Original Article

Isomorphism of Hidden But Existing Time In Quantum Mechanical Formalism and Human Consciousness

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Abstract

Time is thought to be non-existent in the formalism of quantum mechanics. But time can also become unobservable and hidden in classical physics as well as in human consciousness. All physical or societal laws show timeless invariance, indicating that time-dependent movements can show timeless behavior. Therefore timeless behavior includes an unobservable form of underlying movements implying time. Movements in the present can be directly observed and necessarily show time coordinates, but movements accomplished in the past can no longer be directly observed and only leave traces of grouped movements, similar to animal tracks. Invariance of movements can only be stated when individual movements are grouped together in traces and already accomplished in the past. Then time can be estimated and, when necessary, associated with the traces. Time is no longer required, when different traces of movements are compared with each other. Nevertheless, invariant traces give evidence of underlying regular movements and therefore of time, even if time itself is no longer observable in the traces. In a similar way physical formalism includes the present, past and future of movements at a more highly concentrated information level. Since only the present is observable, information including past and future becomes unobservable, thereby hiding time. Time is also hidden in the digit codes of music on recorded CDs and becomes only observable again after reconversion by means of an appropriate device. The phenomenon of hidden time can be found in human consciousness and in classical physics, but becomes dominant in quantum mechanics.

Key Words: hidden time, invariance, quantum mechanics, classical physics, consciousness

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Introduction

The notion of time seems no longer to exist in quantum mechanics, as argued by several authors (Kiefer, 1990; Barbour, 1999; Zeh, 2009). In the physical formalism of quantum mechanics time has become only one variable between multiple other variables, so it has disappeared (Rovelli, 2006). Nevertheless, everybody in the macrocosm continues to perceive time in consciousness as an unavoidable everyday reality. This signifies a profound discrepancy between physical time and the human perception of time. If the absence of physical time were considered as the sole reality, the human perception of time would be an illusion produced by human consciousness.

In considering the claimed non-existence of time in the quantum physics of the atomocosm and the human

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consciousness of the macrocosm three possibilities must be addressed:

1 - time exists in neither and humans are living in a complete illusion.

2 - time does not exist in the atomocosm, but was created as an emergence in the macrocosm, (Rovelli, 2006)

3 – time is only hidden at the more highly concentrated information level of physical formalism, but exists in both, i.e. in physical formalism of the atomocosm in an unobservable form and in consciousness of the macrocosm in an observable form.

The last hypothesis tries to explain the apparent discrepancy by showing that there is isomorphism between hidden time in consciousness in the macrocosm and in quantum mechanics, meaning that, under certain conditions, time can disappear in the macrocosm in a similar way as in quantum physics and reappear under other conditions.

Definition of time perception

Time should first be defined according to the human perception in the macrocosm. The basic definition of time could correspond to successive movements, continuing indefinitely like a clock, and could be called *progressive time*. Humans seem to perceive time in fractions or building blocks of about 30 – 50 ms (Pöppel, 1986) or in snapshots correlated to oscillations of 13 Hertz waves over the right parietal lob (VanRullen, 2006). One hypothesis supposes an inner time clock. When it is stimulated by temperature or click trains (Treisman, 1990; Jones, 2008), it leads to subjective judgments of time, which are longer than real time. Another hypothesis supposes that the amount of neural energy corresponds to subjective time perception; an increased activity of the neuronal system thereby leads to longer subjective time duration (Eagleman, 2009) In highly frightening situations, for instance falling down from a 31m high tower into a safety net, time is overestimated (Stetson, 2007). Arousal corresponding to an increased inner time clock may happen in a situation of holdup on the way to reach an airplane in time, when every minute “lasts forever” (Wearden, 2008). In such cases time may be felt as arrested and could then be called *constant time*. When constant time tends to become infinite, it would correspond to the definition of eternity, a concept used in many religions. The time lapse experienced before threatening situations, like volcano eruptions, hurricanes or floods can be estimated as *probable time*. In other situations one may perceive *relative time,* when time seems to change much more rapidly for instance when sitting in a speeding car as compared to an ox-drawn carriage. Music recorded on a CD implies *unobservable time,* although time will become observable again when hearing the music. Recorded time is hidden in digit codes and can only be perceived again with the assistance of a specific device, able to convert the more highly concentrated information into observable music. The different notions of time perceived in the macrocosm can also be found in physical formalism, due to isomorphism between conceptions of time in human consciousness and physical formalism.

Progressive time, the basis of our perception of time, was used by classical physics to establish the classical physical laws. But the development of two great achievements in physics, general relativity and quantum physics has changed the notion of progressive time in different ways. Einstein’s general relativity showed that absolute time, as imagined by Galileo and Newton, could no longer be maintained; with the result that time is necessarily relative to a referential, called relative time. Finally quantum mechanics introduced two other modalities of time. Since experimentation at the level of elementary particles had given evidence of Heisenberg’s (1927) uncertainty principle, precise time had to be changed into probable time, an important change to the initial concept of the precision of time. Quantum mechanics also introduced superposition of physical states in the wave function, which no longer accepted time as successive movements and could then be called unobservable time. The progress of the physical sciences changed the notion of time continuously. Does this mean that time no longer exists at all, or is it only hidden within the physical formalism, similar to unobservable time hidden in a CD in the macrocosm?

Disappearance of time

Already in normal human perception time can disappear. The fundamental human perception of time is progressive time which changes naturally like day and night, but also artificially for example by means of the pendulum clock, invented by Galileo. But a different human perception of time could be called constant time, when time seems to stop for a while, or when time is artificially defined as a time period. In both cases time is considered as constant and represents progressive time only by successive periods of constant time, similar to a continuous movement shown under a successively flashing light. Since time periods are arbitrary definitions, they may be extended to months, years, or centuries, which lead to disappearance of the notion of progressive time. Nevertheless, progressive time is only hidden under the notion of constant time and may reappear, since time periods are generally defined by an underlying progressive time scale of hours, years or centuries.

Three different reasons may lead to disappearance of time in physical formalism. A first reason is the indifference shown to time evaluation, since time is not always under study in scientific investigations and thus will not appear in the formalism. All scientific approaches tend to make complex situations simpler by cutting them into different aspects. An example in the macrocosm may be the study of car accidents. Different aspects of this complex situation can be selected - for instance the number of dead persons, but also the most dangerous time periods for accidents. As long as time is not directly under study, its individual coordinates can be assembled in artificially defined time periods. Then time is represented by an artificial means representing the multiplicity of individual coordinates by only one mean coordinate, which now represents constant time. The creation of time periods changes the progressive time of individual car accidents into constant time. Nevertheless, a time period does not eliminate the underlying individual time coordinates of each individual accident; it only represents time in a hidden and more concentrated form.

The second reason for disappearance of time in classical physical formalism is the notion of constancy of laws. At a first glance, constancy is the opposite of movement - such as a rock in a rough sea - and could then be called absolute constancy. But a second meaning of constancy, essentially explored in physics, is constancy of the movement of bodies, like the constantly moving earth around the sun and could be called relative constancy or invariance. Movements may show constant behavior like planets or inconstant behavior like butterflies. Constant behavior may be approached with mathematical formalism and then no longer needs time coordinates for precise characterization. Therefore invariance of behavior, although it is necessarily based on movements, allows the abstraction of time. Nevertheless, timeless invariance would not exist without time-consuming movements.

Movements with precise time coordinates can only be observed at the moment of their performance in the present. The planets of the solar system turn with great regularity around the sun, which was described as invariance by the laws of Kepler and Newton. Invariance of movements such as the ellipses of planets can only be stated if instant movements of the present are grouped together in traces, which have already been completed in the past. But traces of movements in the past can no longer be directly observed with precise time coordinates. Time may even be completely lacking, so that it can be detached from movements in the past. Movements can therefore be regarded from different viewpoints with respect to instant movements in the present or their traces in the past. When directly observed movements are considered in the present, they necessarily include time coordinates, whereas indirectly perceived movements as traces in the past compress time or can make it completely disappear. Traces in the form of ellipses no longer contain the notion of time. Ellipses of planet movements can also be projected into the future, but only under the condition that the movements will remain constant.

Physical formalism of ellipses for planet trajectories considers traces of invariant planet movements. The traces do not require time and therefore hide it at a higher concentrated information level. Physical results can be expressed at different and more or less concentrated information levels. The first information level concerns movements in the present, necessarily requiring space-time coordinates. In contrast traces of invariant movements of the past, such as traces of trajectories of planets including all individual time coordinates represent a more highly concentrated information level. Depending on the information level, time is more or less observable. At the lower information level of the present, time coordinates are evident, but at the higher information level, concerned with traces of movements in the past, time can be omitted in physical formalism. Therefore different ellipsoid trajectories of planets can be compared without the notion of time. Nevertheless, traces of movements are evidence of invariant movements in the past, which imply time.

An example of elephants may illustrate the notion of active movements in the present and traces of movements in the past. When we see an elephant walking in the forest in the present, the movements can be defined with space and time coordinates for each foot, whereas the traces of elephant movements in the past are grouped together in tracks and individual time coordinates can no longer be observed. But if a notion of time is still required, for instance to determine if the elephant passed an hour or a day before, time can be roughly estimated for the whole group of traces and retrospectively associated. Nevertheless, if the notion of time is not under study, traces of movements in the past can be detached from time, for instance when comparing traces of elephants to those of tigers. In traces of movements, time is hidden in an unobservable form, although it is a constituent of movements producing the traces. In a similar way in mathematics, multiplication is a more complex form of addition and squaring an even more complex form of it. But in the squaring process the notion of addition is no longer present and therefore hidden within its formalism.

The third reason for the disappearance of time in physical formalism is hyper-concentration of information on physical states, as shown by superposition in quantum mechanics. According to the uncertainty principle of Heisenberg (1927), results of experiments with elementary particles can only be expressed as probabilities. The wave function superposes multiple physical states and indicates their probabilities; thereby the notion of a trajectory of particles requiring precise time and space coordinates becomes impossible (Zeh, 2009). This leads to the impression that time has completely disappeared at the level of elementary particles, although it has remained at the level of the macrocosm. However, superposition of physical states could be considered as a hyper-concentration of information, which resumes probabilities of multiple physical states including present, past and future. The inclusion of past and future physical states seems to give it the higher value of potentiality at a higher information level. Potentiality separates possible physical states, which may happen, from impossible physical states, which cannot happen.

Human observation is limited to the present, therefore two different kinds of realities should be distinguished, on the one hand *observable reality*, a non-concentrated form of information representing the present, which remains directly accessible to human perception and, on the other hand, *unobservable potentiality*, a more highly concentrated form of information on physical states also including past and future, which is no longer directly perceptible. If unobservable potentiality has to become observable reality again, the multiple possible superpositions have to collapse to one only. Observable time reappears after the collapse of superposition and is therefore only hidden in the more highly concentrated form of potentiality.

Macroscopic isomorphism for hidden time in physical formalism

In three different situations, human perception may observe a light point in movement, although its movement and therefore time are only observable in one situation. A brilliant light point is mounted on a wheel invisible in the dark. When the wheel is revolved at normal speed, the light point will describe a circle and therefore time (Figure 1 B).

At too low a speed, movement of the light point cannot be directly observed (Figure 1 C) and only one precise position will be indicated. The observer has to come back much later for another observation in order to measure if the position of the light has changed. This shows the intervention of a secondary system to carry out this observation. If the light point has changed its position, the time for the observer to come back has to be taken into account, since the direct movement of the light cannot be observed. Since the trajectory cannot be directly observed, it has to be imagined and may theoretically consist of a regular geometric figure or of irregular movements, and has therefore to be confirmed by further observations.

If the speed of the wheel is too high, a static circle becomes apparent without any visible movement of the light point (Figure 1A). The absence of movement within the static circle also signifies the absence of time, even though the static circle can only appear if there is in fact a light point in rapid movement. When the speed of the wheel is increased above normal, the initial light point becomes first a short line, which increases its length with higher speed until the first point reaches the last point of the line to form a circle. The perception of a line instead of a point is due to the intervention of a secondary system necessary for observation, which imposes special conditions on the observation process. The human eye receives the light point on its retina, but is unable to restore the impact rapidly, so that it remains still observed, when the light point has already moved forwards. Thereby the retina simultaneously shows the real light point at the beginning of the line, which represents the present, whereas the following light points on the same line represent the past of the movement. When the line becomes a static circle, the secondary intervening system only represents the traces of movement accomplished in the past, thereby eliminating time. The future is also predicted in the static circle but only under the condition that the movement continues with the same behavior. The static circle represents movements as traces after the passage of the light point and therefore indicates that it is in constant movement requiring time. Since movement is no longer directly observable, it seems to eliminate time. Nevertheless, movement is the necessary condition for obtaining the static circle, which would not exist without the unobservable movement. The static circle thereby hides time at the higher information level of the geometric figure.

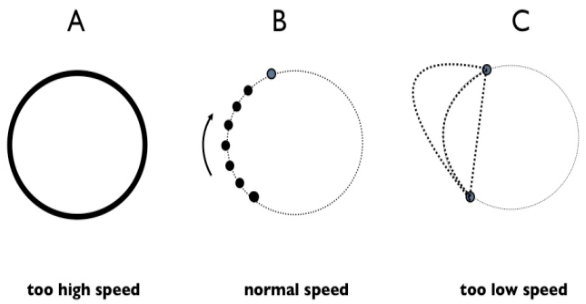

Figure 1. Three situations of human time perception when a light point revolves on an invisible wheel in the dark.
A) speed too high: no visible movement = no time,
B) normal speed: visible movement and time,
C) speed too low: no visible movement and no time, only an introduced secondary time scale suggesting different potential movements, which have to be verified.

In every law, there is a notion of constancy, which may be considered as timelessness. Consequently a law must be followed at any time, by humans for social laws as well as by nature for physical laws. Such relative constancy could be considered as invariance of movements, the opposite of randomness. Although any movement is time-dependent, its regularity may be constant and therefore timeless. Nevertheless, this kind of timelessness is limited to the persistence of movements. For instance when the sun will explode as a supernova in some billions of years, the invariant, timeless movements of planets will disappear. Movements can be characterized at different information levels, which may or may not require time perception. At the first information level, which is concerned with the present, the variable space-time coordinates of movements are observed, but at the more highly concentrated information level, which is concerned with traces of movements accomplished in the past, time has disappeared. Thus time can appear or disappear according to the level of information.

Invariance of physical laws is regularity of movement and is therefore dependent on movements and time. This can be experienced in the laws of nature as well as in societal laws. In most countries, social laws impose limits on vehicle speed on highways. Such laws are expected to be timeless, since they have always to be followed. When an individual driver applies the law, he repetitively diminishes his speed, when it exceeds the established limit. These are time-consuming actions of the driver to fulfill a timeless social law. Although social laws may not always be applied, physical laws do not allow any exception, such as the law of gravity. The regularity of attraction between the masses of physical bodies suggests the law of gravity. Its timeless invariance is based on repetitive movements of attraction in test systems. Thus physical laws are also based on movements and time.

As regards the disappearance of time by superposition in quantum physics, one may envisage macroscopic isomorphism by imagining a short film sequence of a bicycle sprinter. In general, 24 images per second are exposed, one after the other, to make the movement of the sprinter visible (Figure 2). If the 24 images were not projected one after the other, but in superposition all together, the resulting image would also contain all the information but in such a concentrated form that the movement would become imperceptible to the human eye (Figure 3). The concentrated form of superposition no longer corresponds to observable reality but becomes potentiality, i.e. it contains multiple possible realities. The concentrated information of superposed images becomes only observable to the human eye again, if the superposed images collapse to individual images and are projected one after the other (Figure 4). The collapse of superposed images to successive images allows the notion of movements again with the result that time was only hidden at a higher information level.

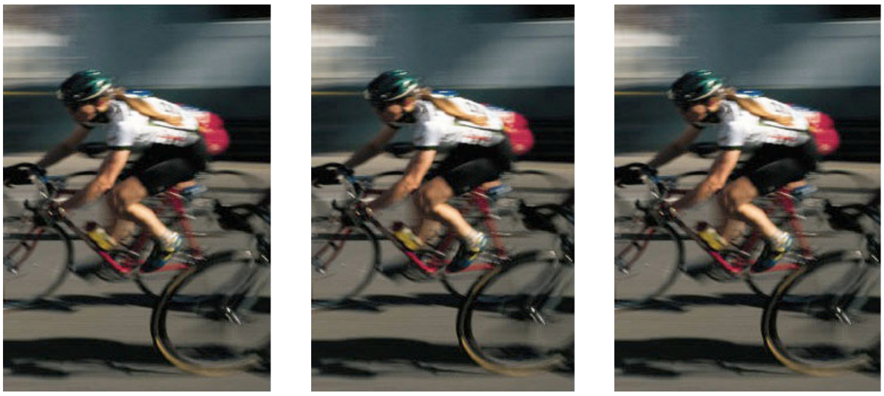

Figure 2. A film sequence of successive but observables images each containing limited information of 1/24 of a second showing the movement of the sprinter.

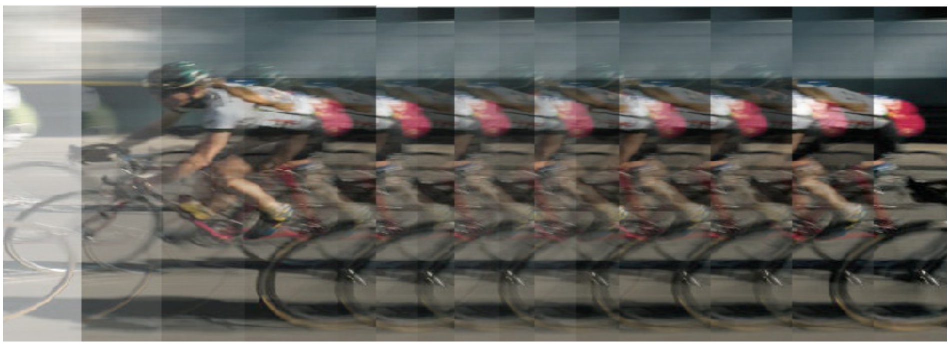

Figure 3. One superposed unobservable image containing all information of 8 superposed images (representing 8/24 of a second) in a film sequence showing the sprinter movement in a static manner.

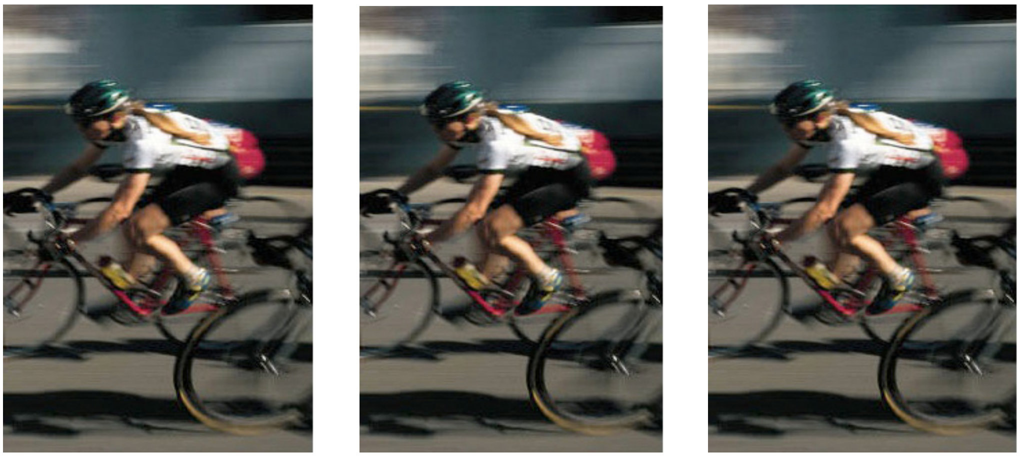

Figure 4. After the collapse of superposition, successive images of a film sequence become observable again and show the sprinter's movement

Another kind of isomorphism can be found in functions of the human consciousness, which is able to consider future events in superposition to each other. Since future events are never certain before they are realized, the human consciousness imagines several possibilities in superposition to each other for the same future time period; it therefore imagines potentiality instead of reality. One may imagine, say, for the following morning a walk or a swim or the reading of a book during the same time period in superposition. Nevertheless, since only one activity can be carried out at any moment of time, the imagined potentialities have to collapse to only one for realization, similar to the collapse of the wave function (Jansen, 2008).

Time in statistical formalism

In general, statistical methods require pooling of individual results to a mean value and thereby reduce individual coordinates of progressive time to a mean value of constant time. In the example of car accidents for instance, individual time coordinates can be grouped into time periods to compare them with other countries. The arbitrary time periods may extend to months, years or even more. The artificial mean no longer corresponds to real individual time coordinates, but renders the scientific approach much simpler by using one unique mean coordinate instead of the multiplicity of all individual coordinates. Simplification of this approach has many advantages; it renders statistical calculations much easier and facilitates human comprehension, but it also allows the possible disappearance of all individual time coordinates. Whereas the artificial mean time value is a virtual reorganization of individual time coordinates and therefore unobservable in reality, the individual time coordinates of each car accident did not disappear and remain observable reality. Therefore individual time coordinates can be considered as hidden within the artificial mean values of statistical approaches, so that statistical formalism becomes a more highly concentrated piece of virtual information about observable reality and seems to make individual time disappear within constant time periods. Nevertheless, observable reality with individual time coordinates remains the basis, from which statistical treatments were calculated.

Applied to other problems, statistical methods are the only way to approach certain physical problems such as in thermodynamics. All molecules are in permanent movement, but the complexity of their individual spatiotemporal coordinates cannot be experimentally explored, only their statistical behavior. Nevertheless, every molecule in movement possesses precise individual time coordinates, which are inaccessible to observation. Once again individual coordinates of progressive time are replaced by mean coordinates of constant time periods for all molecules thereby hiding individual time coordinates.

Time in astronomical formalism

An instructive example of the concentration of time was given by Rovelli (2010) by proposing a physical formalism containing all possible constellations of planets of the solar system, i.e. Venus, Earth and the others. Such formalism would include present, past and future constellations. The introduction of any variable besides time would be sufficient to calculate the other constellations, so that time is no longer necessary. Physical formalism including all constellations of the planets also represents a higher order of information corresponding to potentiality, which is different from observable reality, since it simultaneously includes present, past and future. Although one formula of potentiality includes all possible constellations with undefined open variables (x, y), the observation of reality does not allow the viewing of all constellations at once but is limited to only one single constellation.

The ancient Greeks already had devices, which showed the variance in constellations of some planets by turning a wheel, and the notion of time seemed to disappear. The brief moment needed to turn the wheel was sufficient to change one constellation to another. This did not reflect the natural time needed for the same change of constellation, but a compressed time scale, although time remained present. An isomorphic phenomenon can be found in the macrocosm, when a film is projected with acceleration or deceleration. Although the natural time scale is required for the production of the film, the projection of the film can be done with extreme acceleration or deceleration. The conscious mind has a similar function by changing the natural time scale through acceleration or deceleration. Therefore the mind allows the constellations of planets to be changed in a time-compressed manner without any correlation with the natural time needed for the planet movements.

Time and the theory of general relativity

The notion of an absolute time, which is valid for the whole universe, as originally imagined by Galileo and Newton, is no longer allowed by Einstein's theory of general relativity and thus erases the notion of simultaneity. When we observe a supernova in a far distant galaxy, the explosion seems to be simultaneous with our observation, but it cannot be simultaneous, because the photons had to travel millions of light years before reaching our eye, so that the supernova exploded millions of years before our observation took place. However, the notion of simultaneity can be re-introduced by considering local or relative time. Even if the supernova appears to be simultaneous to our observation, it was in reality simultaneous to previous time periods, for instance to that of the dinosaurs about 100 million years before or to earlier periods on earth.

Therefore time has to be considered with respect to a referential, which is in general the referential of one year, the period of the revolution of the earth around the sun. With a different referential, the calculation of time will necessarily change. The evolution of Mars around the sun is about 2 times longer than the one of Earth, so that a referential based on the year of Mars would change all time calculations. Time is also dependent on speed and changes when its speed approaches that of light. Once again, time has to be corrected with respect to a referential and then becomes relative time, a concept, which maintains, however, the notion of progressive time.

Time and quantum mechanical formalism

Two important changes in the notion of time were introduced by quantum physics, which could be called probable time and potential time. The description of the uncertainty principle of Heisenberg (1927) showed that precise time coordinates could not be observed at the level of elementary particles, but only their statistical behavior, which renders time only probable. This means that the high precision of time in the macrocosm has been completely lost. Nevertheless, even probable time remains time, so that the uncertainty principle renders time merely uncertain without eliminating it completely.

The uncertainty principle can be interpreted in two ways:

a) The observer directly measures the indeterminate behavior of elementary particles (a generally considered interpretation) or

b) The observer cannot directly measure the behavior of elementary particles, since he is hindered by indeterminate observing conditions, with the result that the particles could still have determinate behavior, but this remains completely unobservable.

Whatever the interpretation might be, superposition of physical states in the wave formula can be considered as the best approach to predict phenomena of elementary particles in the atomocosm. With respect to the two interpretations there are opposite positions, that of the Copenhagen School, and the more recent one of *multiverse* (Everett, 1957; Lockwood, 1996; Deutsch, 1997; Zeh, 2009).

One principle of the Copenhagen School was the absence of speculation on superposition before the measurement takes place, a position compatible with both interpretations (a and b) and limited to observable reality only. On the other side, the theory of a *multiverse* directly speculates on the behavior of elementary particles before the measurement takes place by adopting only interpretation (a), which means that each superposition of physical states before the measurement represents an existential reality in the universe and needs decoherence to become observable reality of the macrocosm. In this theory, time has completely disappeared, whereas in the theory of the Copenhagen School the measurement induces collapse of all superpositions in the wave function to only one, which makes time reappear.

There seems to be a certain analogy to classical physical formalism in the macrocosm, when all constellations of planets are included in one formula by eliminating time. Simultaneous information on all constellations becomes unobservable and thereby potentiality. An observer can only detect one unique constellation in the sky, so that all other constellations have to collapse to only one, which corresponds to the actual observation. The formalism of quantum physics also includes information in a hyper-concentrated form by the use of superposition of present, past and future physical states. But superposition of all probable physical states is necessarily unobservable and needs the collapse to one state only, which then can be observed again. This corresponds to the position of the Copenhagen School, which is compatible with hidden time in physical formalism at a higher information level of unobservable potentiality. Time then reappears after reconversion to observable reality. Therefore, the notion of progressive time, although hidden in physical formalism, has never disappeared.

Conclusion and Outlook

The notion of time is first of all a genuine perception in human consciousness linked to successive events or movements and here called progressive time. The interaction of consciousness and quantum physics was described by Bitbol (2008) for the measurement problem of quantum physics. In this paper isomorphism between hidden time in consciousness and quantum mechanics is suggested. Since isomorphism of the disappearance of time can be found in some macroscopic situations, it is not only restricted to the atomocosm.

Human consciousness perceives progressive time only, when reality is directly observed in the present, whereas progressive time in the past and the future can only be indirectly perceived by its traces. The traces of movements are grouped movements accomplished in the past, where time is no longer directly observable. Therefore the ellipses as trajectories of planets have no time. Nevertheless, time can be estimated as for tracks of animals or for trajectories of planets and associated with the traces of the past. In a similar way human consciousness can summarize within a short time period centuries of Roman or Greek culture, thereby concentrating information of the past and hiding the underlying natural time. When time-dependant music is recorded on multimedia support like CDs, time is also hidden in an unobservable potential form and needs reconversion by a special device to become observable again.

Constancy of laws seems to hide the time of underlying regular movements. Social laws try to limit hazardous human behavior in order to transform it into predictable constant behavior. In the same sense timeless constant laws in physics are explored for a better understanding of the future. Nevertheless, certain apparently timeless physical laws, for instance those for planet movements, will have their time limits in the continuously changing universe. The expected constancy is necessarily an expression of the regularity of time-dependent movements, but at a more highly concentrated information level.

Classical physics utilised the notion of progressive time in physical formalism for defining physical laws concerning invariant movement, which avoid the notion of time in its formalism. Nevertheless, invariance always remains invariance of time-dependent movements and thereby indirectly includes time, even if it does not appear in physical formalism. Classical physical laws with undefined, open variables (x, y, z) are a more highly concentrated form of information, which contains in one formula the present, the past and the future. This concentrated information represents only potentiality, which is unobservable reality and therefore includes unobservable, hidden time.

Another notion of time is arrested time, as if it remained constant. Thereby multiple individual time coordinates become extended to arbitrary time periods with only one mean time coordinate. Since such periods are only dependent on definitions, they may be extended to almost infinite periods and give the impression that time could remain constant up to the notion of eternity and thus disappear. Nevertheless, constant time is generally based on underlying progressive time, since constant time periods are, nevertheless, defined in days, months or centuries. Therefore time does not completely disappear in statistics but remains hidden within its formalism.

In astronomy Barbour (2008) suggested that time would not exist in physical formalism by writing *"Duration and the behaviour of clocks emerge from a timeless law that governs change."* But what was first, the timeless law or the change? Did a timeless law create time-dependent movements or inversely was the timeless law only the aspect of invariant, but time-dependant, movements? In the example of the revolving light point, the timeless circle would not have appeared without a time-dependent light in constant rotation.

The theory of general relativity only replaces the notion of absolute time by relative or local time. The time scale has to be re-adapted according to each referential, but the fundamental notion of time as successive events remains. Similarly the uncertainty principle in quantum physics only changes precision of time by rendering it probable, but it does not make progressive time completely disappear.

In contrast, superposition in quantum mechanics seems at the first glance to eradicate time totally, as if it would not exist. Zeh (2009) defending the *multiverse* theory seems to consider that an observer measures the undetermined elementary particles themselves, so that superposition becomes an existential reality, therefore he argued *"there is no time on a fundamental level"*. However, according to the position of the Copenhagen School, a distinction should be made between observable reality and unobservable potentiality, a concentration of multiple observable realities. If superposition in physical formalism with hyper-concentrated information represents potentiality, time seems to disappear. Nevertheless, it reappears at a lower information level after the collapse of superposition, where reality becomes observable again.

The notion of time can become hidden in physical formalism as well as in human consciousness. But can there be any doubt that time exists, that radioactive elements have a half life, that the earth needs one year to turn around the sun and that it has an approximate age of about 4.5 billion years? Time seems to disappear in physical formalism by the transformation into hyper-concentrated information of unobservable potentiality. Nevertheless, it is only hidden and will reappear after reconversion into observable reality.

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