpretation, realist SRT, is equally in need of an explanation through a universal force. Additionally, if we assume that the change is due to the actual behaviour of the phenomena, which in this case implies that the measuring materials do not change, we must be able to justify the difference of behaviour of our material measuring devices and the materials that we set out to measure. The Lorentz transformations do not allow for such a distinction, as they are used in realist SRT. In realist SRT the Lorentz transformations are set as kinematical tools and must therefore apply to all movement, independent of what is moving. There is therefore no possible justification for option 1 and option 2 in duration and distance measurements. However, if both the phenomena and the measuring devices change, there must be some underlying universal force that governs the change. From this we must conclude that the problems of explaining duration and distance measurement results as a function of motion can not be solved through measuring procedures in the same way as in the case of for example heat. Since distance and duration is inherent in all phenomena there is no possible counter measure and therefore no empirically based explanations.

9.2.7. Rejecting the Standard Claims of Realist SRT

We have seen that the idea of duration must be a limitation of the intuition of time as a horizon. So the "certain sense" in which Feynman claims we are to understand that time slows down in a moving system can be none other than in the sense that the duration of regular events appear longer. The standard justification for the supposition of time dilation at this point is that we need to avoid an unobservable universal force. But how does time dilation avoid this need? Can we really treat the slowing down of time as something that needs no explanation? And if we can, why does the slowing down of temporal processes (clocks) need one? We are clearly faced with a situation where the universal force is apparently needed for both explanations and is therefore not valid as a reason for the preference of one of them. So we must ask ourselves if we are justified in equating the apparent expanded duration of processes with the slowing down of time. In order to accept the equation we need a justification for duration in general as a measure of time. We have seen that there can be no such justification and so it appears that the relativity of time as a function of movement based on a framework that presupposes time as a horizon is highly problematic.

The view of realist SRT proponents has been shown to contain two major arguments. The first argument is that time dilation is experimentally proven. This argument is clearly false, since we have shown that the only experimental data we can produce are data of the slowing down of clocks. Since we have also shown that clocks do not directly measure time, there can be no experimental justification of time dilation. The second argument is that clock dilation (i.e. the slowing down of regular processes) needs an explanation that appears possible only through the reference to a universal unobservable force. We have seen that there is indeed such a need, but that this need also pertains to the interpretation of realist SRT.

9.3. Rejecting a Principle

The concept does not exist for the physicist until he has the possibility of discovering whether or not it is fulfilled in an actual case. We thus require a definition of simultaneity such that this definition supplies us with the method by means of which, in the present case, he can decide by experiment whether or not both the lightning strokes occurred simultaneously. As long as this requirement is not satisfied, I allow myself to be deceived as a physicist (and of course the same applies if I am not a physicist), when I imagine that I am able to attach meaning to the statement of simultaneity. (Einstein 1: 24)

The above understanding of the meaning of concepts appears to guide Einstein's thinking about relativity in general. We must however remember that relativity deals with the metaphysical concepts of time and space where we have shown that there is no possibility of operational definitions. We shall reject Einstein's claim that the concepts of time and space have no meanings in physics unless there exist some operational definitions of them, for two major reasons:

1) Operational definitions can only be construed for the measurement of distinct phenomena (i.e. phenomena that can be separated from other phenomena and have possible counter-measures), and time is no such thing.

2) Metaphysical concepts and principles that have no possible meaningful operational definitions (for example causality in general, reciprocity and simplicity) are integral parts of any and all physical theory.

The notion that all concepts and principles must have measured or measurable references, or be rejected as meaningless, is therefore a nonsensical notion that – if taken at face value - implies the rejection of the pretension of any scientific understanding whatsoever. Scientific understanding is the explanation of phenomena. If we are to explain the phenomena we are completely dependent on metaphysical notions such as unity, causality, reciprocity, quantity and so on… We must therefore accept that even though this principle may make sense in the sphere of phenomena, where properties of an object can be given meaning through operational definitions, it does not make any sense in the sphere of metaphysics. When we are dealing with simultaneity, time and space, we are dealing in metaphysics. To simply ignore this fact and treat everything as empirical properties and objects is to submit to the transcendental illusion Kant warned us about.

9.3.1. Reduction from Pure Intuition to Phenomenon among Phenomena

But a thoughtless man who pays attention only to the numbers will think that the same results follow from different hypotheses and indeed that the truth can follow from falsehoods. (Apologia: 141)

The realist interpretation of SRT states that time slows down as a function of the movement of matter in space; this means that time must have dynamical properties that make it a co-operator in physical processes. In other words time has the possibility to influence or be influenced, which is nothing short of defining time as a physical object. A common misunderstanding often lending support to this idea is the notion that aging or deterioration processes of all physical materials are functions of or caused by time. The aging-processes of physical materials are not due to time directly but to the breaking down of the materials caused by physical processes *in* time (as for example the aging of the human body is a function of the destructive force of "free radicals"). If we misunderstand these processes and think that time in some way creates physical processes, the reverse idea that physical processes can also influence time is easily adopted. But none of these ideas have any justification as they are both based on the idea that if something happens *in* time, it happens *because of* time. If we are to believe fully that time and space "act" on objects in the way that realist SRT claims, we need a clarification of the possible ways in which these "objects" can exist. How, when it all boils down to it, can time and space act? If they are objects they can no longer be the prerequisites of objects they have been treated as, and are indeed treated as also in the experimental frameworks of realist SRT.

When applying the possibility of change to the prerequisite of change, we are simply forced into a circular argument where, ultimately, time and space will be their own prerequisites. The paralogisms of equating time with clocks and space with measuring-rods can lead to nothing other than a circular argument of this kind. For, as clocks and measuring-rods may well change, the predicate of change is then applied to that which clocks and measuring-rods are supposed to represent. We have shown that there can be no direct representation of time and space and therefore that the predicates of duration and distance measuring devices cannot justifiably be applied to time and space. So the possibility of change for time and space is, on this basis, unjustified. The transcendental illusion – in this case as treating time and space as objects rather than prerequisites for objects, or as in realist SRT: both - leads to the problematic conception of time and space as empirical entities, either separately existing or empirically derived organizational concepts.

9.3.2. Time as a Phenomenon can only lead to an Empirical Concept

We showed in chapter 3 that there is no meaningful way in which we can think of the concept of time as an empirical concept. This is because any experience that can lead us to the concept of time must itself be temporal. Time is necessarily a priori. But if we see time as a phenomenon (or as an object), there is no other way in which to characterize the concept of time than as an empirical concept. It therefore appears that Einstein got stuck with a view of the concept of time as empirically derived even though we have seen that there can be no such thing. Einstein himself supports this apparent view of time in his *Relativity*:

It appears to me, therefore, that the formation of the concept of the material object must precede our concepts of time and space. (Einstein 1: 144, appendix 5)

With Kant we shall restate the questions of chapter 4 of this thesis. What kind of concept of the material object can we achieve prior to the concepts of time and space? The object cannot be outside of me, it cannot have a figure or indeed any form of extension or size (spatial predicates), it cannot influence me and thereby cause my awareness of it and it cannot exist either as necessary or accidental. In other words, there will be no (such) object!

9.3.4. An Empirical Concept of Time Robs Science of its Justification

In our treatment of Kantian metaphysics we saw that there can be a justification of mathematics as true, only if it is a priori. The synthetic a priori character of mathematics was then justified on the grounds that time and space, as intrinsic prerequisites for mathematical judgments, are a priori pure intuitions. If we treat time and space as empirical, the a priori character of mathematics is lost, and *mathematics will be empirical*. As we also know from Hume's problem that no empirical judgment can be true with necessity, mathematics is deprived of its characteristic form of truth under the realist interpretation of SRT.

We have seen that the fundamental metaphysical categories of causality, reciprocity, substance, unity and so on, are only justifiable for the world of phenomena. The world of phenomena is a world organized by the subjects of observations according to the above-mentioned categories *in* time and space. We have also seen that a metaphysical justification of the truth-values of scientific explanations is to be found through this understanding, as the rules for our understanding of events in the world are also guiding the possible observations of these events. If, therefore, we reduce the concepts of time and space to empirical concepts, we remove the metaphysical justification of the fundamental aspect of natural science to provide explanations through subsuming particular phenomena and groups of phenomena under causal natural laws. In other words: Science must provide explanations. These explanations must be based on secure metaphysical grounds. "Saving the phenomena" is simply not satisfactory, as this will always lead to the possible existence of observationally equivalent theories and ultimately scientific scepticism.

10.0. A Defence for The "Rest System" by Uncovering Paralogisms

In chapter 7 we claimed that the idea of a prior "rest system" has traditionally (in the last 100 years) been rejected due to its commonly assumed connection with a dynamic ether-theory. Without discussing the legality of the rejection on that basis, we shall now, *for the sake of argument,* assume that the validity of a prior rest system cannot justifiably rest on the idea of an ether. We shall therefore seek other reasonable justifications for treating one system as "at rest" while all systems moving relative to that system will be treated as "moving systems".

10.1. A "Rest system" Cannot be Phenomenologically Defined

We have seen that the realist interpretation of SRT can only be justified on mathematical and observational grounds. This is also the case for the idea of a "rest system" as far as we are concerned in this chapter. The main point here is to justify the *methodological* use of a "rest system" for measurement, i.e. for successfully presenting the observations as mathematical formalisms. We are assuming that there is no way to define a system as "at rest relative to space" and therefore also not relative to the ether (as the Michelson/Morely experiment apparently showed). We therefore have no reason to believe that a rest system can be based on the fact that that system is "really fundamentally at rest". If, therefore, we are to argue for a rest system we must argue for it as a tool used for establishing a system of measurements rather than as a physical reality. The first and, to the best of my understanding, only problem involved in this is that the notion of a rest system allegedly contradicts the principle of relativity (in the restricted sense).

10.1.2. Clock Dilation does not Contradict The Principle of Relativity

If two coordinate systems are at uniform parallel translational motion relative to each other, the laws according to which the states of physical systems change do not depend on which of the two systems these changes are related to. (Einstein 2: 128)

We have seen that when clocks move with *uniform parallel translational motion relative to each other*, they are no longer synchronous. This, as Einstein says, does not depend on which of the systems are considered as moving. Certainly there is no reason for assuming that the phenomena at a distance should depend in such a fundamental way on the relative movement of the observer, but the undeniable fact is that when we measure clocks in systems moving relative to each other, the clocks are no longer synchronous. This will be sufficient at this point as we will bring the fact with us: *The loss of clock synchronization due to relative motion of the respective systems that these clocks represent conforms perfectly to the principle of relativity (in the restricted sense).*

We can make this statement because it simply does not depend on where you measure from; as long as you are measuring from one arbitrarily chosen system in a set of systems in relative (uniform) motion, the facts remain the same. Clocks are no longer synchronous.

10.1.3. Clocks are Part of a Bigger Picture

We have seen that clocks do not give direct measures of time, and that the clock indications only make sense as duration measurements as long as they are considered as synchronous with other clocks. However, clocks that are in relative motion to each other are no longer synchronous. Consider the following situation: We synchronize all clocks under conditions *A* (satisfying the criterion of control). We thereby use these clocks, through direct observations, to define units for duration. Using these units of duration, we uncover a systematic coherence in all our temporal measurement. We thereafter discover that if we place a certain amount of the synchronized clocks under conditions *B* (for example heat) we find that the clocks are no longer synchronous. From this we ask the following questions:

1) Are the *B*-clocks' indications representative for the unit of measurement chosen and operationally defined?
2) Should we use the *B*-clocks as duration-measuring devices on the basis that they used to be synchronous? The obvious answer to both questions is NO. If, on the other hand, it turns out that the clocks under conditions B *all change in the same ratio relative to the originally synchronous clocks* (as they do not do under heat-conditions, but do under the conditions of uniform translatory motion), how can we utilize that ratio for the benefit of the measurement of duration? The question is one of *external coherence of measurements*. We saw, in chapter 2, that there are no meaningful facts that stand completely alone. In the present case we are dealing with system *A*

consisting of clocks that are synchronous to *all other clocks in that system, and that system is the one in which we have created temporal measurement-units and performed all our measurements so far (not because the system is "better", but because we happen to live in that system)*. We can, of course, create new units, new definitions, measurements, and so on, based on regular rates of change on a space ship, but this seems highly unattractive. When we have the possibility to simply translate the clock-ticks using the Lorentz transformations and thereby retain the simplicity of our view of nature, we appear to have good reasons to do so. In other words, there are good reasons for treating our "earth system", or for that matter the solar system, the milky way system, and so on, as if it was "at rest" for measurement, even though there is no available indication of absolute rest in the classical sense. This is because it is only in this system that we can justify the synchronous state of clocks in relation to our temporal units. The lack of phenomenological facts or physical hypotheses justifying this choice cannot be used as an argument against giving the chosen system priority at this point, because: first, there exists no alternative way of measuring that has such a foundation. And second, there is a benefit of simplicity in accepting a prior rest system, since it retains the validity of our measuring units. The fact that there exists no alternative way of measuring that has a phenomenological foundation, brings forth the necessity of a choice. What shall we consider to be the prior system? If we choose not to choose there is no way to make sense of the measuring results, as there is no prior determination of motion. By this I mean that if we accept that all systems are simultaneously "at rest", as it appears standard in realist SRT, we have a multitude of different measurements of the same phenomenon and no possibility of deciding which one reflects the actual events. In addition to this the whole concept of motion falls if we at the same time treat all systems as moving and not moving. This does not mean that a choice of "rest system" is ultimate and absolute, but simply that for this or that set of measurements we choose *x* to be "at rest". The "rest" system must then be treated as at rest throughout the investigation.

10.2. Measurement and Reality, a Quick Look at Kinematics

Current kinematics tacitly assumes (...) that at the time t a moving rigid body is totally replaceable, in geometric respects, by the same body when it is at rest in a particular position. (Einstein 2: 129)

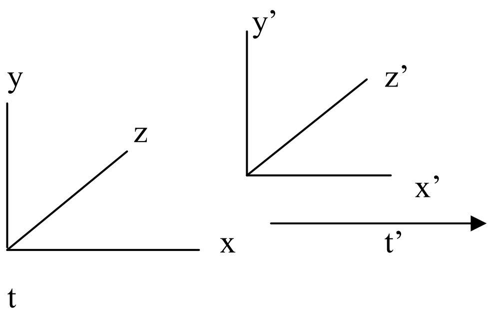
Einstein makes this observation, and rejects current kinematics as contrary to observation. This he can do because the current kinematics to which he refers is built on two arguably implausible ideas:

1) Current Kinematics uses the Galileo transformations.

2) The results of Kinematics can be directly translated into Dynamics and Mechanics.

It is the latter idea that is problematic for us. As we know, kinematics deals with geometrical constructs and the mathematical construction of their motions in space. Our observations, on the other hand, deal with physical objects and their movements in space. If it turns out that the movements of material objects influence the properties of the material objects themselves, there can be no direct transfer from the determinations of Kinematics to those of Mechanics and Dynamics (since such a translation needs physical justification). We must therefore investigate the nature of matter and its behaviour in states of motion and include our knowledge into the translation from Kinematics to Mechanics. Neither can we move directly from observations of the motions of material things to the determinations of motions in Kinematics, as their references to motions are not the same.

Kinematics deals with mathematical determinations of the motions of geometrical figures. Mechanics and our relevant observations deal with the motions of physical objects. We must therefore see if there is a possible, meaningful translation from Kinematics to Mechanics and from Mechanics to Observations of motions of concrete physical objects. As we have shown repeatedly, the Lorentz transformations can serve this purpose. But we must remember that the Lorentz transformations are justified by observations of physical objects, not by the mathematical constructions of the motions of geometrical figures. The Lorentz transformations must therefore be considered not as Kinematical tools, but as tools for the use of Dynamics and Mechanics and subsequently for Observations of physical objects. Let us take a brief look at the transformation again:



$x' = (x-vt) / [\sqrt{(1-v^2/c^2)}]$

$y' = y$

$z' = z$

$t' = t- ((v/c^2)\ x) / [\sqrt{(1-v^2/c^2)}]$

What we see is that under the Lorentz transformations the time and space variables must be treated as non-absolute functions of the systems' movements. In the Galileo transformations they are not. We must therefore conclude that the Galileo transformations are invalid for physical objects and processes. This does not mean that they are invalid as Kinematical tools for addition of spatiotemporally determinable motions, as originally intended, but rather that they cannot be used as translations of (physical) motion measurement between relatively moving systems. The uniform natures of time and space as pure intuitions lead more or less directly to the Galileo additions for spatiotemporal determinations. The Lorentz transformations, however, are perfectly valid for systems of measurements of the motions of *physical* objects established with *physical* clocks and rods. The important thing to remember at this point is that in measurement of physical objects, what is called time and space variables are actually variables of duration of regular rate and end-to-end length measured on a specific physical object in space. They are not mathematical representations of space and time relations considered independently of any physical justification. As it turns out, if we consider the external movement of a system in relation to another system, the actual movement of the system shows a consistency of Galilean laws for the determinations of addition and subtraction of motions. This means that within a given system of measurements, the speeds of two other physical systems can be added to or subtracted from each other in Galilean fashion, as there is no translation involved here. Only when we wish to translate the measurements of motion *from one system of measurement to another* do we modify the Galilean laws by the Lorentz transformations. So even if the Galilean laws for addition and subtraction of motion show themselves invalid for system-translation, they are perfectly coherent when there is no translation involved! We must therefore remember that the Lorentz transformations are not laws for addition and subtraction of speeds per se, but transformations of those additions and subtractions from one system of measurement to another. However, when we are dealing with physical objects we must consider the plasticity of those objects, and thereby find a way to systematically represent the changes in the objects in a rigid mathematical set of formalisms. This can be done by simplifying the relation between Kinematics and Mechanics in general, *treating the objects as if they were rigid* (i.e. as geometrical figures) and time and space as if they were functions of relative velocity. This simplification is a truly powerful one and it allows us to retain the simplicity and uniformity of the mathematical treatment of the measurements of physical objects. It is, however, also a dangerously seductive one if we do not pay attention to what we are doing. If we simply equate the statements "time and space measurements can be treated as functions of relative velocity in mechanics" and "time and space actually does change as a function of relative velocity", we are making the age-old mistake of paralogisms. This is because "time" and "space" in the statements have two different meanings. In the latter they are taken as ontologically real entities (under the genus of physical hypotheses), but in the former they are taken as units of measurement of spatiotemporal relations (as in geometrical and kinematical hypotheses). To make it blatantly clear: a drawing of my sock is not the same as my sock. It is a representation of it. A clock's indication is not time. It is an operational definition of a part of it (i.e. as a measurement of relative duration). If we fail to see this we are indeed falling into age-old ditches.

10.3. A Prior System "at rest" is Invalid only if Paralogisms are assumed

We showed earlier that there is a justifiable methodological reason for treating one system as the prior "rest system", because this allows us to relate the measurements we make to other measurements in that same system in a sensible manner. If, however, we think that the use of a "rest system" means that this system is really at rest in relation to space, we are once again committing paralogistic errors. "At rest" as a tool for synchronizing clocks and rods with other measurements is the meaning in which the use of a prior system is justifiable. This is because any inertial system can be treated as "at rest" (the realistic SRT indeed treats all systems as "at rest" at the same time – a blatant contradiction). All that is needed is that duration and distance units and definitions are constructed in that system. "At rest" in the sense of being at rest relative to absolute space or the ether or any non-object has turned out to be difficult to determine phenomenologically as movement is undetectable from within a system. To "move" therefore means to move relative to something else. If we think that the former meaning somehow also implies the latter meaning, we are once again confusing two different uses of a single term. We are in other words committing the error of paralogistic judgement. To treat the earth as a system as "at rest" is to treat it as the system in which our clocks are synchronous and the end-to-end distance of our meters is one and the same. This is perfectly justifiable on the methodical grounds of simplicity of measurement (the guiding principle of both Kepler and Einstein).

11.0. Concluding Remarks

My personal motive for writing this thesis has been a simple wish to understand the most prominent physical theory of modern times; the theory of special relativity. This naturally led to an investigation of the meaning of understanding whatsoever and to a constant self-reflection over the possibilities for a non-scientist to review scientific understanding. When opposing the vast majority of great physical minds of our time, one cannot but feel somewhat frightened of the prospect of humiliation. The authority of Albert Einstein ranges high, but the authority of a single person or group must never range higher than the power of argument, if human understanding of our temporary home is to advance. So by utilizing the work of Kant and Kepler we have been able to show that the realist interpretation of SRT is less plausible than the principle interpretation. This has been shown on more than one occasion.

First of all we have seen that there can be no justification of empirical concepts of time and space. If one is to propose the realist interpretation this is an inevitable difficulty that needs resolution. The proposal of empirical concepts of time and space and the justification of their relativity based on the behaviour of clocks and rods is to my mind the greatest weakness of the realist interpretation. There is simply no conceivable way in which I can even imagine a justification of such concepts and even less the introduction of them into a plausible philosophical and scientific realism. The lack of justification of such a fundamental aspect of the theory must be taken seriously if science is to progress.

The second main problem of the realist interpretation, as I see it, is the incoherent and sometimes directly contradictory use of the terms “time” and “space”. The paralogistic treatment of these terms is constant throughout Einstein’s writings and I see no other reason for these paralogisms than a dogmatic adherence to the principle of operational definitions of any and all physically relevant concepts. If one imagines that all physical concepts must be operationally defined, the paralogisms are easily committed, although the implied double meanings sometimes come into light. Most clearly the paralogistic use of the terms “time” and “space” is seen in Einstein’s treatment of the measurements of simultaneity, where he fails to recognize that the concepts ‘time’ and ‘space’ used implicitly in his framework directly contradict the concepts of time and space he ends up with.

In paragraph 9.3 we saw that there is indeed no justification for the principle of operationally defining all relevant concepts. The principle is indeed impossible to apply consistently when doing physics. Any scientific theory utilizes general metaphysical concepts that cannot be represented by such definitions. The ideas of rules, necessity, simplicity, and so on, must be grounded in metaphysics while utilized and particularized coherently in physical theory. So if one is under the transcendental illusion and believes that all aspects of physics can and must be treated in the same way, the road to paralogisms is short. We have seen that treating pure intuitions methodologically different from the objects made possible through those intuitions has rendered the special theory of relativity understandable in a way that an interpretation based on a transcendental illusion can never do.

11.1. On the Role of Metaphysics in Contemporary Science

One of the major “victories” of modern physics is often understood as the casting away of the dogmatic chains of metaphysics. In this thesis we have seen that no such victory can be claimed, since metaphysics is inherent in any and all physical theory. The very idea of causality, which is at the core of any physical theory, must be justified on metaphysical grounds if one is to avoid the scepticism that follows from Hume’s insights. The destructive aspect of this assumed victory seems to be that one is prone to accept metaphysically relevant inconsistencies in contemporary physical theory. This is an arena that now as much as ever needs the entry of philosophers.

11.2. On the Typical Counter-arguments

In the time I have written this thesis I have had the privilege to discuss my understanding with educated physicists of different specializations. The main counter arguments I have been met with in these discussions are “technological development and measurement shows the validity of the realist interpretation of SRT”, “By using machines we can avoid human interpretation in measurements”, and “Gödel showed that all systems, including the Kantian set of categories, are ultimately unjustifiable”. I will spend some time on the latter argument here as I have showed the invalidity of the former two in 3.5.

In order to treat the “Gödel argument” I will phrase it to the best of my understanding: *Gödel showed that any system is valid only on the basis of the basic axioms of that system. If one is to justify the “truth value” of that system one must refer to a more fundamental system. Ultimately the choice of the most fundamental system must be arbitrary.* I will not discuss whether this is the actual meaning of Gödel’s theorem or not, but rather take it as it is because it keeps coming back to me. The underlying attack on Kantian metaphysics and the justification of the categories is that since the categories are the fundamental system of human understanding they cannot be justified on anything but themselves and must therefore be considered arbitrary.

My answer to this objection is yes and no. Yes, there is a lack of purely rational justification of Kant’s categories and Kant more than admits so. However, this does not mean that the categories are arbitrarily chosen. We have seen in this thesis that the categories are uncovered through an architectonic approach where the totality of functions for human judgment is set as the goal. The Kantian defence is not “I argue for the reality of the categories thus… ”. The reality of the categories is something that one must check for oneself. The simple fact is that they are there and by being there they influence and make possible our observation of the world. This is, as far as I can understand, the reason why Kant so emphatically focuses on human knowledge as the only knowledge attainable for human understanding.

These underlying structures guide human understanding and the same goes for our observational abilities. To try to answer why there are these and not other categories is to go beyond the realm of phenomena. Many interesting suggestions can be made to such a solution but they will ultimately always be self-referential as we are using human understanding to reveal the ground of human understanding. The fact that one imagines to even look for a “cause”, which is implied by trying to understand its origin, shows the necessary self-referential nature of such an investigation. We must simply check whether our understanding is guided through these categories and try to unveil the nature of nature accordingly.

11.3. "If the numbers fit, then why bother?"

In this thesis I have focused somewhat on the mathematical and observational equivalence of the principle and realist interpretations of SRT. One might therefore ask why, in the realm of physics, one should care to re-evaluate the metaphysical ground of SRT. There are two main answers to this question. First of all there are discrepancies within physics concerning the possibility of uniting quantum theory with relativity. One of these discrepancies is on the nature of gravity. So since General Relativity, in which Einstein's concept of gravity is formed, is based on the concepts of time and space as introduced in SRT we must at the very least consider solving the problem by re-evaluating SRT as such. This thesis might be seen as part of that process. If SRT is allowed to stand as dogma in physics, we might miss out on the opportunity to unite Einstein's two brainchildren.

The second answer is that the truth-value of any scientific theory ultimately rests on metaphysical arguments for scientific realism. We have seen that a plausible argument for scientific realism can be found in the unity of Keplerian philosophy of science and Kantian metaphysics. If such a possibility is available I can see no reason to reject it on other than argumentative grounds. The role of the sceptics is to show holes in our arguments and the role of the realists is to attempt to mend them. The possibility of securing our knowledge should not simply be brushed off for the assumed benefit of what turns out to be an incoherent interpretation of a theory. By shaping our understanding of SRT we see that there are new roads to understanding open and these should be investigated.

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