



# World Scientific News

WSN 74 (2017) 106-120

EISSN 2392-2192

---

## **Quantum Physics, Metaphysics, Theism: Interpretations, Ontologies, Theological Remarks**

**Paolo Di Sia**

University of Bolzano, Piazza Università 5, I-39100, Bolzano, Italy  
ISEM, Institute for Scientific Methodology, Via Ugo La Malfa 153, I-90146, Palermo, Italy

E-mail address: [paolo.disia@gmail.com](mailto:paolo.disia@gmail.com)

### **ABSTRACT**

Modern physics is based on two big pillars, the theory of relativity and quantum mechanics; the first describes the macro-cosmos, the second one the micro-cosmos. With the relativity we have witnessed a revolution of concepts of space and time, with quantum physics very unusual weird and out of any classical logic phenomena have been and are being discovered, with all implications at ontological level in relation to the nature of reality. The features of quantum mechanics are seen as puzzling, but also as a resource to be developed, rather than a problem to be solved. It gave rise not only to interpretative puzzles, but also to new concepts in computational environment and in information theory. In this paper, after a general introduction to quantum physics and its key concepts, I focus the attention on its various interpretations, on cosmological concepts like the creation of the universe, the concept of multiverse, the fine tuning, the intentionality, the quantum computation, the entanglement.

**Keywords:** Modern and Contemporary Physics, Metaphysics, Theism, Faith, Ontology, Universe, Information, Computing, Human Being

### **1. INTRODUCTION**

Despite its status as key part of contemporary physics, there is no consensus among physicists and philosophers of physics about the question of what the great empirical success

of quantum theory is telling us in relation to the physical world. This has led to a number of philosophical questions known like "interpretations of quantum mechanics". We do not think that what quantum physics has currently obtained is only a mathematical formalism with no links to the physical world; rather there is a common core of interpretations resulted in formulations for the probabilities calculation of experiments results performed on systems which are subjected to particular preparation procedures of the system state.

In classical physics, any physical system has associated a space of states, which represents the totality of the possible ways to assign values to the dynamic variables characterizing the state of the system. For example, for a system consisting of point-like particles, the status of the system is given specifying the positions and the moments of all particles with respect to a given reference system. For systems with many degrees of freedom, a complete specification of the system state may be not possible or not easy to be determined; the classical statistical mechanics helps in such situations with the use of probability distributions on the space of the system states.

In quantum mechanics the picture is different; there are no quantum states that assign defined values for all physical quantities. The quantum description of a physical system proceeds in a first step by associating the dynamic degrees of freedom with the operators on a suitably constructed Hilbert space. A state is characterized by assigning expectation values to the physical quantities. These assignments are required to comply with algebraic relations between the corresponding operators; a complete set of such expectation values is equivalent to specify the probabilities for the results of all experiments that can be performed on the system.

The core of quantum theory consists of rules for identifying, for any given system, the appropriate operators representing its dynamical quantities, plus an appropriate Hilbert space in which these operators act. In addition we have requirements for the evolution of the system state when it is subjected to the action of external specified forces and/or various manipulations. But being quantum theory more than a means for calculating the probabilities of results of experiments, it embraces issues that are also topics of contemporary philosophical discussion.

Quantum mechanics is usually referred to the quantized version of a theory of classical mechanics, which involves systems with a fixed and finite number of degrees of freedom. The quantization of a field theory gives rise to a quantum field theory; the transition to a quantum field theory brings with it new additional interpretive problems. There are interesting differences, both technical and interpretative, between theories of quantum mechanics and quantum field theories. The standard model of quantum field theory, which has had and has great success at today, does not incorporate one of the four known fundamental forces of Nature, the force of gravity. Attempts to develop a theory that does right even of gravitational phenomena give rise to very serious conceptual problems.

Much of the philosophy connected with quantum theory is the problem of "how we should understand the theory (or an extension or revision of it) in realistic terms", and how this should be done. The various approaches to the measurement problem propose different answers to these questions.

There are also other issues of philosophical interest; they include the "quantum non-locality" in relation to our understanding of the structure of space-time, the "causality", the "ontological character of quantum states", the "implications of quantum mechanics for the

information theory", the "collocation of quantum theory with respect to other theories", both real and hypothetical. In the following, I consider aspects of each of these issues [1].

## **2. COLLAPSE, NON-LOCALITY, NON-SEPARABILITY, ENTANGLEMENT**

a) *Collapse*: in quantum mechanics there is the "collapse of the wavefunction" when a wavefunction, which is initially in a superposition of several possibilities, appears to be reduced to a single state, after an observation. This is the essence of measurement in quantum mechanics. The collapse is one of the two processes by which quantum systems evolve in time; the other one is the evolution of the system through the Schrödinger equation. At this level, the collapse appears to be a black box for the interaction with the classic environment; therefore "the measurement process affects the state of the system". Paul Dirac expressed this concept in terms of "measurement", rather than of "observation", not specifying about the fact that a conscious observer should be aware of the measurement result so that the collapse occurs. Von Neumann points out that the collapse can be linked to the interaction of the quantum system with measurement instruments, before to recognize a "conscious observer of the result".

A version of the collapse phenomenon according to which "a measure is not complete until the result is not observed by an observer" is recognizable in London and Bauer in 1939; however they deny that it represents a mysterious type of interaction between the observer and the quantum system. These two interpretations of the phenomenon of the wavefunction collapse, both as a "real change of the physical state of the system", or as a "simple updating of information by an observer", remained in the literature until today.

b) *Non-locality*: the concept of non-locality refers to more than one context. In this paper I consider the "action at a distance" and the "quantum non-locality". In physics for "action at a distance" it is meant that an object can be moved, modified, however "interested without being physically in mechanical contact with another object"; it is a not local interaction between objects that are spatially separated. This term has been widely used in the first gravitational and electromagnetic theories (for example Coulomb's law and the law of universal gravitation) to describe how an object responds to the influence of distant objects.

More generally, the action at a distance describes the failure of the first atomistic and mechanicistic theories that tried to reduce all physical interaction to collision phenomena. The exploration of this particular phenomenon has led to significant developments in physics, from the concept of "field" to descriptions of "quantum entanglement" and carrier particles of the Standard Model.

c) *Non-separability*: in addition to the non-locality, the non-separability of subatomic particles is a truly stunning look. According to an important theorem demonstrated in 1964 by the Irish physicist John Stewart Bell, an experience occurred in the past between two subatomic particles creates between them a form of "connection"; the behavior of one instantaneously affects the other, regardless of the distance that separates them. To date, no valid argument has been found able to questioning the validity of this theorem.

The experiments carried out so far have confirmed the result obtained by Bell, i.e. that the non-locality must be considered a fundamental characteristic of the microscopic world; subatomic particles can communicate instantaneously, regardless of their distance. This

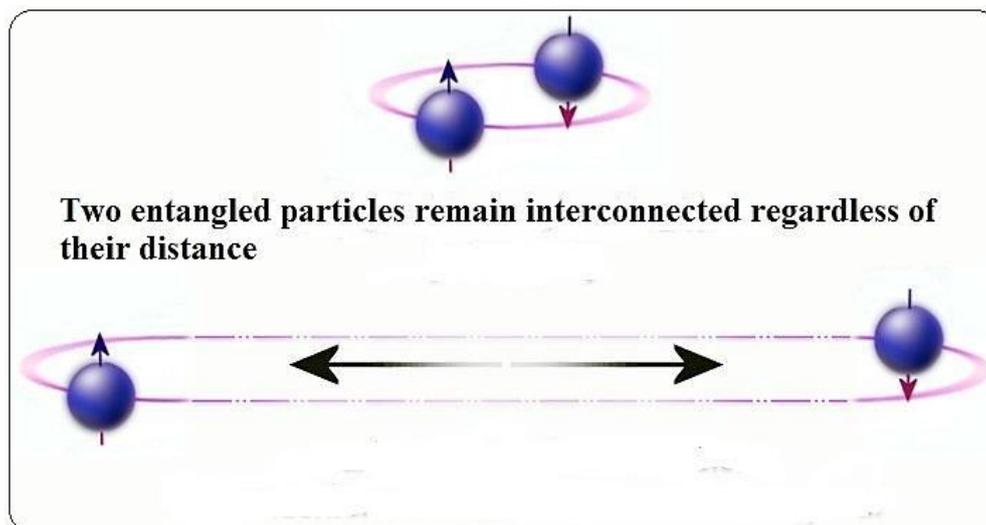
"instant communication", also known with the technical term of "quantum entanglement", is considered as one of the greatest mysteries of human knowledge. It is an observable and repeatable phenomenon, but does not seem to have a clear logical explanation.

The non-separability can be explained based on the existence of "different levels in the physical reality" that, in the deepest level, is characterized by waves associated with different particles that bind them together in a kind of "continuous entirety". Such instant communication can be seen as a consequence of the idea that, at the fundamental level of reality, the physical space has an "atemporal character" and that this space character allows the transmission of information between two subatomic particles first joined and then separated and brought to big distance.

d) *Entanglement*: it is a physical phenomenon that occurs when pairs or groups of particles are generated or interact in such a way that the quantum state of each can not be described independently from the others, even when the particles are separated by a big distance.

Measurements of physical properties such as position, moment, rotation, performed on "entangled particles", appear to be suitably correlated. For example, if a pair of particles is generated in such a way that their total rotation is zero, if a particle has a clockwise rotation with respect to a given axis, the rotation of the other particle, measured on the same axis, will be counterclockwise, as might be expected because of their entanglement (Figure 1).

This behavior produces paradoxical effects. Any measurement of the property of a particle acts on the particle and changes its original properties; in the case of entangled particles, this measure will be on the "entangled system considered as a unit". A particle of an entangled pair "knows" what measurement was made on the other, even if there is no known information communication means between the particles; at the time of measurement, particles may be separated by arbitrarily large distances.



**Figure 1.** Entanglement among particles.

The effect is instantaneous and this leads us to consider possible also greater speeds than the speed of light, limit upon which modern physics is based. The quantum entanglement is currently an area of very active research; its effects have been experimentally demonstrated with photons, neutrinos, electrons, small diamonds. The research is also focused on the use of entanglement in quantum information and quantum computing [2-4].

### **3. IT DEVELOPMENT: QUANTUM COMPUTING AND QUANTUM INFORMATION**

Quantum mechanics has not only given rise to interpretative puzzles, but has allowed the development of new concepts in information theory. The quantum information theory studies the possibilities of processing and transmission opened by quantum theory. Looking at quantum theory from a different point of view, its puzzling features have been seen as a resource to be developed, rather than a problem to be solved.

Quantum computing studies the computing systems which make direct use of quantum mechanics phenomena, such as superposition and entanglement, for performing faster and new operations on data. Quantum computers are different from the binary electronic digital computers. The novelty lies in the following fact: the common digital calculation requires that data are coded in binary digits (bits), which are always one of the two defined states 0 or 1; quantum computation instead uses quantum bits, also known as "qubits", which can be in a superposition of states. A single qubit can represent the state 0, the state 1, or any quantum superposition of these two states; a pair of qubits can be in any quantum superposition of 4 states, three qubits in any superposition of 8 states. In general, a quantum computer with  $n$  qubits can "simultaneously" be in an arbitrary superposition up to  $2^n$  different states, while a classical computer can only be in one of these  $2^n$  states. The calculation ends with a measure, namely the collapse of the qubit system in one of the  $2^n$  pure states, where each qubit is 0 or 1 as in the classical state.

"Quantum information" processes the information of quantum systems. It can be manipulated by using engineering techniques related to the elaboration of quantum information. Quantum information science involves theoretical questions and more experimental issues of quantum physics, including what can and can not be done. The research areas incorporate quantum computing, quantum complexity theory, quantum cryptography, quantum communication, quantum error correction, quantum entanglement, quantum teleportation [5,6].

### **4. INTERPRETATIONS OF QUANTUM MECHANICS**

Although quantum mechanics has proved its power through rigorous and in-depth testing, many of these experiments are open to different interpretations. Among the various unsolved problems, there is the problem of whether quantum mechanics can be understood as "deterministic", what its elements can be considered "real" and other important issues; this is reflected in the so-called "everything theories" that involve it a constructive-theoretical point of view.

On average, all interpretations of quantum mechanics share two qualities:

- a) they interpret the mathematical formalism of the theory;
- b) they interpret the phenomenological aspects.

Two qualities vary in different interpretations:

- c) the ontology;
- d) the epistemology.

A phenomenon may receive both the ontological and epistemic interpretation; for example, the indeterminacy can be attributed to limitations of human observation and perception (epistemic aspect), or can be explained as a real fact, maybe encoded in the universe (ontological aspect) [7-9].

The best known interpretations are:

1) *The Copenhagen interpretation*: it is the standard interpretation of quantum mechanics, formulated by Niels Bohr and Werner Heisenberg in Copenhagen in 1927; they extended the probabilistic interpretation of the wavefunction originally proposed by Max Born. According to this interpretation, the measurement process "randomly chooses" one of the many possibilities offered by the wavefunction of the state, in a consistent way with the probabilities assigned to each possible state. The interaction of an observer or external device to the quantum system is the cause of the wavefunction collapse, then "the reality is in the observations, not involved in the particles" [10].

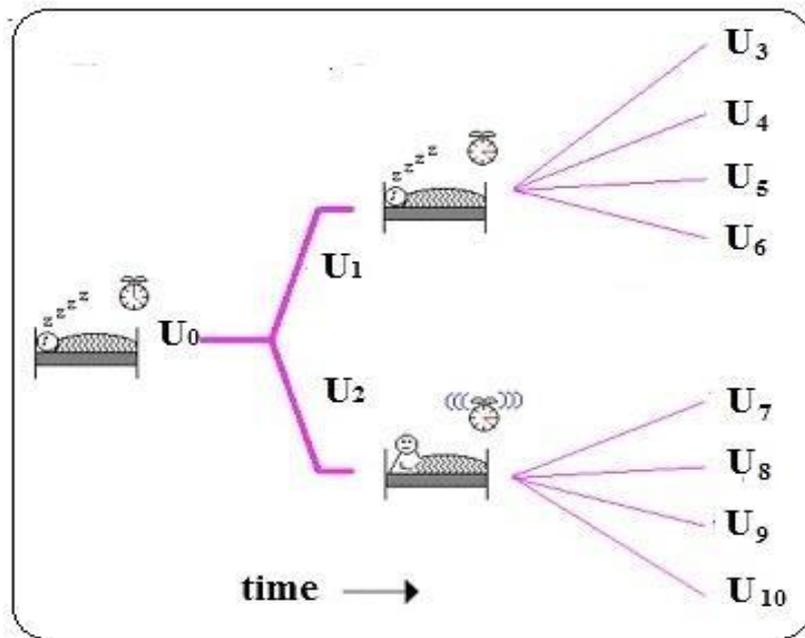
2) *"Hidden variables" theories*: are those whose structure includes the quantum state, but also an additional structure, with the objective to circumvent the problem of the measurement. It has been argued in a famous article by Einstein, Podolsky and Rosen (EPR) and in subsequent publications [11] the fact that a description of the quantum state can not be considered as a complete description of physical reality.

3) *The "pilot wave" theory*: it was developed by de Broglie and by him presented at the fifth Solvay conference in Brussels in 1927; reconsidered by David Bohm in 1952, it is currently an active area of research by physicists and philosophers. The idea was to consider "as physically real both particles and waves". The theory predicts that the particles are considered as point-like and are "guided" by the wavefunctions along particular trajectories (perpendicular to surfaces at constant phase); for this fact the theory was called the pilot wave theory.

The advantage of conceiving the corpuscle embedded in a wave field and rigidly coupled to its evolution, leads to the ability to retrieve a localisation for the particle, however taking into account the existence of diffraction and interference phenomena able to affect the trajectory of microscopic objects. Bohm has expanded the original theory to include the measurements. The particles are guided by the wavefunction, which evolves according to the Schrödinger equation; it does not collapse. The problem of the measure would be solved by the fact that the particles have defined positions at all times. In the Bohmian mechanics an experiment is not simply a measurement, rather an interaction between the system and the measuring device, whose statistical results can be predicted and coincide with the results of the usual quantum algorithms. For understanding the "active role" of the measurement process in the Bohmian mechanics, we do not consider this process simply as a "black box" or as a "deus ex machina" [12].

4) *Theories of objective collapse*: this type of theories differs from the Copenhagen interpretation in regard to both the wavefunction and the process of collapse as "ontologically objective". In objective theories the collapse occurs randomly (spontaneous localization), or when a physical threshold is reached, with observers who do not have a special role; therefore, they are realistic, indeterministic, and not at hidden variables. The collapse mechanism is not specified by the standard quantum mechanics, and must be extended if this approach is correct. Examples include the theory of Ghirardi-Rimini-Weber, which proposes to solve the problem of the measure and to remedy the lack, in the Copenhagen interpretation, to describe how is the wavefunction collapse [13], and the Penrose interpretation, supporting the argument that consciousness is the product of quantum-type, probabilistic, not entirely determined effects [14].

5) *"Everettian", or "many-worlds" theories*: in his doctoral thesis of 1957, Hugh Everett III proposed that quantum mechanics can be considered as it is, without a postulate of collapse and without hidden variables. The Everett's work inspired a family of views that go under the name of "many worlds interpretations"; the idea is that "each of the terms of the wavefunction corresponds to a coherent world, and all these worlds are equally real" (Figure 2).



**Figure 2.** Everettian interpretation.

With time a proliferation of these worlds occurs, then a multiplicity of results. The phenomena associated with the measurement are explained through the decoherence, which occurs when states interact with the environment, and "divide" the universe into separate universes within a larger multiverse. In this interpretation the wavefunction has objective reality [15].

6) "*Relational quantum mechanics*": the essential idea is that "different observers may give different descriptions of the same series of events"; for example, to an observer at a given time a system can be into a single collapsed state, while to another observer at the same time can be in a superposition of two or more states. Consequently, the relational quantum mechanics states that the concept of state does not describe the observed system in itself, but the "relation" or "correlation" between the system and its observers. Any "measurement event" is seen simply as an ordinary physical interaction. So the physical content of the theory involves the relations among objects [16].

## 5. ONTOLOGY OF QUANTUM MECHANICS

A central question related to the interpretation of quantum mechanics concerns the quantum states, "if in fact they represent something in the physical reality". If the answer is yes, this gives rise to new questions about the type of physical reality represented by quantum states, and if they could, in principle, exhaustively account of the physical reality. The key issues are:

- a) *the principle of superposition*, where an object can be in an "existentially indeterminate physical state";
- b) *the wave-particle duality*, where particles are thought to be both particles and waves;
- c) *the observation problem*, where the simple act of observing a quantum system "necessarily alters it".

Quantum mechanics comes into conflict with the Aristotelian logic and the philosophical realism, but it has been empirically well verified at today, therefore it is necessary to accept also what is counterintuitive. A mathematical model may admit different physical and metaphysical interpretations. What is actually happening in Nature, when we are not looking? Suppose that such a question has a definite answer, involves a belief in an objective reality, i.e. a reality that is beyond the subject that thinks and feels. If we ask in what sense a thing can be when we are not looking at that, we are making an ontological inquiry, concerning the reality of being as such it is.

The most widely followed approach for interpreting quantum mechanics is the "Copenhagen interpretation". Common features of this interpretative approach include:

- a) the wavefunction as a *probabilistic description of phenomena*;
- b) *the Bohr principle of complementarity*, where the matter exists simultaneously and contradictorily as wave and particle;
- c) the impossibility of knowing at the same time *non-commuting properties*, for the *Heisenberg uncertainty principle*;
- d) *the principle of superposition*, where the matter can simultaneously exist in two well defined different states;
- e) *the wavefunction collapse* and various related paradoxes, where the reality is altered by the act of observation.

Bohr tried to preserve the theoretical independence of physics from philosophy, denying that it is possible to know something beyond the experimental results. What we sure know by quantum mechanics is that its mathematics predicts the statistical results of the experiments; it does not give us secure indications "on the objective reality of unmeasured events", and "if this question has a definite answer". The avoid to involve metaphysics leads to the risk to inconsistently oscillate between realistic and subjectivistic interpretations.

Therefore, there is really a problem with quantum mechanics, or it is just the fact that the theory is counterintuitive, that uses a complicated mathematics and the world is indeterministic? According to a followed point of view, this is not a real problem. The central problem is the "measurement problem", but it can be considered as "the problem of the wavefunction meaning"; the wavefunction is a vector in an abstract space and it is not clear what this means. In classical mechanics the notion of "force" is not clear, but forces act on particles, determining the movement. So in classical electromagnetism the notion of wave propagating in vacuum is obscure, but waves act on particles guiding their movement. Similar considerations hold for curved space-time of Einstein's general relativity. Dürr and Teufel argue that in all these theories there is an "ontology", i.e. something that exists independently by any human observation and by the existence of man himself. In ordinary quantum mechanics, instead, the abstract vector called wavefunction has the only meaning to enter into an algorithm that accurately predicts the "results of measurements". Beyond this, there is an unknowable reality, but not because not predictable; quantum physics offers indeed some of the best previsions in science, and modern technology is practically based on our knowledge of quantum mechanics [17,18].

## **6. METAPHYSICAL WAVEFUNCTIONS AND VIRTUAL PARTICLES**

Physics admits also metaphysical assumptions; it is not an irrelevant matter that physicists interpret a particular theory in a way that contradicts the necessary conditions of physical science. The possibility of rejection of the non-contradiction principle or of the objective reality can relate to physicists not less than philosophers. If physicists are concerned with understanding the natural world, instead of making only quantitative forecasts, the correct ontological interpretation of quantum mechanics is a matter of great importance.

Metaphysics is for many aspects unavoidable in quantum mechanics, since this theory exceeds the limits of sensible experience. The metaphysically simplistic idea that existence is the only kind of being, does not hold in front of quantum superposition. It is taught that some theoretical objects are purely mathematical and not physical, so they should not be treated as physically causative agents; other theoretical objects, such as fields, are considered physically real, due to the fact that they have observable physical effects. The quantum wavefunction, however, does not fit with none of these descriptions. It is a non-physical object that has anyway real physical effects, contradicting the common assumption of metaphysical naturalism, where only palpable physical objects can produce physical effects.

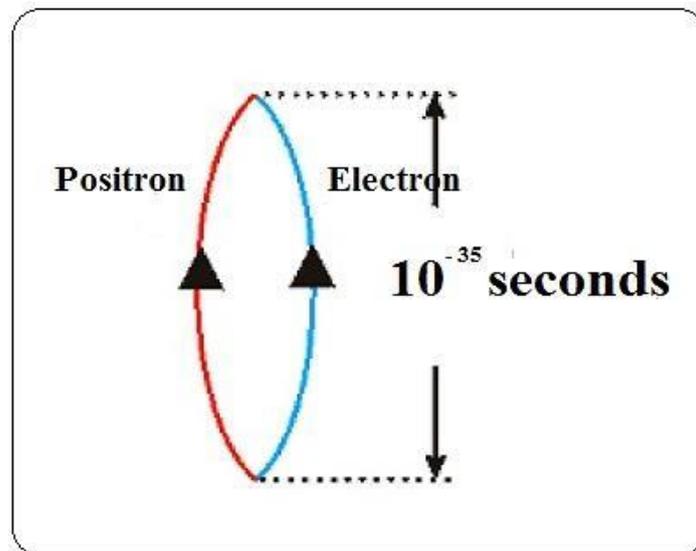
This leads to an oscillation in the interpretation of the wavefunction, which is alternatively conceived as a means for calculating the probability or as a real "ghost entity" that accompanies a system. Some scientists, such as Bohm, have gone to the extreme, treating the wavefunction as a defined physical object, in order to restore the determinism in physics.

The quantum wavefunction makes physically explicit the dependence of physics from metaphysics. We must recognize that the wavefunction is something, but not a specific object nor a property of a specific object. The probability is the connection between the quantum wavefunction and the physical reality, so the interpretation of the wavefunction depends on our ability to correctly interpret the quantum probability. All objective quantum or not quantum distributions of probability are measures of the real tendency of a system to reach a final state, given a distribution of initial states.

The "propensity" is a way to speak of some potential, describing it as a tendency to actualize a state over another. The concept of propensity is particularly useful in quantum mechanics, where the objective probabilities are different for various possible states, implying real tendencies or inclinations towards more probable results.

The need of an interpretation that metaphysically sounds, can be seen also in the treatment of "virtual particles". As the wavefunction, virtual particles are mathematical constructs with real physical implications, intermediate steps in quantum calculations for interactions among particles. The presumed proof of their real physical existence is that the final products of interactions are carefully planned by models that assume their mediation. The same can be said for many models that use mathematical objects that do not correspond to physical objects; in these cases the insistence on the fact that something having physical implications must itself be physical, leads to inconsistency.

In the case of virtual particles, we are forced to anti-empirically state that a virtual particle does not live enough to be measured. The mathematical formalism is indifferent with respect to the nature of the measurement apparatus, so the non-measurability of virtual particles goes far beyond any practical limitations. But if virtual particles are fundamentally unobservable, this is the same as saying that they never become real? It is usually said that the characteristic time of the transition among their initial and final states is so small to not have enough time to observe them. We can say that virtual particles do not exist in time, but rather represent intermediate metaphysical causes in particle interactions (Figure 3) [19,20].



**Figure 3.** Creation and annihilation of a pair electron-positron. The involved time is extremely small.

## 7. GOD AND MODERN PHYSICS: REMARKS

Always the latest questions related to the human being and the universe led to the idea of God, highest being seen as primordial creator of everything exists. Many attempts have been made in the course of human history to deny or confirm the existence of God through science and its developments. Many scientific questions lead to general considerations that reach the way of each of us. In particular:

a) *The creation of the universe:* by a scientific point of view it has been studied possible ways which are out of the hypothesis of a divine creation of the universe.

a<sub>1</sub>) A possibility is that the matter has been created as a slightly higher percentage than the antimatter, on the order of a unit on a billion (for proton-antiproton and electron-positron pairs). The calculations do satisfactory results. From a theological point of view, however, it is argued that these processes do not explain the creation of matter from nothing, but only the conversion of an existing energy into matter. Also attributing the cause of creation to a natural activity before the creation itself, it is not exactly understood how the creation "from nothing" can be given in a natural way.

a<sub>2</sub>) *The "self-reproducing" universe:* if we think the universe as a highly elastic sheet, we can imagine a bulge on it. Growing, it can get detached from the sheet, the cut closes and the sheet returns to be continuous as at the beginning of the process. The "bubble son" is independent and separated from the original sheet, and likewise it can generate other bubbles.

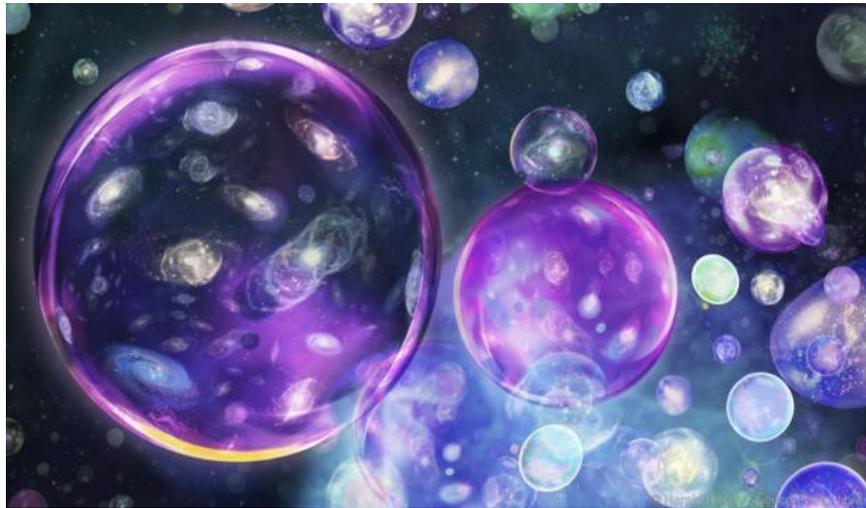
The "physical creator principle" resides in the "mother sheet", which is beyond our space-time; for that in our universe we do not find a cause that justifies its existence. The presence of God would not seem necessary, even if, however, it remains the questions stated above about the primordial event, the mother sheet (Figure 4).



**Figure 4.** Self-reproducing universe.

a<sub>3</sub>) *The multiverse*: according to modern cosmology, the universe in which we live may be one of an extremely big, perhaps infinite number of universes, which form the so-called multiverse. It would seem explainable in naturalistic terms, without the need to consider supernatural forces to explain its origin (Figure 5).

There is currently no scientific evidence providing the multiverse, but many people have seen it as element that dispenses us from the dependence on God. It has been shown that also this type of models can not however prevent the beginning; therefore, even if our universe is a very small part of a multiverse, this last should have a beginning, and we return to the dilemma mentioned above about the origin [21-23].



**Figure 5.** Multiverses containing universes.

b) *Why is there what exists rather not nothing?* This question is often seen as the "mother of all questions" and inevitably points on the beginning of the universe.

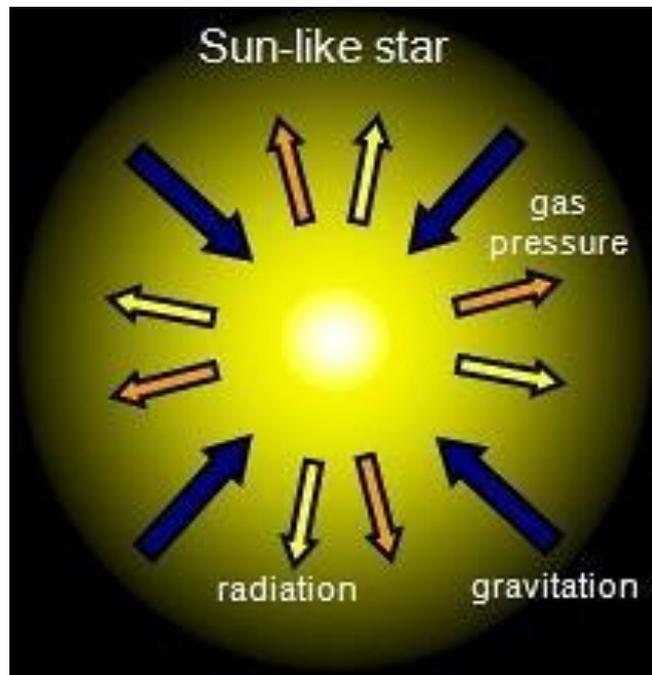
b<sub>1</sub>) A school of thought believes that there is no point on asking this question, because if we assume that the time is born with the big-bang, nothing existed before that; it is in this way avoided the question related to a cause preceding it.

b<sub>2</sub>) Another school of thought believes the big-bang as an event happened within a larger universe, containing ours. In this broader context one could explain the big-bang through an anterior cause, but this does not explain the existence of such "container universe". It is an attempt that moves the problem back, but it does not fully resolve it.

c) *The mystery of the "balance" of forces in nature*: physics seeks to explain the antagonism in Nature between different forces that are opposed and seek to prevail one over another. If there is an "almost perfect balance", all systems would be overpowered in a very short time by one of the playing forces.

The balance is not totally perfect, because on fact in a very long time one of the forces prevails; so, for example, stars are born, live and die, the universe has an own path, an own life. However, this "seemingly accidental suspension of death" seems to be a mystery. It is indeed a long stability, even if not eternal, which allows the universe to postpone its death. It

is not clear and still not properly explained the reason of this slowness, this near-perfect balance among opposing forces (Figure 6) [24-27].



**Figure 6.** Balance of forces for a star.

## 8. CONCLUSIONS

Despite the undisputed successes of quantum mechanics on the applicative level and the numerous experimental confirmations established from its inception, this theory has given rise to heated debates on its foundations. There are many aspects that make it as exotic and mysterious, far from the common sense. Perhaps objective human limitations are not allowing and will not allow to have definitive answers about its effective power in the description of reality.

Science has not the task of demonstrating the existence of God. In the past, this claim has led to a rift in the relation between science and faith; many people still believe that science has the task of "proving" or "denying" the existence of a superior creative mind, not considering that we are in the presence of an "ontological leap". The reasons that may have led a reality to the existence must not to be confused with the laws governing the dynamics of this reality.

Science and (rational) faith are two ways which have more possible interactions than destructive interference or overlapping claims. Science offers an interesting and powerful way for the search of truth. The knowledge of reality in its various aspects (reductionist and holistic, physical-mathematical and non-materialistic) can sure allow to understand ourselves and the meaning of the universe that hosts us.

### Biography

Paolo Di Sia teaches physics by the University of Bolzano-Bozen (Italy) and is a member of ISEM in Palermo (Italy). He obtained a bachelor in metaphysics, a master in theoretical physics and a PhD in mathematical modelling applied to nanotechnology. He is interested in classical-quantum-relativistic nanophysics, theoretical physics, Planck scale physics, mind-brain science, philosophy of science, science education. He is author of 220 works at today (articles on national and international journals, international book chapters, books, internal academic notes, works on scientific web-pages, in press), is reviewer of two mathematics academic books, reviewer of many international journals. He obtained 9 international awards, has been included in Who's Who in the World 2015 and 2016, selected for 2017 "Albert Nelson Marquis Lifetime Achievement Award", is member of 7 scientific societies and of many International Advisory/Editorial Boards.  
<http://www.paolodisia.com/>

### References

- [1] M. Tegmark, J. A. Wheeler, 100 Years of Quantum Mysteries, *Scientific American*, 284, 68-75 (2001).
- [2] J. von Neumann, *Mathematical Foundations of Quantum Mechanics*, Princeton University Press, Reprint ed. (1996).
- [3] N. Harrigan, R. W. Spekkens, Einstein, Incompleteness, and the Epistemic View of Quantum States, *Foundations of Physics*, 40, 125-157 (2010).
- [4] P. Di Sia, *Fondamenti di Matematica e Didattica I*, Aracne Editrice, 214 pp. (2013).
- [5] G. Chiribella, R. W. Spekkens (eds), *Quantum Theory: Informational Foundations and Foils*, Springer (2015).
- [6] P. Di Sia, Extreme Physics and Informational/Computational Limits, *Journal of Physics: Conference Series*, 306, 012067 (8 pp.), (2011).
- [7] H. Reichenbach, *Philosophic Foundations of Quantum Mechanics*, University of California Press (1944).
- [8] D. Dürr, S. Teufel, *Bohmian mechanics: The physics and mathematics of quantum theory*, Springer (2009).
- [9] P. Di Sia, Exciting Peculiarities of the Extreme Physics, *Journal of Physics: Conference Series*, 442(1), 012068 (6 pp.) (2013).
- [10] G. Bacciagaluppi, A. Valentini, *Quantum Theory at the Crossroads: Reconsidering the 1927 Solvay Conference*, Cambridge University Press (2009).
- [11] A. Einstein, B. Podolsky, N. Rosen, Can Quantum Mechanical Description of Reality Be Considered Complete? *Physical Review*, 47, 777-780 (1935).
- [12] D. Z. Albert, Elementary quantum metaphysics, in J. T. Cushing, A. Fine, S. Goldstein (eds.), *Bohmian Mechanics and Quantum Mechanics: An appraisal*, Kluwer, 277-284 (1996).
- [13] M. S. Leifer, Is the Quantum State Real? An Extended Review of ontology Theorems, *Quanta*, 3, 67-155 (2014).

- [14] B. Rosenblum, F. Kuttner, V. Raman, S. Kak, H. Stapp, Y. Neuman, L. Schäfer, I. Barušs, M. Kafatos, M. Mensky, *Quantum Physics of Consciousness*, Cosmology Science Publishers (2011).
- [15] H. Everett III, *The Everett Interpretation of Quantum Mechanics: Collected Works 1955–1980 With Commentary*, J. A. Barrett and P. Byrne (eds), Princeton University Press (2012).
- [16] C. Rovelli, Relational Quantum Mechanics, *International Journal of Theoretical Physics*, 35(8), 1637-1678 (1996).
- [17] W. C. Myrvold, What is a Wavefunction? *Synthese*, 192, 3247-3274 (2015).
- [18] A. Ney, Fundamental physical ontologies and the constraint of empirical coherence: a defense of wave function realism, *Synthese*, 192, 3105-3124 (2015).
- [19] A. Ney, D. Z. Albert (eds.), *The Wave Function: Essays on the Metaphysics of Quantum Mechanics*, Oxford University Press (2013).
- [20] J. S. Bell, *Speakable and Unspeakable in Quantum Mechanics*, 2nd ed, Cambridge University Press (2004).
- [21] S. Saunders, Many Worlds? An Introduction, in S. Saunders, J. Barrett, A. Kent, and D. Wallace (eds.), *Many Worlds? Everett, Quantum Theory, and Reality*, Oxford University Press, 1-50 (2007).
- [22] B. S. Dewitt, N. Graham (eds), *The Many Worlds Interpretation of Quantum Mechanics*, Princeton University Press (2015).
- [23] D. Wallace, *The Emergent Multiverse: Quantum Theory according to the Everett interpretation*, Oxford University Press (2012).
- [24] P. Di Sia, About the existence of the universe among speculative physics, metaphysics and theism: an interesting overview, *International Letters of Social and Humanistic Sciences (ILSHS)*, 9(1), 36-43 (2015).
- [25] P. Di Sia, Dio e la creazione dell'universo: riflessioni tra fede e fisica speculativa, *Giornale di Filosofia della Religione*, New series (2014).
- [26] P. Di Sia, Buchi neri e universo: fede e scienza speculativa si interrogano, *Giornale di Filosofia della Religione*, 2, New series (2014).
- [27] P. Di Sia, Caso o Intenzionalità? Fede e Scienza speculativa si interrogano, *Periodico di Matematiche*, 7(1), 103-107 (2015).

( Received 25 April 2017; accepted 10 May 2017 )