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THE CONSTRUCTION OF REALITY AND ITS INFLUENCE ON THE 'UNDERSTANDING' OF QUANTUM STRUCTURES.

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We present a formalism to analyze 'the construction of reality'. We want to use this formalism to understand some aspects of the reality of the classical and the quantum world on a deeper level. A more complete presentation of the formalism also including applications to other fields than classical and quantum mechanics can be found in [1].

One of the aims is to detect 'hidden' prejudices that are 'unconsciously' used to interpret and criticize certain parts of reality, that do perhaps not obey these prejudices. It will follow that some of the difficulties that we have to understand the quantum reality are due to 'pre-scientific' prejudices about the way in which we think that reality **has** to be, prejudiced which we have completely forgotten about. We will try to put in evidence some of these 'pre-scientific' prejudices. To do this we will have to introduce new concepts. We will see however that the concepts needed to understand the aspect of the quantum reality that we want to investigate in this paper are not mysterious and un-understandable. They exist and are used frequently in situations of everyday life. Therefore we will introduce these concepts by means of examples of everyday life, such that they are intuitively clear.

The formalism is not yet completed, a lot of steps are still un-finished, and have to be investigated further. But the methodology is clearly stated. In this sense it can be a starting point for further research on the understanding of other parts of 'human' reality [2].

I started to work on the elaboration of this formalism in the early eighties. There are several works that have inspired me. First of all there is the research on quantum physics, and the elaboration of the state-property theory in Geneva under the guidance of Constantin Piron, in which I have been collaborating. This state-property theory delivers a realistic interpretation of ordinary quantum mechanics, but as a theory goes far beyond it [3]. The formalism presented here and in [1] can in a certain sense be used to found the state-property theory [3], a relation that is explained in detail in [1]. There is the work of Charles Randall and David Foulis, their (still un-ended but fascinating) quest for the construction of a universal language for the sciences [4]. Also their work has been of great value for the elaboration of certain aspects of the presented formalism. The relation is explained in [1]. There are the many works of those making research in and around the field commonly called quantum logic [5]. There are also the work and thoughts of Henri Poincaré, presented in the little book "La science et l'hypothèse" [6], which for the first time made me understand that it is not a priori necessary to consider the world as given, and we as observing it. Poincaré analyses already (before the existence of quantum mechanics) the subtle role of man in the construction of some aspect of reality, such as Euclidean space. There is the work of Jean Piaget, that has convinced me that a lot of this pre-scientific

construction of reality is happening all again in the early years of childhood for every human being [7]. There is the book by Erwin Schrödinger [8] which made me understand how to approach the problem of 'life' in the formalism, and made me find the energy to go and study the findings of the neo-Darwinists. And there is also the more recent and fruitful collaboration with Jean Reignier, on the quantum problematic of non-locality and its connection with the construction of reality, in which we propose an operational definition for the concept of quantum non-locality, and are investigating its relation to the construction of macroscopical space [9].

Actually the formalism, of which only a little part is presented in this paper, is still in full development, and it is my opinion that a lot of other scientific problems can be expressed in it, with the aim of bringing some clarification among the problems and pseudo-paradoxes, and in this sense coming closer to the understanding of the real mystery of our existence.

We shall begin by describing how we as human beings come into contact with the world, and start constructing reality.

1. THE LIVING OF AN EXPERIENCE.

When we are born, there is not much reality in our world. The reality of the others, the older people, is already around us, but we cannot 'understand' it, neither can we influence it. But our 'self' is already constructed in this way that we constantly interact with it. Our world is a stream of such chaotic interactions. It is from this stream of interactions that we start constructing our personal reality. We do not make this construction as an isolated human being. Constantly we are in contact with other human beings, also still further constructing their realities, and with animals also constructing their realities, and with plants, and with material objects, and with...

We 'live' certain parts of this stream of interactions. These parts we will call 'experiences'. When we 'live' such an experience, we will say that this experience is 'present', and we will call it our 'present experience'.

The experience that we 'live' is 'present' and we will call it our 'present experience'.

2. THE IDENTIFICATION OF AN EXPERIENCE.

To be able to use an experience for the construction of our reality, we have to be able to 'identify' it. The first time I tasted sweet, was when I got honey on my comforter. This was the 'living' of a new experience. The collection of family-pictures shows that this experience was repeated often afterwards. In this way this experiences got an 'identity'. I could identify "The tasting of sweet", which I will call experience **E₁(I taste sweet)**. This experience of 'tasting sweet' happened to me. Neither could I control it, nor could I predict it. But I could 'identify' it. And I liked it, this (as I know now) because by means of the cells of my tongue, certain parts of my brain were triggered. And the triggering of these parts gave me a feeling of satisfaction. Therefore it would be nice for me to be able to control more or less the happening of this experience, such that I could look it up. After some time it became clear to me that when I cried hard enough, sometimes (certainly not always) the nice experience of 'tasting sweet' happened to me. This 'tasting sweet' experience seemed to be a particular type of a more general experience.

I could 'taste' also other things than just 'the sweet'. Some of it (food?) tasted good, and some of it tasted bad. But clearly I could identify the experience of 'tasting' which I will denote **E₂(I taste)**.

Of course millions of other experiences happened to me in my first life-months. I could 'touch' things. Let me denote this experience by $E_3(\mathbf{I\ touch})$. This was a very interesting experience. I also could identify it. And amazingly enough, compared to the 'tasting', that more or less just happened to me, this 'touching' could be controlled much better. If I wanted to I could start 'touching', and if I wanted to I also could stop 'touching'.

I could 'see' things. This was even a more amazing experience with a lot of subtle variations in it, but anyhow easy to identify. Again I could control more or less this experience. I could stop 'seeing', and I could start 'seeing' But once I had decided to 'start seeing', not much control over what I was seeing was left over to me. Let me denote this experience by $E_4(\mathbf{I\ see})$.

I could 'hear' things. Again a very 'identifiable' experience. Less controllable than the 'seeing' and the 'touching'. It more or less also happened to me, and in this sense resembled more the 'tasting' experience. The difference was that the hearing was almost always there, while the 'tasting' experience only happened from time to time. Let me denote this experience by $E_5(\mathbf{I\ hear})$.

3. THE POWER OVER AN EXPERIENCE.

If an experience remains that 'unreachable' for me such that the only thing I can do with it is to 'live' it and 'identify' it, it will not 'contribute' very much to the construction of my reality. The reason is very simple. Such an experience only 'happens' to me in an unpredictable and uncontrollable way, and although I can live it and identify it when it happens to me, that is the only thing I can do with it. Such an experience 'exists' for me, as a 'possible' experience. But that is all. Therefore such an experience I will call an '**unreachable experience**'

We all of us have still these kinds of experiences in our reality, but most of us do not pay much attention to them, and since they do not contribute to the construction of our reality, they are not very important for us. But sometimes a human being can come in a situation where such 'unreachable experiences' happen to him in such a way that they become 'important' experiences. The more this happens to a human being, the more he will start living in a miserable and unreachable reality. And sometimes this human being will more 'be lived by' than 'live'.

The first step for the construction of our reality starts with the gathering of 'power' over our living of the experiences. This 'power' can have very different forms. We will analyze them in the next sections.

4. THE POWER OF KNOWLEDGE AND THE POWER OF CREATION.

For those experiences that 'just' happen to me when I live them, as the 'tasting' experience, and the 'hearing' experience, there is one way of getting power over them. That is by trying to 'know' them. Let us give an easy example to show what we mean.

I can hear my mothers heart beat. And even if this hearing just happens to me, I know that after one heartbeat, always will follow another. This knowledge gives me a power over the experience, in the sense that it does not just happen to me, because I 'know' it will happen, and hence I can 'predict' it. Let me denote this experience of 'hearing my mothers heart beat' by $E_6(\mathbf{I\ hear\ my\ mothers\ heart\ beat})$. So from the class of all 'possible experiences' those experiences that can be known will be a special subclass.

*To know an experience is to have the power to **predict** all the aspects of this experience while I live it.*

Even if the heartbeats just 'happen' to me, I can more or less 'predict' when will come one of these 'heart-beat' experiences. Later I learn to have the power of prediction about aspects of much more complicated experiences. Let us observe that 'knowledge' is a 'passive' power. On the other extreme we have the active power of creation.

If I start crying to evoke the experience of 'tasting sweet' then I am trying to get another kind of power than the power of knowledge. I have used my power of creation. It is with this same power of creation that I can control the experience of 'touching', and that I can close my eyes if I want to stop the experience of 'seeing'.

*To create an experience is to have the power to **control** all the aspects of this experience while I live it.*

Neither there exists an experience that we 'know' completely, nor there exists an experience that we create completely. For all experiences we try both types of power, and usually we alternate between creation and knowledge if we really want to have power over an experience. It is by means of this approach that we start using our experiences to construct our reality. How we do this will be the investigation of the following sections.

Human beings are entities that have these two powers, the power of 'knowledge' and the power of 'creation'. And it is by using these two powers that we 'construct' our reality [10].

5. MY PERSONAL TIME.

The most primitive order that can be introduced is the order of 'before', 'present', 'after'. The experience that I live is present. The experiences that I have lived are 'past', and the experiences that I will live are 'future'. In this sense in principle I could start 'counting' the 'present experiences'. One after the other. The series of numbers that I get in this way, is the root of my 'personal time'. Since this time is 'personal' the only properties I attribute to it are 'subjective' properties. It 'never stops' and always 'flows forwards'. It can change in speed. Sometimes it goes fast, and sometimes it slows down. It is carried by those aspects of my experiences that I don't create, don't control, and cannot predict. The aspect that makes that 'I have to experience'.

Personal time is the most primitive construction of my reality. The construction that could already have been made by means of only **unreachable** experiences. Indeed, even if all my experiences would be unreachable, hence I can live them, and identify them, then personal time would already have been constructed. Therefore time gives us this feeling of not being able to escape to it. Exactly because in it we have structured the 'unpredictable, uncontrollable and hence unreachable aspects' of our experiences.

6. MY FIRST STEPS OUT OF PERSONAL TIME.

With those experiences that are not unreachable, a lot more of reality can be constructed. Indeed, if I have power of knowledge and power of creation over an experience, this means that I have chosen more or less to live this experience. The 'living' of the particular experience is not opposed upon me. I have **chosen** to live it. But from this fact follows that I could have made another choice, and I could have lived another experience **in replacement** of the 'present experience'. It is very important to understand the consequences of this fact. Since I could have chosen to live another experience in replacement of the present experience, it makes sense to introduce the concept of '**possible experience**'. Let us give a concrete example to explain what I mean.

I consider the following situation : I am inside my house in Brussels. It is night, the windows are shut of. I sit in a chair, reading a novel. I have a basket filled with walnuts at my side, and from time to time I take one of them crack it and eat it. My son is in bed and already asleep. New York exists and is busy.

My present experience is, **E₇(I read a novel)**. But, a lot of other things 'happen' while I am living this present experience. These things 'happen' in my 'present reality'. While "I am reading the novel", some of the happenings that happen are the following : **H₇(the novel exists)**, **H₈(the inside of my house in Brussels exists)**, **H₉(it is night)**, **H₁₀(the basket, and the walnuts exist, and are at my side)**, **H₁₁(my son is in bed and is sleeping)**, **H₁₂(New York exists and is busy)**. All these happenings, and much more, 'happen', while I live the present experience **E₇(I read a novel)**.

Why do I have constructed reality in such a way that what I am just saying is evident for everybody (and therefore it shows that we are not conscious of the construction that is behind this evidence).

Certainly it is not because I 'experience' also these other happenings. My only **present** experience is the experience of reading the novel. But, and this is the reason for this type of construction, I could have used my power to live an experience including one of the other happenings **in replacement** of my present experience. Let me put down the list of these experiences that I could have chosen to experience in replacement of my present experience : **E₈(I observe that I am inside my house in Brussels)**, **E₉(I see that it is night)**, **E₁₀(I take a walnut, crack it, and eat it)**, **E₁₁(I go and look in the bedroom to see if my son is asleep)**, **E₁₂(I go to New York, and observe the business)**.

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

7. CREATIONS AND HAPPENINGS.

To see what I mean, let us consider the experience **E₁₀(I take a walnut from the basket, crack it, and eat it)**. In this experience, there is an aspect that is an 'action' of me, the taking and the cracking, and the eating. There is also an aspect that is an 'observation' of me, the walnut and the basket. By studying how our senses work, I can indeed say that it is the light reflected on the walnut, and on the basket, that gives me the experience of 'walnut' and the experience of 'basket'. This is an explanation that only now can be given, it is however not what was known in earlier days when the first world-models of humanity were constructed. But without knowing the explanation delivered now by a detailed analysis, we could see very easy that an experience contains always these two aspects. A **creation**-aspect, and an **observation**-aspect. Simply because our will can only control part of the experience. This is the creation-aspect.

For example in **E₇(I read a novel)** 'the reading' is created by me, but 'the novel', is not created by me. In general we can indicate for an experience the aspect that is created by me, and the aspect not created by me. The aspect not created by me, lends itself to my creation. We can re-formulate an experience in the following way : **E₁₀(I take a walnut, crack it, and eat it)** becomes **E₁₀(A walnut is taken by me, and lend itself to my cracking and eating)** and **E₇(I read a novel)** becomes **E₇(The novel lends itself to my reading)...**

The 'taking', 'cracking', 'eating', and 'reading', will be called **creations** or actions and will be denoted by C_{10} (**I take, crack and eat**) and C_7 (**I read**). The 'walnut', and 'the novel', will be called **happenings** and will be denoted by H_{10} (**the walnut**) and H_7 (**the novel**).

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

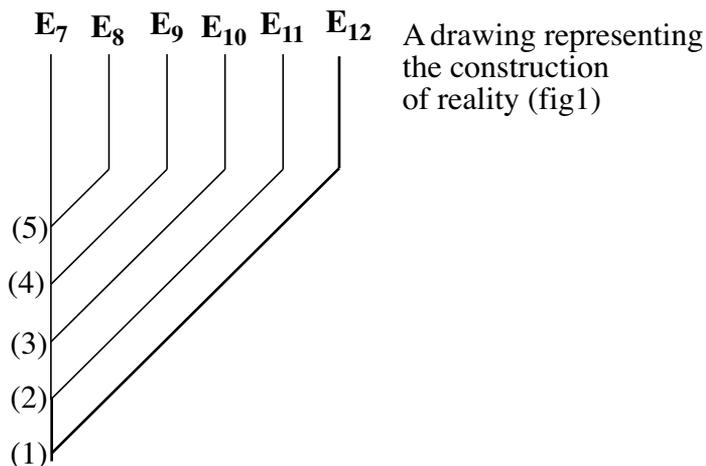
An experience is determined by a description of 'the creation', and a description of 'the happening'. Both creation and happening can be expressed by verbs. To take, to crack, to eat, and to read, are the verbs that describe my creations in the examples. 'The walnut', and 'the novel', are happenings that have the additional property of being objects, this means, happenings with a great stability. They are expressed by the verbs 'to be a walnut', 'to be a novel'.

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

A beautiful image that can be used as a parable for our model of the world, is the image of the skier. A skier skis downhill. At every instant he has to be in complete harmony with the form of the mountain underneath him. The form of the mountain represents his happening. The way of putting himself in harmony with this form represents his creation. His creation, in harmony fused with his happening, is his experience.

8. THE CONSTRUCTION OF REALITY, PRESENT, PAST AND FUTURE.

Let us again consider the collection of experiences : E_7 (**I read a novel**), E_8 (**I observe that I am inside my house in Brussels**), E_9 (**I see that it is night**), E_{10} (**I take a walnut, crack it, and eat it**), E_{11} (**I go and look in the bedroom to see if my son is asleep**) and E_{12} (**I go to New York, and observe the business**). And let us represent the construction of the reality that is made out of this little collection of experiences by means of the drawing represented in fig.1.



E_7 (**I read a novel**) is my present experience. In my past I could however at several moments have chosen to 'do something else' and this choice would have led me to have another present experience than E_7 (**I read a novel**). For example :

At (5) I could have decided to stop reading and observe that I am inside the house. Then E_8 (**I observe that I am inside my house in Brussels**) would have been my present experience.

At (4) I could have decided to stop reading and open the windows and see that it is night. Then **E₉(I see that it is night)** would have been my present experience.

At (3) I could have decided to stop reading, take a walnut from the basket, crack it, and eat it. Then **E₁₀(I take a walnut, crack it, and eat it)** would have been my present experience.

At (2) I could have decided to go and see in the bedroom whether my son is asleep. Then **E₁₁(I go and look in the bedroom to see if my son is asleep)** would have been my present experience.

At (1) I could have decided to take a plane and fly to New York and see the business. Then **E₁₂(I go to New York, and observe the business)** would have been my present experience.

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

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

- 1) I have to be able to perform the creation.
- 2) The happening has to be available.

For example the experience **E₈(I observe that I am inside my house in Brussels)** is a possible experience for me, if

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

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

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

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

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

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

My 'present personal power' consists of all the creations that I can perform at present. My 'past personal power' consists of all the creations that I could perform in the past. My 'future personal power' consists of all the creations I shall be able to perform in the future.

Happenings can happen at once, because to happen, a happening does not have to be part of my present experience. It is sufficient that it is available, and things can be available at once. Therefore, although my present experience is only one, my present personal reality consists of thousands of happenings all happening at once. Again I want to state clearly that if I say : At present, happening **H** happens, this does only mean that at present I could have had an experience **E = (C, H)**, were **C** is the creation I would have chosen to make in this case.

This concept of reality is not clearly understood in actual physical theories. Physical theories know how to treat, past, present and future. But reality is a construction, about the 'possible'.

It is constructed by means of the experiences **I could have** lived, but probably never will live [11].

The reality of the skier is the form of the complete mountain. These are the happenings waiting for him, if eventually his life would pass that spot of reality. His present reality is the form the mountain has in the present.

9. CLASSICAL REALITY, QUANTUM REALITY, DETERMINISM AND PROBABILITY.

Most of the modern human part of our reality we have been investigating by the act (creation) of 'observation'. That is the reason why the constructions of modern technology are often considered to be alien to natural reality (they are considered to be 'artificial'). This creation of observation is a very passive one, and almost only leads to a gathering of power of knowledge. This period dominated by the 'observational paradigm' has been very long (perhaps million of years, from the time that all our cells came together to form a body with eyes to observe), and is still dominating the nature of our actual human world-model. This situation has paved the way for the classical mechanics world model, a model where the world is considered to be a huge clock-work, and we humans observe it and gain knowledge about it, and we are ourselves part of it, and controlled by it. This classical mechanics world model still determines a lot of the thinking in different disciplines of science. It is a world-image where it is thought that the only active part of humanity in the construction of reality is an act of observation [12].

This of course is obviously wrong, and in the research on the nature of quantum reality physicists have been forced to suffer the consequences of this wrong set of ideas. The fact that this classical set of ideas is wrong is so obvious that it has been very difficult to recognize. The consequences of this wrong set of ideas have shown up inside the very difficult formalism of quantum mechanics, where anyhow nobody really knew what were the creations and what were the happenings. This fact is the main reason for the existence of so many paradoxical aspects related to quantum mechanics and the reality of the quantum world.

Classical reality, as it appears to us from the classical physical theories, is deterministic. There exists a probability theory describing situations inside this classical reality, but the lack of determinism in these probabilistic situations is explained by interpreting the probability as describing the lack of knowledge that we have about the 'complete reality' of the situation. It is a probability theory conditioned by the 'observational paradigm' of the classical world-view. As we shall see, now that we have introduced the necessary elements to discuss clearly the concept of 'reality' itself, the state of affairs is not that simple. Probability can show up very naturally in another way, and then give rise to quantum mechanical probability structures.

We consider the same situation. I am inside my house in Brussels, and I am reading a novel. But we will concentrate a little bit more on the experience formed by the creation **C₁₀(I take a walnut, and crack it, with the aim of eating it)**. I must explain a little bit more about the actual creation that I am performing. I do not use a professional tool for cracking the walnut. I just take it between my both hands, put all the force I have, and see what comes out. Everybody who has had some experience with this way of eating walnuts knows that with a given walnut as happening **H₁₀(a walnut)**, different experiences can follow. Let us analyse some of the possibilities.

1) If a walnut after cracking it, shows to be mouldy, then I don't eat it.

This means that for a particular walnut number k , let us call this particular walnut happening **H_{10,k}**, of the basket containing N walnuts, my creation **C₁₀** can fuse with this happening and

give rise to different experiences. Let us denote two types of them by $E_{10,1}$ (**I crack the walnut, and eat it**) and $E_{10,2}$ (**I crack the walnut, and don't eat it**).

Suppose that from the N walnuts in the basket, M are mouldy. Then the probability that walnut k will lead to experience $E_{10,1}$ is given by $(N-M)/N$, and the probability that walnut k will lead to the experience $E_{10,2}$ is given by M/N . This is a probability that finds its origin in my lack of knowledge of the complete reality of the walnuts. Indeed, everybody will believe me when I suppose that already before I start to perform my creation of cracking the walnut number k , it was mouldy or not, and if I would have been able to know this, I could have eliminated the probability by only taking those walnuts that were not mouldy, and only trying to eat these ones. Whole of classical probability theory is based on this way of thinking about reality.

Everybody who has some experience with cracking walnuts knows that other things can go wrong such that it will not be possible any more to eat the walnut. Indeed, sometimes the cracking destroys the walnut in such a way that the nut is completely mixed up with the shell. If this happens, I will have a quick investigation whether it is still possible to disentangle them, and if it is not the case, I will not eat the walnut.

2) *If a walnut, after cracking it, is too strongly mixed up with the shell, then I don't eat it.*

This again leads to the fact that for a particular walnut number k , hence happening $H_{10,k}$, the fusing with my creation C_{10} can give rise to two different experiences. Experience $E_{10,3}$ (**I crack the walnut, and eat it**) and $E_{10,4}$ (**I crack the walnut, and don't eat it**). And again, as in the foregoing, we can attribute a probability to the two possible experiences.

We immediately feel that this type of probability is of a different nature, and depends on the way the cracking will be performed (depends on the creation aspect of the experience). Indeed, unlike the foregoing case of the M walnuts that are mouldy, and the $N-M$ walnuts that are not mouldy, we cannot subdivide the collection of N walnuts in the basket apriori (before the cracking takes place) into those that I will eat, because they are cracked well, and those that I will not eat, because they are cracked wrongly. Such a sub division does not exist before the creation C_{10} of 'cracking'. Hence here we have an explicit example of how a part of reality is constructed by me cracking the walnuts.

The interesting fact is now that the mathematical probability structure that is needed to describe the in-determinism (which in our formalism expressed means that equivalent creations and equivalent happenings can fuse together to deliver different experiences) that follows from such a kind of situation is different from the mathematical probability structure needed to describe the in-determinism that follows from situations where before the creation (and hence before the experience) there is a more complete reality of the happening in question, of which we lack the knowledge. And what is even more interesting is that :

The probability structure describing in-determinism that comes from a lack of knowledge on the more complete reality of the happening in question is a classical-like probability structure.

The probability structure describing in-determinism that comes from the fact that during the creation a new piece of reality is created, not existing before the creation, is a quantum-like probability structure.

We do not have the space in this paper to proof these two important statements, but we can refer to earlier work, where (not in the context of this formalism) the statements were proven in general, and by means of concrete examples [13]. In the same book where this paper is published, we repeat one of the examples of [13], showing explicitly that it has a quantum logical structure, although it only consists of mechanical macroscopical physical entities [14]. A complete and general proof inside the presented formalism can be found in [1].

10. THE CRACKING OF WALNUTS AND QUANTUM REALITY.

Let us now consider the situation where we have been able to put away all the mouldy walnuts of the basket. So I am in the situation to have next to me a basket with only 'non-mouldy' walnuts. In classical mechanics language one would say that every individual walnut in the basket is now in a 'pure' state as to the property of 'being non-mouldy'. In the original situation, where the mouldy walnuts were still present, an individual walnut would have been presented in classical mechanics formalism by a 'mixed' state of 'mouldy, non-mouldy' walnut, with weights given by M/N and $(N-M)/N$.

In this new situation we have a basket with non-mouldy walnuts. We consider now a more refined happening H_{13} (**non-mouldy walnut**). With the creation C_{13} (**I crack**) it can be fused to deliver an experience E_{13} (**I crack a non-mouldy walnut**). However taking into account the reasoning of the forgoing chapter, even such a non-mouldy walnut will not always be eaten. I will eat some of these walnuts, and will not eat others of them depending on the quality of the cracking. The cracking of the walnut changes its state in such a way that (if the cracking succeeds) it becomes really 'ready to be eaten', or (if the cracking does not succeed) it has become un-eatable. In this sense we must introduce another concept, and say, that although the basket is now full of 'non-mouldy' walnuts, since the cracking still has to take place, they are only '**potentially** ready to be eaten'.

Nobody has any problem in understanding the example of the walnut. Our proposal is now that we have to use our human mind to understand the quantum reality in analogy with this kind of very natural and very abundant situations in our everyday life. Of course, in the quantum reality the state of **potentiality** appears in relation with other happenings than the happening of 'ready to be eaten'.

Walnuts are only 'eatable' or 'un-eatable' after they have been cracked. We could state this by saying that walnuts are 'potentially eatable and potentially un-eatable'.

Quantum entities in general are potentially localized and potentially non-localized in a certain region R of space. And the experience of finding or not finding the quantum entity in this region of space is taking place after the real apparatuses to detect the quantum entity have been installed in the laboratory, and the interaction of the quantum entity with these apparatuses has begun. Before they are 'potentially **present** and potentially **non-present**' in region R .

The same can be said for the property spin of a quantum entity, and in relation with this property we have worked out in detail a macroscopical mechanistic example giving rise to the quantum mechanical probability model of the spin of a spin 1/2 quantum particle [15]. What we have called 'measurements' in [15] would be called 'creations' in the formalism of this paper, and what we have called 'states of the entity' in [15], would be called happenings in the formalism of this paper. Also using this way of interpreting quantum reality we could give an example of a mechanistic laboratory situation giving rise to a violation of the Bell inequalities exactly with the same numerical values as the EPR violations [16]. The problem of potential-locality (or potential presence) of quantum entities is analyzed by means of the examples of concrete laboratory experiments in [7].

We have to come back now to our analysis of the construction of reality to be able to understand the real nature of quantum reality. Let me consider once again the same situation : My present experience is, E_7 (**I read a novel**). And while "I am reading the novel", we consider the following happenings H_7 (**the novel exists**), H_8 (**the inside of my house in Brussels exists**), H_9 (**it is night**), H_{10} (**the basket, and the walnuts exist, and are at my side**), H_{13} (**each walnut of the basket is potentially eatable and potentially un-eatable**) , H_{11} (**my son is in bed and is sleeping**), H_{12} (**New York exists and is busy**).

The construction of my reality consists of accepting the existence of these happenings, because I could have decided in the past to use my free will and fuse one of my creations with one of these happenings and hence have one of the experiences. We want to consider now the happening **H₁₃(each walnut of the basket is potentially eatable and potentially un-eatable)** and the creation **C₁₃(I crack)** that I could have fused with it to have one of the experiences **E_{13,1}(I crack a walnut and eat it)** or **E_{13,2}(I crack a walnut and don't eat it)**.

We see that the construction remains valid. The fact that the fusing of **H₁₃(each walnut of the basket is potentially eatable and potentially un-eatable)** with **C₁₃(I crack)** can give rise to two different experiences, **E_{13,1}(I crack a walnut and eat it)** or **E_{13,2}(I crack a walnut and don't eat it)**, does not destroy the validity of the construction of reality as we have presented it. But 'observer-minded' as we are 'conditioned', we indeed have the feeling that the happening **H₁₃(each walnut of the basket is potentially eatable and potentially un-eatable)** is 'less real' than the other happenings that happen while I am reading the novel. This is the reason why we have also this 'for so many physicists uneasy' feeling in relation with quantum entities. They seem to exist 'less' than ordinary macroscopical entities. I think it is not important to discuss whether this is true or not as a matter of fact. What is important is to understand why we have this feeling, and how it can be explained and understood by means of everyday examples of experiences. And this was one of the aims of this paper.

In the next sections we shall try to propose an explanation for the fact that happenings such as **H₁₄(an entity is potentially localized and potentially non-localized in a certain region R of space)** do not exist in our macroscopical reality. While in the quantum reality they do exist. To investigate this we have to start introducing aspects of this macroscopical material reality.

11. THE INTRODUCTION OF MATERIAL TIME AND A TOPOLOGICAL STRUCTURE FOR REALITY.

We want to proceed with the development of the formalism, and introduce aspects of the construction of reality that are already closer to our everyday classical conception of it.

From ancient times mankind has been fascinated by happenings going on in the sky. The motion of the sun, the changes of the moon, the motions of the planets, and stars. These happenings in the sky are **periodic**. By means of these periodic experiences, man started to **coordinate** the other experiences. He introduced the counting of the years, the months, and the days. Later on watches were invented to be able to coordinate experiences of the same day. And in this sense **material** time was introduced in the reality of the human species. Since reality is a construction, also material time is part of this reality construction. Indeed, my present experience very seldom is a material time-like experience. But in replacement of my present experience, I always could have consulted my watch, and in this way have a material time experience **E₁₄(I consult my watch)** . So, although my present experience is very seldom a material time experience, my present reality always contains a material time happening, namely the happening **H₁₄(my watch)**, which is the happening that with the creation **C₁₄(I consult)** forms the experience **E₁₄(I consult my watch)**. By means of this material time happening I coordinate my present reality.

By means of material time I coordinate my reality [17]. By means of time I can also attribute a magnitude or length to a particular experience. To do this I introduce a unit particle of time. Let me call it the chronon. This can be done by referring to a well known periodic experience. Each experience can then be measured by the number of chronons it takes from the beginning

till the end of the experience. A reality that contains material time happenings has a certain metrical structure because, by means of time I can give a more precise definition of my present reality.

My present reality is the collection of the happenings of all the experiences I could have lived at the same moment of time as my present experience.

Let us look again at fig.1. By measuring the time needed to go from (5) to E_7 and from (5) to E_8 , I can give a measure of the distance between experience E_7 and experience E_8 . To go from "reading the novel" towards "observing that I am in the room" will take me very little time. Let us say 1 chronon (this depends on how we define the chronon). Then we put $d(E_7, E_8) = 1$ chronon. To check whether it is night takes me 10 chronon. Thus we will put $d(E_7, E_9) = 10$ chr. To take a walnut, crack it, and eat it takes me 50 chronons. Hence $d(E_7, E_{10}) = 50$ chr. To see whether my son is asleep takes me 100 chronons. Thus $d(E_7, E_{11}) = 100$ chr. To take a plane and fly to New York takes me 5 kilo-chronon which is 5000 chronons. Thus $d(E_7, E_{11}) = 5$ kchr.

The function d is not really a distance (in the mathematical sense). Indeed, the magnitude of $d(E, F)$ not only depends on the experiences E and F , but also on the way we take to switch from experience E to experience F . Usually there are different ways. To get from 'reading the novel' to 'being in New-York', can be done in different ways, by means of different intermediate experiences. The distance, if to be made objective (inter-subjective) should be defined on the reality, hence on the collection of happenings. For two happenings H and I we can take $d(H, I)$ to be the smallest (highest lower bound) of all the $d(E, F)$ where E is an experience which contains the happening H , and F is an experience which contains the happening I . But also this is not yet a distance in the mathematical sense, because there exist also different ways to get from happening H to happening I , even if we consider for every way the smallest one concerning the creation aspect. This is just the expression for the fact that my reality has more than one dimension (in a reality of one dimension only one sequence of intermediate happenings would exist between two arbitrary happenings) [18].

These different ways will take in general a different amount of time, and hence lead to different values for $d(H, I)$. We come to a real distance if there is a consensus about which road between two happenings is going to be taken the representative one for the distance between these two happenings. Such a consensus has existed probably many times for the human species. I have often heard my grand-father tell me that in his time, the distances between different places (cities, towns, villages) were expressed in hours, and minutes, and the consensus was the time needed for an average person to go (by feet) from one place to the other following a particular road. In modern times this consensus has lost its utility, because there are too many different ways of transportation and so many different roads for a person to go from one place to another.

If the skier has a watch, material time is defined for him by the number indicated on the watch. To ski from one spot of the hill to another spot of the hill, can take him different amounts of time, depending on his speed, and on the road he takes. Also his reality, the shape of the mountain, has more than one dimension.

We want to give an example of a construction of a reality, just to explain more in detail the level on which we are reasoning at this moment, and to make clear that we are still far away from the construction of material space.

Suppose we consider the situation where I am watching some kind of television, and this watching of television is the only type of experience that I can have. The only power of creation I have is to change the channel. Then it is clear that although my present experience consist of watching one particular channel, I make the construction, as explained in section 8, and the

other channels exists in my present reality as happenings, because I could have chosen to watch one of the other channels, in replacement of the actual channel that I am watching. The topological structure of this kind of mini-reality is worth specifying. The switching from one channel to another one takes me the same amount of time, and since I only have one manner of switching, the distance is uniquely defined. It will be the same between all channels. I can represent this mini-reality by locating all the channels on the surface of a sphere with radius r , and myself in the centre of this sphere. The distance between each channel is then equal to $2 \cdot r$. It is important to remark that although this very poor situation is sufficient already to construct a reality, it does not give me any information about the distance between the different channels. But a representation (because we can easily imagine the real situation that we have on our actual televisions) needs already a reality of more than one dimension. We will analyse much more in detail this problem in [1]. Here we only want to mention it to prepare the thoughts expressed in the next section.

12. THE FLOW OF REALITY.

As follows immediately from our analysis, reality is not given once and for all. Other living beings, even on our own planet earth, must have constructed a completely different reality than our human reality [19]. Insects, of which some have certainly developed a high level of social life (e.g. bees and ants), have probably never started to study the periodic motions of the planets and stars. Of course part of our reality (the happenings) is certainly also valid for them, because of the simple fact that they are part of our reality. For example also their bodies are made of matter, and this matter is the same one that we have studied and tried to understand in our human physical theories. But this part of our reality is probably no part of their reality, because they cannot fuse their creations with these happenings. We cannot really imagine what their relation to matter is [20].

It is rather obvious that these remarks are even more true for the entities that 'constitute' matter. These entities are, for the simple fact that they constitute matter, **not matter**. But independently of this fact they seem to 'be' entities. Exactly as a walnut before cracking it, contains the happening H_{13} (**the walnut is potentially eatable and potentially un-eatable**), these pre-material entities seem to contain the happening H_{14} (**the entity is potentially localized and potentially non-localized in a region R of space**). This actually means that these pre-material entities do not really exist inside space as we know it (exactly as a walnut is not yet cracked). The absorption and structuring of one of these pre-material entities in a matter-structure brings it into a state inside space as we know it. Exactly as the cracking of the walnut brings it into a state of eatable or un-eatable walnut.

To understand better this analogy of how 'structuring' can bring happenings of the 'potential' type into happenings of the 'actual' type, we will give an example, to show that the same process is still going on. Before nations existed, humans had no nationality. Let us consider such a concrete human being named Boduognat, and also consider all his descendants. Then because of the structuring process of society into nations, we know that all his descendants that live now have some kind of nationality. We can consider the happening H_{15} (**this person has Belgian nationality**) and the inverse happening H'_{15} (**this person has non-Belgium nationality**). Then for each descendant of Boduognat, the happening H_{16} (**this person has potentially Belgian nationality and potentially non-Belgian nationality**) has changed into one of the two happenings H_{15} (**this person has Belgian nationality**) or H'_{15} (**this person has non-Belgian nationality**). That there once have been humans without nationality (hence in our world such a human is neither a Belgium, nor a non-Belgium, because every non-Belgium in our actual world has another nationality), is not difficult for us to imagine, and hence believe. This because we still consciously know the structuring process that led to the situation where all the humans of the world were given a nationality. To imagine that there are entities that have no place in space (are not localized) is more

difficult for us. This is because we do not know consciously the structuring process that led to space and its macroscopical entities.

A human without nationality could be described as a 'superposition' of different nationalities, namely those nationalities that he could take during the process of structuring. Let us call Ψ a certain descendant of Boduognat that will be nationalized in a certain country. Then we can write $\Psi = a \cdot \text{Belgian} + b \cdot \text{French} + c \cdot \text{German} + d \cdot \text{Dutch}$. The weights, a , b , c , and d of each nationality must correspond to the probability that he will be nationalized in this country.

In the same sense the wave function $\Psi(x, y, z)$ of a quantum mechanical entity has to be interpreted. It is a superposition of different points (x, y, z) of space, where the magnitude of the absolute value of the wave function in a certain point does not represent a 'presence' in this point (as would be the case if the wave function is interpreted as a field), but is related to the probability that the quantum entity will localize in this point, if the process of structuring of matter (the measurement corresponding to the detection) takes place.

It was our aim to point out that this state of affairs is not mysterious if we use analogies of similar situations and processes in our everyday world. Evidently a lot of other examples can be given (see the last section of [21]).

NOTES AND REFERENCES

[1] D. Aerts, "*The construction of reality*", in preparation, TENA, VUB, Pleinlaan 2, 1050, Brussels.

[2] We think of the social, economic, and cultural parts of human reality, and of psychological, medical, biological, and bio-chemical aspects of our 'selves'(human body and human mind). And the connections that have to be made with theories studying these domains.

[3] C. Piron, "*Foundations of Quantum Physics*", W. A. Benjamin, Inc., Reading Mass, (1976) and D. Aerts, "*The one and the many*". Towards a unification of the quantum a classical description of one and many physical entities. Doctoral dissertation, VUB, Pleinlaan 2, 1050, Brussels, (1981), and D. Aerts "*Description of many physical entities without the paradoxes encountered in quantum mechanics*", Found. Phys., 12, 1131 (1982) and D. Aerts, "*Classical theories and non classical theories as a special case of a more general theory.*" J. Math. Phys., 24, 2441 (1983) and C. Piron, "*Recent Developments in Quantum Mechanics*", Helv. Phys. Acta, 62, 82 (1989) and C. Piron, "*Mécanique Quantique, Bases et Applications*", Press Polytechnique et Universitaire Romande, Lausanne, (1990).

[4] C.H. Randall and D.J. Foulis, "*A Mathematical Language for Quantum Physics*", in "*Les Fondements de la Mécanique Quantique*" 63-148, edited by Christian Gruber, A.V.C.P. Lausanne (1983) and C.H. Randall and D.J. Foulis, "*Properties and Operational Propositions in Quantum Mechanics*", Found. Phys. 13, 843, (1983), and D.J. Foulis and C.H. Randall, "*Dirac revisited*" in "*Symposium On the Foundations of Modern Physics 1985*", ed. P. Lahti and P. Mittelstaedt, World Scientific, Singapore (1985).

[5] References on quantum logic can be found in the proceedings of the two conferences that meanwhile have been organized on the subject: "*Current Issues in Quantum Logic*", ed. Beltrametti, E., and van Fraassen, B.C., Plenum, (1981), and "*Recent Developments in Quantum Logic*", ed. Mittelstaedt, P., et al., in *Grundlagen der Exakten Naturwissenschaften*, vol.6, Wissenschaftsverlag, Bibliographisches Institut, Mannheim (1985) and also in the excellent survey book: Beltrametti, E. and Cassinelli, G., "*The logic of Quantum Mechanics*", *Encyclopedia of Mathematics*, vol. 15, Addison-Wesley (1981).

The collection of researchers working in the domain called 'quantum logic' is in fact a collection of people studying 'quantum structures' in general. Historically this domain has been called quantum logic, although the research on the pure logical aspects of the quantum structure is only one aspect of the content of the domain.

[6] H. Poincaré, " *La science et l'hypothèse* ", Flammarion, Paris (1902, 1968).

[7] J. Piaget , " *The child's conception of time* " , London, Routledge and Kegan (1969), J. Piaget and B. Inhelder, " *The child's conception of space* " , London, Routledge and Kegan (1971).

[8] E. Schrödinger, " *What is life* " , Cambridge University Press (1944).

[9] D. Aerts and J. Reignier, " The spin of a quantum entity and problems of non-locality " , to appear in the proceedings of the " *Symposium on the Foundations of Modern Physics 1990* " , World Scientific, Signapore, and D. Aerts and J. Reignier, " *A minimal operational definition for non-locality in quantum reality* " , in preparation, TENA, VUB, Pleinlaan 2, 1050, Brussels.

[10] Some ages, and in some cultures, more attention has been given to one of the two powers, and depending on this the reality constructed by such a culture will be different. When more attention is given to the power of 'knowledge' the constructed reality will be more exterior. Human will be seen as a little part of the huge 'universe of knowledge', and in the extreme of this attitude a 'fatalistic reality' will be constructed. A reality where everything is 'controlled' and 'created' by the 'external fatum'. When more attention is given to the power of 'creation' the constructed reality will be more 'individualistic'. Human will be seen as the 'masterpiece' of the universe, and in the extreme of this attitude an 'egoistic reality' will be constructed. A reality where everything is 'controlled' and 'created' by the self. During the ages of existence of humanity, the constructed reality always has fluctuated between these two extremes, as it is easy to find examples in the history of civilization. It is not our aim to study the social aspects of these fluctuations, although they are very deep and important, but we want to study the effects of this fluctuations on the 'primitive' and in general 'pre-scientific' construction of reality.

[11] Therefore, all languages, which are in fact pre-scientific models of the world, contain different modes of description of this world. The indicative mode is about the happening-part of my experiences, present, past, or future. The demanding mode is about the creation part of my experiences, present, past, or future. The conditional mode is about the construction of reality. In a language I can say, being in Brussels, : "New York exists at this moment". Because : "I could have been in New York, if I would have decided so in the past". Try to say the same without using the conditional mode.

The positivist (and strict operationalist) attitude of the beginning of this century has had a negative influence on the understanding of the nature of the construction of reality. This attitude has had its great merit in helping science to get rid of many of the disturbing metaphysical beliefs, but at the same time has created the thought that science should limit itself to the 'observable', and should not argue about the 'possible'. The conditional mode was considered un-scientific.

For example the young Einstein was a strong adept of this attitude, and it is certainly partly this attitude that was at the origin of his analysis of the concept of 'simultaneity' and the consequences of this analysis for the construction of relativity theory. Later Einstein changed rather fundamentally. His famous paper of 1935, later refereed to as containing the EPR paradox, shows an attitude much closer to the one that we expose in this paper (what is called an element of reality by Einstein, is directly related to what is called a property in [2], and what is called a happening in this paper, and [1]).

One could think that the formalism presented here is realistic (philosophically speaking), and hence can only be accepted by those people that call themselves 'realists'. We do not agree with

this. In a certain sense the formalism 'avoids' the philosophical debate around 'realism'. Let us explain why. A new concept is introduced. It is the concept of 'to happen'. And it is stated that an happening can 'happen' without me living the experience that contains this happening. This is a precise way of telling that I am not the creator of the happening, and that a happening can 'happen' without me fusing it with one of my creations. This explains that more than one happening can happen at present. But we say more. We make explicit what are the happenings that can happen at present. The happenings that can happen at present, are those that could have been fused with one of my creations, if I had somewhere in the past made another choice, such that my present creation would have been different than the present one. Hence in this way is defined 'operationally' the meaning of the concept 'to happen'.

Our opinion is that the methodology of operationalism is alright. But the philosophy going with it is too limited in a lot of ways. For example it does not seem to want to take into account the fact that 'constantly' new objects are created by humanity, and these are to be compared as to their status of reality with the existing objects. The discussion about what is real and what is not real, should become a quantitative discussion. Instead of asking about the reality of a certain object, one should compare the object to others : " Is this object 'as real as' that one, or 'less real than' that one ". We shall probably in the future have to start quantifying reality. Karl Popper, by introducing his different worlds, has made an attempt in this direction. But it remains a 'qualitative' classification, too much dominated by our actual macroscopical reality.

[12] We are of course well aware of the fact that this is not true, and probably the great social, economic, and cultural crisis that humanity is living at this moment is due to the fact that the 'observational paradigm' is changing. Humans shall have to start a construction of reality (of human society, hence its economic, social and cultural aspects) that will be again more of the creation-type (as had to be done during the period where all our cells came together to form a body). But a lot of resistance against such an international creation-like enterprise exists for a multitude of reasons. We think that one of the fundamental reasons for the resistance to such a project is the fact that we as humans have not yet freed ourselves of the 'observational paradigm'. It is time that humanity starts to get conscious of this fact, and takes responsibility for its creations, by planning them, taking into account its effects on the construction of long term future reality. There will be no choice (since these periods are determined by profound long-term laws going together with the methodology of humanity to construct reality) if humanity want to avoid the risk to collapse into a chaotic reality with the only possibility of living 'unreachable' experiences.

[13] D. Aerts, *J. Math. Phys.*, **27**, 203 (1986), and D. Aerts, " *The origin of the non-classical character of the quantum probability model* " in " *Information Complexity and Control in Quantum Physics* ", ed. Blanquiere, A., Diner, S. and Lochak, G., Springer Verlach (1987), and D. Aerts, " *The description of separated systems and quantum mechanics and a possible explanation for the probabilities of quantum mechanics* " in " *Micro-physical Reality and Quantum Formalism* ", edited by van der Merwe A. et al., Kluwer Academic Publishers, (1988), and D. Aerts, " *An attempt to imagine parts of the reality of the micro-world* " in the proceedings of the conference " *Problems in Quantum Physics ; Gdansk '89* ", to be published by World Scientific Publishing Company, Singapore, and D. Aerts, " *A mechanistic classical laboratory situation violating the Bell inequalities with $2\sqrt{2}$, exactly 'in the same way' as its violations by the EPR experiments* " to be published in Helv. Phys. Acta.

[14] D. Aerts and B. Van Bogaert, " *A mechanistic classical laboratory situation with a quantum logic structure* ", to be published in the proceedings of the conference " *Quantum logic* " in Gdansk, 1990, by Nova Science Publishers, Inc., New York.

[15] D. Aerts, *J. Math. Phys.*, **27**, 203 (1986), and D. Aerts, " *The origin of the non-classical character of the quantum probability model* " in " *Information Complexity and Control in Quantum Physics* ", ed. Blanquiere, A., Diner, S. and Lochak, G., Springer Verlach (1987).

[16] D. Aerts, " *A mechanistic classical laboratory situation violating the Bell inequalities with $2\sqrt{2}$, exactly 'in the same way' as its violations by the EPR experiments* " to be published in Helv. Phys. Acta.

[17] We use the term 'material' time, because indeed all watches used nowadays by mankind are based on periodic happenings of material objects.

[18] We want to mention that the fact that reality has more than one dimension is directly related to its construction. And to the fact that we accept that at any moment I (and other humans, and animals, and plants, and...) have a free will to choose partly which creation I will fuse with which happening. A material particle, that follows its path, obeying Newtons deterministic laws (or the deterministic laws of general relativity), is in fact 'existing' in a one dimensional reality. Indeed two arbitrary happenings of this material particle can only be connected by one intermediate sequence of happenings. More concretely, I live in a macroscopical world of more than one dimension, because I can decide at any moment to move forwards or backwards, to the left or to the right, upwards or downwards. We humans also classify all the other material objects (living or not) in this more dimensional space, because every one of us can take such a material object in his hands and 'freely' choose to make it move in different directions (of course against the laws of Newton). In this aspect already, the formalism that we present here, differs from the ordinary physical theories. These physical theories try to make a model for the world and also for me, such that also I am controlled and created by the physical laws that control and create the material particles of the world. In our approach, the concept of (human) **will** is a primitive concept, that we shall not try to deduce from other concepts.

[19] It would very illuminations to study by means of the methodology that we have introduced in this paper, realities of other living beings. Parts of such studies have been undertaken. We mention for example the episode on the physics of vision counted by Richard Feynman in the Lectures on Physics, vol 1, section 36. Feynman compares the human eye with the insect eye, and indicates some aspects for the construction of reality. For example, a human eye is sensitive for light from red (7000 angstroms) to violet (4000 angstroms). A bee however cannot see red but can see ultraviolet (down to 3000 angstroms). Therefore bees can distinguish between many flowers which to us look alike. Apparently white is not very interesting to the bees, because all these white flowers have different proportions in the ultraviolet ; they do not reflect one hundred percent of the ultraviolet as would a true white. All the light is not coming back, the ultraviolet is missing, and that is a colour for the bees, just as for us, when the blue is missing, the flower is yellow. So all the flowers are coloured for the bees. What about the red flowers. Are they black for the bees ? Not so! A careful study of red flowers shows, first, that even with our own eye we can see that a great majority of red flowers have a bluish tinge because they are mainly reflecting an additional amount in the blue, which is the part that the bee sees. Furthermore, experiments also show that flowers vary in their reflection of the ultraviolet. So if we could see the flowers as bees see them, they would be even more beautiful and varied. It has been shown however that there are a few red flowers which do not reflect in the blue or in the ultraviolet, and would therefore appear black to the bee. This was of quiet some concern to the people who worry about this matter, because black does not seem like an interesting colour, since it is hard to tell from a shadow. It actually turned out that these flowers are not visited by bees, but by hummingbirds, and hummingbirds can see the red.

[20] Erwin Schrödinger studies in detail in ref [8], relying on the second law of thermodynamics, why a kind of 'stable intelligent life' could only have developed by collecting an amount of matter of the order of the amount of matter collected in the bodies of the living entities on earth.

[21] D. Aerts, " *An attempt to imagine parts of the reality of the micro-world* " in the proceedings of the conference " *Problems in Quantum Physics ; Gdansk '89* " , to be published by World Scientific Publishing Company, Singapore.