Quantum Mechanics is not Physical Reality But Mental Potentiality Because of the Law of Non-Contradiction

Franz Klaus Jansen

ABSTRACT

Quantum mechanics have always shown great predictive successes, but also some weird aspects concerning the mathematics-reality correspondence, such as superposition of contradictory events, like a dead and alive cat. Although physicists claim that we have to live with these contradictions, a psycho-biological analysis could propose another explanation. Observation of extra-mental reality is based on direct physical contact between an object, its corresponding sense organ and its mental representation in the brain. In contrast, prediction of the future is no longer directly linked to extra-mental reality, but projects possible observations from the memory of the past into the future. Due to the uncertainty of the future, predictions require mental potentiality, meaning that it may or may not happen in extra-mental reality. Nevertheless, if past observations are regular as in classical physics, they allow predictions with high reliability, whereas if they are irregular as in quantum physics, they are limited to uncertainty and probability. Superposition in classical physics increases space or time units accordingly, whereas quantum superposition considers multiple space locations for the same object at the same time. Thus, the quantum mechanical formalism is in direct contradiction to the philosophical law of non-contradiction, which does not allow considering it as extra-mental reality. However, it has all characteristics of mental potentiality, which allows prediction of future outcomes with probability. The consideration of quantum mechanics as mental potentiality would solve the superposition problem, as well as the measurement and the non-locality problem. According to the regularity or irregularity of observation, classical or quantum mechanical formalism has to be applied for prediction of future dynamics. There is no collapse or continuation of superposition in the wave function, but simply the replacement of an uncertain prediction model by the more certain observation. With this interpretation some weird aspects could be completely eliminated.

Key Words: quantum superposition, non-locality, reality, potentiality, observation, imagination
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Introduction

Quantum mechanics were introduced in the early 20th century by Bohr (1928), Heisenberg (1927), Schrödinger (1926) and others to predict the behavior of elementary particles, like electrons. The quantum mechanical laws had several weird consequences with respect to classical physics, such as Heisenberg's uncertainty principle, Bohr's complementarity of particle or wave structure and Schrödinger's superposition in the wave function. Some weird aspects were already eliminated in more recent physical publications. Bohr's complementary principle tried to explain the simultaneous particle and wave structure of elementary particles. Under specified experimental conditions, only one of both structures could be found, but not both

Corresponding author: F. K. Jansen
Address: 126 Chemin des Fesquets, F-34820 ASSAS, France.
Phone: + (0) 609908347
e-mail * jansen.franz@orange.fr
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simultaneously. Nevertheless, Afshar (2007) after choosing more complex experimental conditions proved that both properties could be found simultaneously in the same experiment. With a macroscopic system Couder and Fort (2006) demonstrated a simultaneous particle and wave behavior in the macrocosm with silicon oil droplets bouncing on a vertically vibrating bath of the same liquid and showing interference patterns. Zheng-Johansson (2010) described an Internally Electro-Dynamic (IED) particle with an electric charge in movement, thereby creating electro-magnetic waves, which also follow particle equations. Nevertheless, other weird aspects still remained, such as superposition in the wave function, which led to quite different interpretations. The Copenhagen interpretation requires a collapse of the wave function, when the outcomes of quantum mechanical experiments are observed with the help of the observer's consciousness. More recent interpretations consider that the reduction of superposition happens before observation, such as spontaneous localization Ghirardi et al. (1986) or objective reduction Penrose (1994). Finally other propositions maintain superposition of the wave function and claim multiple worlds (Everett, 1957) or multiple minds (Zeh, 1970). The American physicist Tegmark (2014, p.228) claimed: "*... the world is weird, and we just have to learn to live with it.*" However, from a psycho-biological perspective, there could be other possibilities to overcome the weird aspects of quantum mechanics.

For long time there were discussions, whether quantum mechanics are ontological corresponding to physical reality, or if they are epistemic only reflecting our knowledge on physical reality. However, it is difficult to define the meaning of ontological, since in philosophy the mind-brain theory of physicalism could consider the brain functions as physical events, thus our knowledge could also be considered as ontological. From a psycho-biological perspective, one would better distinguish between extra-mental reality and its mental representation reality (Jansen 2014). With this perspective, one could ask, if quantum mechanics correspond to extra-mental physical reality or only to its mental representation, which are separate phenomenological entities. The philosophical law of non-contradiction excludes quantum mechanics from extra-mental reality, but accepts it as mental potentiality, which also corresponds to human mental functions predicting a yet unknown future (Jansen 2008).

1. Physical Interpretations of Quantum Physics

Goldstein (1998) claimed that: "*Despite its extraordinary predictive successes ... It is not at all clear what quantum mechanics is about*." Bohr (Schilpp, 1949) considered the *"impossibility of any sharp separation between the behavior of atomic objects and the interaction with the measuring instruments ...* Heisenberg (1958, p.129) wrote "*the idea of an objective real world whose smallest parts exist objectively in the same sense as stones or trees exist, independently of whether or not we observe them ... is* impossible *... . We can no longer speak of the behavior of the particle independently of the process of observation."* Schrödinger (1935, p.156) who described the wave function, declared: *"That it is an abstract, unintuitive mathematical construct ..."* and due to the measurement problem following macroscopic superposition, he found it difficult to consider quantum mechanics as *"representing reality"*. Thus from the beginning, there was a doubt, if quantum mechanics could be considered as extra-mental reality existing outside of an observer.

Nevertheless, many attempts tried to reconcile quantum mechanics with reality. The measurement problem concerns superposition in quantum mechanical formalism for the prediction of experimental outcomes, which contrasts with observation, since only one result can be observed. Consequently the quantum mechanical superposition had to collapse as claimed by the Copenhagen interpretation. Von Neumann (1932) extended the wave function from the *atomocosm* to the *macrocosm* by considering that the entire universe could be made subject of the wave function. Thus, something outside the calculation had to be responsible for the wave function collapse considered as physical reality, which could be the consciousness of the observer. Wigner (1961) followed von Neumann's interpretation of the collapse in human consciousness. Hameroff and Penrose (1996) combine an objective reduction (OR) of the wave function through instability in the intrinsic feature of space time geometry with superposition of proteins in the microtubules of nerve cells. In these interpretations superposition is physical reality and the collapse occurs in the brain.

Other interpretations claim quantum theories without observers, which necessitate that the collapse of superposition happens in physical reality. Goldstein (1998) evokes three basic categories: decoherent histories, spontaneous localizations and pilot waves. Decoherent histories initiated by Griffits (2002) are based on quantum interference effects resulting in coarse graining. A different approach is decoherence by superselection through interaction with the environment (Zurek 1981). The second category comprises the GRW theory by Ghirardi, Rimini and Weber (1986) focusing on spontaneous localization after spontaneous random collapses at the atomic level, which avoids macroscopic superposition. The third category concerns the Bohmian pilot wave approach, in which quantum theory essentially concerns particles and secondarily wave functions, which only govern the motion of the more fundamental variables.

2. The Superposition Principle

A major constituent of quantum mechanics is Schrödinger's wave function, which includes linear superposition of multiple physical states. Superposition is a general mathematical principle, already established for classical physics and indicates that, for all linear systems, the net response at a given place and time caused by two or more stimuli is the sum of the responses, which would have been caused by each stimulus individually (Illingworth, 1991). The general superposition principle was also applied in the wave function, but in a different manner.

2.1 Superposition in Mathematics

Major properties of superposition are additivity and homogeneity and a linear mathematical function satisfies these properties. In classical physics without superposition, there is only one space unit for one time unit (Figure 1A). In the case of superposition, either the time or the space unit have to be increased, thus two superposing water waves create a new wave which occupies more space (Figure 1B) or the same wave can occupy several time units (Figure 1C). Different waves can naturally occupy different time units separately (Figure 1D).

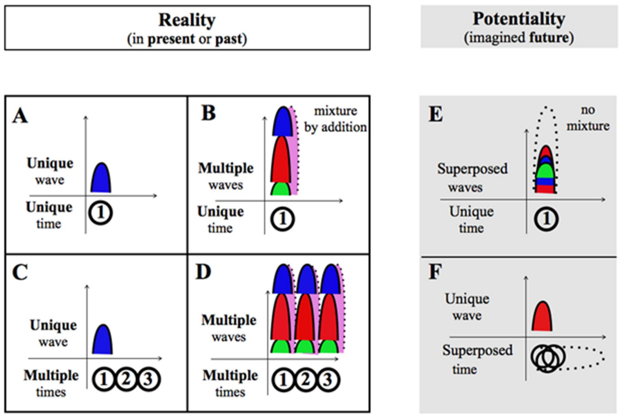

Figure 1. Time to space relation illustrated by water wave superposition. Classical superposition leads to increased time or space units, whereas quantum superposition requires multiple space locations for the same object and the same time point.

The general superposition principle was also applied in Schrödinger's wave function. Instead of an increase within one space or time unit, now several space locations are simultaneously superposed for the same object and the same time (Figure 1E). Quantum superposition holds that a physical system — such as an electron — exists partly in all its theoretically possible states simultaneously. Dirac explained the main characteristics of superposition in quantum mechanics (1947, p.12):

> *"... Whenever the system is definitely in one state we can consider it as being partly in each of two or more other states. The original state must be regarded as the result of a kind of superposition of the two or more new states, in a way that cannot be conceived on classical ideas. ... The non-classical nature of the superposition process is brought out clearly if we consider the superposition of two states, A and B. ... What will be the result of the observation when made on*

the system in the superposed state? The answer is that the result will be sometimes a and sometimes b, according to a probability law depending on the relative weights of A and B in the superposition process... The intermediate character of the state formed by superposition thus expresses itself through the probability of a particular result for an observation ... not through the result itself being intermediate between the corresponding results for the original states." (Figure 2).

REALITY :

CLASSICAL SUPERPOSITION :

Summing up of parts of physical states

(with **increasing** time or space units)

POTENTIALITY :

QUANTUM SUPERPOSITION :

Summing up of multiple physical states simultaneously

(with **unchanged** time or space units)

Figure 2. Characteristics for superposition in classical physics and in quantum mechanics.

Quantum mechanical superposition is therefore the superposition of multiple whole states for the same time unit, whereas classical physical superposition only increases physical properties within one state and the same time unit. According to Dirac the intermediary result after superposition of two states does not indicate the real location of an elementary particle, but the calculated probability with the corresponding weights to find it in one of the possible locations. A calculated probability is necessarily the result of a mental function and not an extra-mental physical phenomenon. In the same sense, but from a psycho-biological perspective, there is a major conflict between quantum mechanics and the philosophical law of non-contradiction, which does not allow that quantum mechanical formalism could represent extra-mental reality.

2.2 Superposition from a Psycho-Biological Perspective

A physical observer is not only a passive collector of information, but includes the transformation of information into physical laws by cognitive processes, like Schrödinger. The mental processes have also to be analyzed for their influence on the final physical theory. Extra-mental reality can only be perceived by the brain with the help of sense organs, which transmit all information from extra-mental reality with the help of physical factors, such as electromagnetic waves for the eyes or other physical factors for all other sense organs. Physical factors are transformed by the sense organs into neural activity called sensory transduction. Light enters the eye as electromagnetic waves and stimulates sensory neurons in the retina, which transform the physical stimulation into depolarization of neurons and transmit their information to specialized brain regions. Mechanical waves enter the ear and stimulate specialized receptors, which transmit their activation to specialized regions in other brain regions. All sensory organs function in a similar way, since they are stimulated by physical factors and transmit their activity to their corresponding special brain regions (Jansen, 2014).

With information perceived by all sensory organs, the brain constructs a mental representation of extra-mental reality. However, if the perception organs are inactivated such as by closing the eyes or the ears, there is no longer any direct physical contact between the extra-mental reality and its mental representation in the brain and then no observation of extra-mental physical events is still possible. Now the brain is completely cut from its outside environment and functions only with its memory, such as perceptions from the past encoded in the memory and retrieved again. The distinction between sensory perception through direct physical contact with the extra-mental reality and memorized perceptions of the past is very important, since pure bottom-up perception from sensory organs to the brain remain unchanged. The intensity of powerful light flashes or unsupportable noise cannot be voluntarily changed, whereas perceptions of the same events after their memorization become modifiable, for instance they can be forgotten or recalled a day later and do no longer induce the same pain feelings. Since memorized past perceptions can be cognitively modified, they allow rearrangements in the representation of extra-mental reality by imagining new situations, which no longer correspond to prior perceived extra-mental reality. These functions are essential for imagining the future by reorganizing past memory perceptions in a different way and projecting them mentally into the future. Since the future is generally uncertain, it can only be imagined with potentiality. Thus several possibilities have to be imagined simultaneously, although with different probabilities, which correspond in humans to mental superposition for the prediction of an unknown future.

2.3 Superposition and the Non-Contradiction Principle

The human mental capacity to foresee the future strikingly resembles the prediction of quantum mechanics for the future behavior of elementary particles, since different possible wave functions are simultaneously superposed and only lead to probability estimations (Jansen, 2008). The initial question, if quantum mechanics are ontological physical reality is now restricted to the question, if they correspond to extra-mental reality or to its mental representation of future events, which is potentiality. The direct perception of extra-mental reality with active sense organs is essential for observation of physical events in the present, whereas the modification of observations from the past by cognitive functions allows a prediction of future events, but only with potentiality (Jansen, 2014). Mathematical models with physical formalism predict the future behavior of elementary particles in a similar way. The question, whether quantum mechanics belong to extra-mental reality or to its mental representation reality, can be clearly answered, since there are precise conditions permitting the distinction between extra-mental reality and mental potentiality.

Reality is only possible with a precise space and time relation, evoking unicity of one space location for only one time point. The philosophical law of non-contradiction concerning reality, already introduced by Aristotle, prohibits that the same space location could simultaneously be occupied by different objects for the same time. Gottlieb (2011, p.2) expressed Aristotle's non-contradiction principle in the following way: *"It is impossible for the same thing to belong and not to belong at the same time to the same thing and in the same respect"* However, different objects can be imagined to occupy the same space for the same time with potentiality predicting the future. Thus according to the reality concept, the presidential chair of an elected president cannot simultaneously be occupied by several presidents. In contrast before an election is finished, potentiality allows imagining that the presidential chair could be occupied by several presidents in the future. With this distinction in mind, quantum mechanics could be analyzed from a psycho-biological view point for its correspondence to mental potentiality instead of extra-mental reality, but there are different definitions for the word reality.

3. Definitions of Reality

The word reality can take quite different meanings and must therefore be precisely defined. According to the Oxford Dictionary it is: "*The state of things as they actually exist".* Nevertheless, real can be interpreted in different manners, such as observed, or reliable or successful:

1. the world is *real* when it *is observed* with active human sense organs and is *potential* when only *imagined* without active sense organs;

2. classical physical laws are *real*, since they predict experimental outcomes with *reliability;*

3. the wave function is *real*, since it predicts probable experimental outcomes with *success.*

In these expressions the word "real" has two different meanings, real in the sense of *observable* and real in the sense of *imaginable.* Observable reality is the perception of extra-mental reality with human sense organs, whereas imaginable reality concerns mental cognitive functions utilizing already memorized perceptions of the past no longer depending on direct contact to extra-mental reality. Observable reality can be illustrated by my car, visible in front of my house, when I saw it in the evening. Imaginable reality is my imagination on the next morning that my car should still be in front of my house. However, it could have been stolen during the night, so that imaginable reality is a mental function utilizing potentiality, since it might or might not correspond to observable reality. Observation of extra-mental reality is generally accepted with a high degree of certainty, whereas imaginable mental reality can be reliable for the prediction of moon cycles but uncertain for weather forecasts.

Classical physical laws are not simply observations of the presence of extra-mental physical objects, but they describe their dynamics relative to space and time, which needs mental cognition. Observation of dynamics requires besides sensory organs for observation, also mental cognition and memorization, since in a dynamic event the starting point is no longer observable and has already become the past, when the endpoint is reached. Thus, even classical laws on physical dynamics are mental reality, which only allows a representation of extra-mental reality in the brain. Mental reality itself can be absolutely certain, like the laws of logic or mathematics, but also only potential, like the predictions of the future. After observation, mental reality can reorganize memorized past events and project them into the future. If past events were regular, the prediction of the future is, nevertheless, highly reliable. Therefore the predictions of physics cannot be considered as extra-mental reality, only as mental reality, which may be erroneous, since Newtons's laws had to be replaced by Einstein's laws and classical physics by quantum mechanics. Physical laws are generally expressed by mathematical models, since they allow the best correlation between the ideal proportionality inherent to mathematics and nature's proportionality.

Concerning quantum mechanics, Albert (2013) defines in his article on *"Wave Function Realism"* the wave functions *"as concrete physical objects".* The meaning of *"concrete"* could be misinterpreted, since they are not concrete objects *"in the same sense as stones or trees"* as mentioned by Heisenberg (1958; p.129), but rather unavoidable, basic physical formalism belonging to mental reality. One essential constituent of quantum mechanics is linear superposition of wave functions, which became necessary to take account of the irregular behavior of elementary particles during observation. Consequently they can only predict a similar irregular future behavior with probabilities. In this sense, quantum mechanical laws are mental reality, which predicts with potentiality only probable future behaviors. Thus, superposition of wave functions is not directly observable extra-mental reality, but remains a mental construct with physical formalism for the prediction of extra-mental reality.

Mental reality can be absolutely certain, as for logic and mathematics, but also remain uncertain for the prediction of an unknown future. Thus, it has always to be verified, if mental potentiality completely corresponds to observable extra-mental reality. Mental potentiality can predict with different degrees of certainty :

a) reliability when predicting from regular past events and

b) uncertainty when based on irregular past events.

Predictions concerning ocean tides or moon cycles show a high degree of reliability, whereas weather predictions can only be established with probability estimations. In a similar sense, classical physical laws are mental potentiality with high reliability, whereas quantum mechanics are uncertain mental potentiality with probability estimations.

4. Characteristics of Potentiality

Whereas reality is observable with sensory organs in the present, such as the eyes or the ears for distant objects, potentiality is only imaginable. A lamp hanging from the ceiling can be directly observed in the present and corresponds to extra-mental reality (Figure 3). Nevertheless, it is imaginable that the constant presence of gravitational forces has the potential to attract the lamp to the ground and to break it. If this does not happen during observation in the present, it could happen in the near or far future.

In contrast to observable extra-mental reality, potentiality is a mental projection of all imaginable possibilities in the future, which could be envisaged. For regular events mental potentiality predicts with reliability, but for irregular events it predicts only with probability. The lamp hanging on the ceiling can be broken for a variety of irregular, unforeseeable reasons with different probabilities and timings ranging from the near to the far future (Figure 4). Rapidly after fixation, the wire of the attachment can break, or some hours later, one may hit the lamp with one's head. It can also be broken some months later, when displacing a piece of furniture or some years later by a fire in the ceiling, or finally decades later by a bomb in a future war. All these potentialities are not observable in the present, but are imaginable in a mental representation of the future with probability estimations. In a similar sense, the wave function also predicts possible future behaviors of elementary particles, which are irregular due to Heisenberg's uncertainty principle. Thus, quantum mechanics correspond to the human mental function of imagining the future extra-mental reality, which is not yet observable in the present (Jansen, 2011).

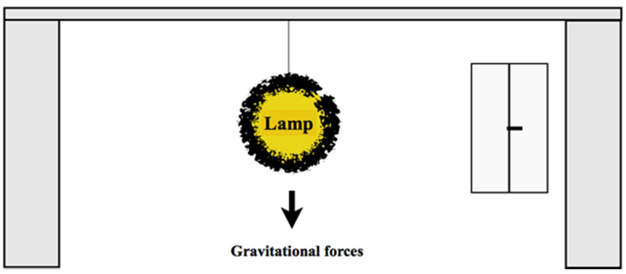

Figure 3. Observable reality in the present, like a lamp hanging from the ceiling without breaking, but attracted by gravitational forces.

5. Weird Aspects in the Math-Reality Correspondence

From a psycho-biological view point, observable reality is expected to correspond to predicted reality by physical formalism, which could be called the Mathematics-Reality Correspondence (or Math-reality correspondence), but this correspondence could be incomplete. Classical physics respect the unicity of one space location for one time point and should therefore allow a truthful representation of extra-mental reality. However, from a psycho-biological perspective, quantum mechanical formalism no longer considers the unicity of one space location for one time point and cannot completely correspond to the reality concept. Different interpretations were proposed by physicists concerning the correspondence of quantum mechanical formalism to reality?

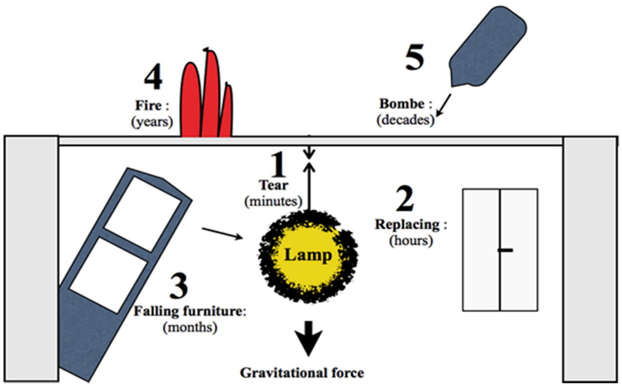

Figure 4. Potentiality predicting five possibilities with different probabilities to break the lamp in the near or far future.

5.1 Superposition Problem

The Copenhagen Interpretation holds quantum mechanics for a theoretical concept. Bohr emphasized that science is concerned with predictions of experimental outcomes and that additional propositions are not scientific but meta-physical (Wikipedia, 2015). Heisenberg already introduced the notion of potentiality with reference to Aristotle's potentia: *"It was a quantitative version of the old concept of "potentia" in Aristotelian philosophy. It introduced something standing in the middle between the idea of an event and the actual event, a strange kind of physical reality just in the middle between possibility and reality* (Heisenberg, 1958; p.41). During the later development of quantum mechanics, only some interpretations accepted non-reality, such as the stochastic mechanics of Nelson (1966), the relational interpretation of

Rovelli (1996), the ensemble interpretation (Ballentine, 1998), the consistent histories of Griffiths (2002) and the potentiality and conceptuality interpretation by Aerts (2010).

The idea that the wave function could be physical extra-mental reality was introduced by von Neumann (1932) and thereafter supported by many physicists. Von Neumann also developed the idea that the wave function collapse is real and that the consciousness of the observer had a causal role for its collapse. His interpretation was followed by Wigner (1961) and Stapp (2005). Other interpretations maintained the reality nature of quantum mechanics, but its collapse no longer needed an observer, such as the hidden variable theory of Bohm (1951), the objective collapse theory by Ghirardi, Rimini and Weber (1986), the transactional interpretation by Cramer (1986) and the objective reduction (OR) of Penrose (1994).

Other authors also maintained the reality of quantum mechanics, but eliminated its collapse. In this sense Everett (1957) created the multi-worlds theory and Zeh (1970) a multi-minds theory. Everett's interpretation is continuously supported by Deutsch (1997) and Tegmark (2014).

The by most theories claimed extra-mental reality of quantum mechanics, which could collapse, is in direct conflict with the philosophical law of non-contradiction for the concept of reality. Consequently all quantum mechanical interpretations claiming extra-mental reality for the wave function cannot be considered as extra-mental, but as mental reality, predicting with potentiality and probability. Thus, there is a great resemblance of quantum mechanics with the human prediction of the future, since also multiple potential events have to be imagined simultaneously for the same time point (Jansen, 2008).

5.2 Measurement Problem

Quantum mechanics predict with linear superposition multiple experimental outcomes, but observation only allows finding one individual outcome. Thus, interpretations of quantum mechanics as reality require the collapse of the wave function or its permanent existence. When considering the wave function as mental reality utilizing a mathematical model based on potentiality, there is no longer any need for the collapse or the permanent existence of superposition.

In mental reality, there are two mathematical models for prediction, which are both based on potentiality. The one for classical physics with reliability potentiality is based on regular observations and the one for quantum mechanics with probability potentiality is more adapted to irregular observations. In classical physics, prediction from regular outcomes will be followed by observation of one unique outcome, whereas prediction from irregular outcomes in quantum mechanics can only expect irregular outcomes with probability. This interpretation also allows another explanation of the Heisenberg cut, no longer differentiating between macrocosm and atomocosm, but between regular and irregular experimental outcomes. The successful application of quantum mechanical formalism outside physics in the psychological realm of decision making clearly confirmed this interpretation (Busemeyer *et al.,* 2006).

Prediction with potentiality is succeeded by the mental function of observation, when a first imagined future becomes the new present. Since prediction of an unknown future is always uncertain, it will be abandoned, when the more certain observation becomes available. Thus, there is no collapse of superposition, but the replacement of an uncertain mental function by a more certain one, i.e. mental prediction by direct observation. In the same sense an uncertain weather forecast is no longer considered, when the weather can be directly observed, or a sailor abandons his calculations on the navigation map, when the target harbor becomes directly observable.

5.3 Non-Locality Problem

Quantum mechanical formalism is constructed with linear superposition, which signifies a simultaneous superposition of multiple physical states. Thus by definition, any individual location in space is replaced with multiple locations of the same object for the same time point. Thereby the conception of the mathematical formalism already excludes any individual locality. As indicated by Dirac (1947, p.12): "*Any state may be considered as the result of a superposition of two or more other states ...,*" which signifies that different space locations are considered for the same time point. Harrigan and Spekkens (2010) studied the possibilities of hidden variable theories, in order to re-introduce locality. Nevertheless, the introduction of locality in the wave function should be extremely limited, since supplementary hidden variables could not change the basic structure of linear quantum superposition excluding individual locality. This confirms Bell's claim (1987) that quantum mechanics are non-local. How could the wave function be compatible with locality, if its basic mathematical construct already excludes any individual location in space?

However, if the wave function is considered as potentiality, it could accept simultaneously multiple locations for the same object at the same time point. Potentiality is much larger than reality and could be qualified as a kind of over-reality, since it includes reality, but only as one of multiple possibilities. Thus, Einstein's claim at the Solvay conference 1927 (Fine, 1996) seems also to be justified, that quantum mechanics are incomplete for representing extra-mental reality due to their incomplete math-reality correspondence.

6. Conclusion and Outlook

The wave function has extraordinary predictive successes and could be applied in different disciplines (Tarlaci and Pregnolato 2015), but maintains some weird aspects with respect to the math-reality correspondence. A psycho-biological perspective could allow another view and help finding a different interpretation. The utilization of the same mathematical superposition principle in the formalisms of classical physics and in quantum mechanics may have induced incoherences in their respective math-reality correspondence. Within the formalism, a mathematical operation may perfectly correspond to mathematical laws, but nevertheless, induce incompatibility for its correspondence to extra-mental reality. In classical physics superposition of individual properties creates a new space or time unit. In quantum physics linear superposition of multiple physical states is considered for the same space and time unit. According to Dirac, electrons are considered to be simultaneously in all possible physical states. This kind of physical formalism is in direct contradiction with the philosophical law of non-contradiction concerning the reality concept, although it is in complete conformity with potentiality, which is a human mental function of predicting events by projecting simultaneously different possibilities with probabilities into the future. If quantum mechanical formalism is considered as prediction of the future behavior of elementary particles, it would perfectly correspond to mental potentiality, but not to extra-mental reality (Jansen, 2008).

According to Allori, physical formalism is first created and thereafter interpreted for its correspondence to physical reality. *"Physics works through mathematics: a theory contains several mathematical objects, some with a physical significance, others without"* (Allori, 2013; p.6) *"... the mathematical formalism of a theory can be interpreted a posteriori, whereas it was fixed a priori by the physicist when she formulated the theory"* (Allori, 2013; p.7). Besides confirming interpretations a posteriori, it is also necessary to verify, if the physical formalism correctly reflects extra-mental reality. Although mathematical operations may be in complete conformity with mathematical laws, they could, nevertheless, have an unexpected math-reality correspondence. From a psycho-biological perspective, there is a considerable difference, between the math-reality correspondence for classical and for quantum mechanical formalism. For the concept of reality, quantum mechanics are not in conformity with the philosophical law of non-contradiction, but they correspond perfectly to the characteristics of mental potentiality, thus imitating human cognition for the evaluation of the future. When interpreting quantum mechanical formalism as mental potentiality and not as extra-mental reality, some weird aspects, such as the superposition collapse, the measurement and the non-locality problem would completely disappear.

The measurement problem signifies that several predicted probable outcomes of the wave function correspond to only one observable outcome. However, direct observation of reality and prediction of the future with potentiality and probability are completely different mental functions. Observation requires the direct physical interaction between outside objects and their mental representation. In contrast prediction with potentiality is completely cut from any outside contact with physical reality and only proceeds with rearrangements of memorized past experiences projected as probable events into the future. The essential distinction between both mental functions is their different degree of certainty. Observation is always considered as more certain than potentiality, which only considers probable events.

If quantum superposition is considered as mental potentiality with probabilities, there is no longer any requirement for the collapse of superposition in the wave function. The simple mental replacement of the uncertain, only probable potentiality by the much more certain observation would be sufficient. In a similar manner uncertain weather forecasts are simply no longer considered and replaced by the certain information from direct observation. If superposition in the wave function is considered as mental potentiality and not extra-mental reality, the measurement problem is solved.

Non-locality is a direct consequence of superposition of multiple physical states for the same time unit. Quantum superposition signifies that one object is located in multiple spaces for the same time point, which necessarily entails general non-locality. Since the mathematical conception of the wave function is based on non-locality, it is impossible to expect any information on locality of elementary particles. In agreement with Einstein's remark (Fine, 1996), quantum mechanics remain incomplete for representing observable extra-mental reality, due to the prior elimination of any locality information by the mathematical concept.

From a psycho-biological perspective, physical formalism in general is not extra-mental but mental reality, allowing a mental representation of extra-mental reality. The prediction of physical dynamics is achieved with mathematical models based on potentiality. After observation of regular dynamics, classical physics predict the future dynamics of macroscopic objects with reliability potentiality. After observation of irregular dynamics, quantum mechanics predict dynamics of elementary particles with probability potentiality. The potentiality character of quantum superposition excludes its belonging to extra-mental reality. Mathematical models are only mental models for some aspects of extra-mental reality and have still to be verified by observation for their degree of correspondence.

References

Aerts D. A potentiality and Conceptuality Interpretation of Quantum Physics. Philosophica 2010; 83: 15-52.
Afshar SS, Flores E, McDonald KF, Knoesel E. Paradox in Wave-Particle Duality. Found Phys 2007; 37, 295.
Albert DZ. Wave function realism. In: The wave function, A. Ney and D.Z. Albert, eds. Oxford University Press, New York, 2013.
Allori V. Primitive Ontology and the Structure of Fundamental Physical Theories, in D. Albert, E Ney (eds) The Wave Function, Oxford University Press, Oxford, 2013.
Ballentine LE. Quantum Mechanics: A Modern Development. World Scientific. 1998.
Bell JS. Speakable and Unspeakable in Quantum Mechanics. Cambridge University Press, 1987.
Bohr N. Quantum postulate and recent developments in atomism. Naturwissenschaften 1928, 16: 245-257.
Bohm D. Quantum Theory. Prentice-Hall, New York, 1951.
Busemeyer JR, Wang Z and Townsend JT. Quantum dynamics of human decision making. Journal of Mathematical Psychology 2006; 50, 220-241.
Couder Y and Fort E. Single-Particle Diffraction and Interference at a Macroscopic Scale. PRL 2006; 97, 154101.
Cramer JG. The Transactional Interpretation of Quantum Mechanics. Reviews of Modern Physics 1986; 58 (3): 649.
Deutsch D. The Fabric of Reality, Viking Penguin, London, 1997.
Dirac PAM. The Principles of Quantum Mechanics (2nd edition). Clarendon Press. 1947.
Everett H. Relative state formulation of quantum mechanics. Reviews of Modern Physics 1957; 29: 454-462.
Fine A. The Shaky Game: Einstein, Realism and the Quantum Theory. (2nd ed.) University of Chicago Press, Chicago, 1996.
Ghirardi GC, Rimini A and Weber T. Unified dynamics for microscopic and macroscopic systems. Phys Rev 1986; D 34: 470.
Goldstein S. Quantum Theory without observers. Part One: Physics Today 1998; 38-42.
Gottlieb P. Aristotle on Non-contradiction. Stanford Encyclopedia of Philosophy, 2011. http://plato.stanford.edu/entries/aristotle-noncontradiction (Accessed 1.12. 2014)
Griffiths RB. Consistent quantum theory. Cambridge University Press, New York, 2002.
Hameroff SR and Penrose R. Conscious events as orchestrated spacetime selections. Journal of Consciousness Studies 1996; 3(1): 36-53.
Harrigan N. and Spekkens R.W. Einstein, incompleteness, and the epistemic view of quantum states. Found Phys 2010; 40: 125-157.
Heisenberg W. Über den anschaulichen Inhalt der quantentheoretischen Kinematik und Mechanik. Zeitschrift für Physik 1927; 43: 172-198. (English translation in Weeler and Zurek, 1983: 62-84)
Heisenberg W. Physics and Philosophy, Harper and Row, New York, 1958.
Jansen FK. Partial isomorphism of superposition in potentiality systems of consciousness and quantum mechanics. NeuroQuantology 2008; 6(3): 278-288.
Jansen FK. Isomorphic concepts for uncertainty between consciousness and some interpretations of quantum mechanics. NeuroQuantology 2011; 9(4): 660-668.
Jansen FK. The Observer's Now, Past and Future in Physics from a Psycho-Biological Perspective. Cosmology 2014; 18: 376-401. http://cosmology.com/ConsciousTime112.html (Accessed date 1.12.2014)
Illingworth V (ed). The Penguin Dictionary of Physics, Penguin Books, London, 1991.
Nelson E. Derivation of the Schrödinger Equation from Newtonian Mechanics._Physical Review 1966; 150: 1079–1085.
Penrose R. Shadows of the mind. New York: Oxford, 1994.
Rovelli C. Relational Quantum Mechanics. International Journal of Theoretical Physics 1996; 35: 1637-1678.
Schilpp PA (ed.). Albert Einstein, Philosopher-Scientist. Library of Living Philosophers, Evanston, IL, 1949.
Schrödinger E. An Undulatory Theory of the Mechanics of Atoms and Molecules. Physical Review 1926; 28 (6): 1049–1070. In Wheeler J.A. and Zurek (eds) Quantum Theory and Measurement. Princeton University Press, Princeton, 1983.
Schrödinger E. Die gegenwärtige Situation in der Qantenmechanik, Naturwissenschaften 1935; 23: 807.
Stapp H. Quantum theory in neuroscience and psychology: a neurophysical model of mind/brain interaction. Phil Trans Royal Society B 2005; 360(1458): 1309-1327.
Tarlacı S, Pregnolato M. Quantum neurophysics: From non-living matter to quantum neurobiology and psychopathology. Int J Psychophysiol. 2015 Feb 7. pii: S0167-8760(15)00046-X. doi: 10.1016/j.ijpsycho.2015.02.016.
Tegmark M. Our Mathematical Universe: My Quest for the Ultimate Nature of Reality. Knopf A. New York, 2014.
Von Neumann J. Mathematische Grundlagen der Quantenmechanik, Springer, Berlin, 1932. (Translated as Mathematical Foundations of Quantum Mechanics, Princeton University Press, 1955).
Wigner E. Remarks on the Mind-Body Problem, in: The Scientist Speculates, Good IJ, ed. Heinemann, London, 1961; 284-302.
Wikipedia, Copenhagen interpretation, http://en.wikipedia.org/wiki/Copenhagen_interpretation (Accessed 1.12.2014)
Zeh HD. On the interpretation of measurements in quantum theory. Found Phys 1970; 1: 69-76.
Zheng-Johansson JX. Internally Electrodynamic Particle Model: Its Experimental Basis and Its Predictions. Physics of Atomic Nuclei 2010; 73(3): 571–581.
Zurek WH. Pointer basis of quantum apparatus: into what mixture does the wave packet collapse? Phys Rev 1981; D24: 1516-1525.