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ELEMENTARY PHILOSOPHICAL AND THEOLOGICAL CONSEQUENCES OF QUANTUM MECHANICS

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Abstract

Modern science (and notably Quantum Mechanics) is giving a wealth of precious information that has impact on our view of the Universe (and of ourselves). In this paper, I will show that the commonly held Western view of a strict subject-object separation is at variance with the *Weltanschaung* suggested by Quantum Mechanics.

Keywords: quantum mechanics, epistemology, philosophy

1. Introduction

The aim of this paper is to review the interplay between spirituality and scientific vision of reality in the light of the scientific developments that took place in the past century. In particular I will consider the change in our view of reality brought about by modern Physics (or, best said, Quantum Mechanics) and discuss this change in relation with the world view intrinsically (or explicitly) proposed by religious approaches, both western and eastern.

Since the author is a particle physicist this will likely constitute bias for the present work. Being aware of some of these biases, I have tried at least to point them out in the 'caveat' paragraph at the end of this paper.

Most of the following are not original considerations. On the contrary, the subject is widely discussed in papers and at conferences on Philosophy of Science, Theoretic Philosophy and the like. However, this is usually made in a specialist's language and it is not easy to grasp for the general public. Moreover, it seemed easier to summarize the relevant considerations in a few paragraphs than to suggest a cumbersome bibliography.

Final considerations are made, however, that I believe are original in their character and relate to the western view of the world (*Weltanschaung*), which is challenged by the epistemological view of modern science. In this paper, I will put forth the thesis that the western theological *Weltanschaung* can be maintained only at the price of giving up to the goal of interpreting reality with human reason.

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2. Before 1900 - Classical Mechanics

Classical Mechanics is the branch of Physics which very often deals with simple mechanical systems such a stone falling from a tower or a pendulum hanging from the ceiling of a building. This may seem a rather narrow field of investigation. On the contrary, Classical Mechanics has an amazingly wide variety of applications (in Physics and other sciences) as well as a tremendous conceptual importance. The motion of planets is governed by the laws of Classical Mechanics and so is an important part of our everyday lives. Also in the atomic world the laws of Classical Mechanics (together with Electromagnetism) gave a crucial contribution to the understanding of physical phenomena even if they were surpassed (and ultimately shown to be incorrect) at the atomic and nuclear scales by Quantum Mechanics.

Electromagnetism, the theory of charges and currents, summarised in Maxwell laws, offered a sound basis for the understanding of all electromagnetic phenomena. This can also be considered a classical theory (in the sense of a non-quantum theory).

Classical Mechanics, Electromagnetism and other ‘classical physics’ theories (Thermodynamics, for instance) were essential in the process of laying down the foundations of modern technology. Even today most of the ‘ordinary’ technology is based on this conception of the fundamental interactions. Engines, houses, power stations, trains, theatres, submarines, coffee machines are all operated by exploiting concepts developed by Classical Physics. It is only when we try to understand the working principle of some very special devices (lasers, atomic clocks,…) that Quantum Mechanics is essential and Classical Mechanics is no more adequate.

Needless to say, Classical Physics has deep interrelations with (and in some cases helped to lay the foundations of) many other modern sciences such as Chemistry, to name only one.

However, from the modern theoretical viewpoint, Classical Mechanics is now only an approximate tool (albeit a very good one) for the understanding of the physical world. Quantum mechanics – at the best of our today knowledge – is the ‘real’ theory of the fundamental microscopic phenomena. Classical (non-quantum) Physics can be used in many cases (not all!) only as a good approximation to Quantum Mechanics.

Parallel to the ‘quantum revolution’ of the beginning of the last century, Einstein’s Relativity revolution took place as well and helped to lay the foundations of modern Physics. It changed our views of space-time, matter and energy and offered a key for the interpretation of the very fabric of the Universe. However, for the purposes of the present paper, the distinction between relativistic and non-relativistic physics is of lesser importance. We will instead focus on the distinction between quantum and non-quantum physics. We will see that these two different domains bring about radically different views of reality and bear on the philosophical question of the subject/object distinction.

One very important thing to be considered is that Classical Mechanics is somehow 'easy' from the viewpoint of a westerner and can offer a *weltanschaung* that is very intuitive to the human mind. One can think of Classical Physics (roughly speaking, most of Physics before the year 1900) as a relatively simple kind of description of reality: every material body can be considered as made of some constituents that will perfectly follow deterministic laws (these constituents were not fully understood at the year 1900 but this is irrelevant for our story). In this picture of the Universe, these little constituents (we can call them atoms, *a la* Demokritos) are interacting with each other by means of electromagnetic and gravitational forces and bounce back and forth from each other following perfectly deterministic laws (Newton's dynamical law for the force). The solar system is another typical prototype of such a view: given the positions and velocities of the planets and their physical characteristics (like masses) one can in principle solve the equations of motion in an exact way and find the position of the planets anytime in the future (yes, Laplace's dream!). Mathematically this property stems from the characteristics of Newton's dynamical equation: given initial positions and velocities it exist one (and only one) solution to the problem of motion.

This kind of agreement (or naturalness) of Classical Physics with our common sense is due to the fact that our intuition was developed in a spacetime where typical velocities are much smaller than c (the speed of light in vacuum) and the physical actions turn out to be much bigger than h (Planck's constant). It is because of these facts that our intuition seems to tell us that physical reality is a perfectly deterministic mechanical clockwork, in agreement with Classical Physics formalism. Experiments in Physics at the atomic and subatomic scale, on the other hand, tell a different story, which will illustrate in the following.

As an aside: Classical Physics can be recovered (from Relativity) in the limit where c goes to infinity and (from Quantum Mechanics) where h goes to zero. However the quantum limit is in many cases more problematic than the relativity limit [1]. This fact is not surprising given the profound conceptual differences between the worldview of a 'Classical Physicist' and a 'Quantum Physicist' which are discussed in this paper.

3. Classical Physics and the relation of Western Thought with nature

Let us now come back to the classical vision of a deterministic physical reality.

First of all, one should be aware that this deterministic view of the Universe is of a fundamental character, i.e. has nothing to do with imperfections in measuring instruments. It is of course *de facto* true that there are imperfections in measuring instruments, in the skill of the experimenters and so on… that will introduce errors in the measurements of physical quantities. However, it is a basic tenet of Classical Mechanics that these errors can be minimized (with no problems in principle) by a better technology of the measuring apparatus, an increased skill of the experimenter and so on. The point is: *in principle* our knowledge of a physical quantity can become arbitrarily close to the real value. It goes (almost) without saying that in this view physical quantities are believed to exist irrespective of any observer (or intelligent being) that is actually trying to measure them. In philosophical terms, this view is a form of *realism.*

This realistic (and mechanistic) view is actually embedded in most of Science and even in the ordinary thinking of people. Scientists and laymen tend to believe that physical quantities exist by themselves (yes, realism!); if two people speak of the Mont Blanc mountain they both will easily admit that this mountain has some definite height. And they will continue to think so even if, during their conversation, none of them recalls the real value of the Mont Blanc height (something like 4,810 meters above sea level). This way of thinking is actually so natural that makes a part in our everyday life. And in fact it appears to be a good approximation to the physical world as we can perceive it with our limited sensory apparatuses.

There is no basic conflict between such a view of the mechanistic universe and the typical man-nature distinction of the western religious view. According to this view - in the general western monotheistic tradition - the human being is made following a divine imprinting and has a different *quality* than nature than surrounds him. It is only the human being (man and woman) that has this different quality. This concept is deeply rooted in western religiosity and can be found since the very early verses of the Genesis: "*God said: 'Let us make man in our image, after our likeness....'"* (Genesis 1.26)

Moreover, God explicitly gave man dominance over all animals in nature: "*...Have the dominion over the fish of the sea, and over the birds of the sky, and over every living thing that moves on the Earth*" (Genesis 1.28).

We can very clearly find this view summarized in the philosphical thinking of Renée Descartes according to whom, man is qualitatively different from animals (and from the material world). Descartes basically thought that animals were biological automata, lacking mind and soul. This view is essentially the subject (person) versus object (nature) distinction of a vast part of western thought.

The various western religious traditions have elaborated the concept in various ways. While attributing respect and value to nature (animals included) as a masterpiece of God's creation, mankind has always remained at a higher ontological level than the rest of nature.

This view has deeply influenced western thought throughout the centuries. Because of these reasons western people (even if atheistic) typically tend to consider nature as something radically different from themselves and different (if they believe in God) from God [2].

As a final consideration, this subject/object distinction has also been a very efficient and productive attitude in the relation of western science and technology with nature. Exploitation of natural resources was allowed without any constraint and the use of nature for the betterment of human conditions was considered as a natural and reasonable thing. After all, Nature was somehow ‘given’ to mankind as a resource to be exploited without clear-cut limits.

I spite of all this, I will show that this view is now very seriously challenged by Science itself at the fundamental level of atomic and subatomic particles.

4. Positivism and Realism

It is now time to take a little detour and discuss some more the Positivism/Realism controversy, mainly at the epistemological level. The debate about the height of the Mont Blanc already showed a little preview of the subject.

Generally speaking, according to the realist approach, physical quantities exist independently of the act of observation. It does not matter if somebody actually takes the burden of doing the measurement. The realist would say that the Mont Blanc has a height and this is independent of any human being actually measuring it.

The positivist has a different view; according to her it is only meaningful to speak about things that we actually measure. Only what we see with our senses (or measuring apparatuses) is considered by the positivist as really worth discussing. It is not that the positivist negates the existence of quantities in themselves; she simply thinks we cannot seriously tackle the issue of existence versus non-existence. So, according to the positivist viewpoint it is only when we make a measurement that we can really speak about the quantity considered.

This difference between positivist and realist point of view is, however, relatively unimportant in Classical Physics. This is because the process of measurement of a physical variable can be done without disturbing the variable itself. Let us see how that happens.

Suppose we want to measure the height of the Mont Blanc. Maybe we can use triangulation techniques, laser beams, radar beams and so on. It appears that all these devices will not alter the quantity we intend to measure, i.e. we can safely measure the height of the Mount Blanc without in any way disturbing the Mount Blanc itself. A realist would say that the height existed before the measurement, while a positivist would probably maintain that only after the measurement we can discuss about the height. The truth (or consensus) remains that – after the measurement – both realists and positivists can happily go to dinner together since they both have a number, 4,810 m, which is the desired quantity. In addition, if the next day somebody wants to do the same measurement again, the result will be the same.

Now, suppose instead (*hic sunt leones*) that the realist and the positivist now set about measuring a microscopic quantity, say the velocity of an electron. As we will see later on, the situation is radically different from the Mont Blanc height. But, one can argue, the situation for the electron is only *quantitatively* different; one can imagine that the only difference is the mass of the object being considered and that the conceptual problems to be encountered in measuring the height of the Mont Blanc and the velocity of an electron would be the same.

Together with Classical Mechanics, our common sense is telling us that measuring the velocity of the electron is harder than measuring the height of the mountain, because of practical reasons; it is easier to study mountains than tiny subatomic particles.

Common sense seems to indicate in a reasonable way that there is no *qualitative* difference between these two problems and – in particular – the realist can speak about the velocity of an electron without actually measuring it. It seems obvious that the velocity exists, has some value that can in principle be measured (with arbitrary accuracy by having better and better devices and more and more skilled experimenters) and this statement seems to hold true irrespective from the existence of an observer actually performing the measurement.

Much to our surprise, this '*reasonable*' viewpoint turns out – to the best of the knowledge of today science – **completely incorrect**.

5. After 1900 - Quantum Mechanics

In the very year 1900 Max Planck proposed the introduction of quantized steps in the process of energy exchange between electromagnetic fields and matter. It was the birth of the quantum era. More than one century after that, Quantum Mechanics is widely recognized as the most quantitatively successful theory in Physics (if not in Science). The atom, the atomic nucleus, the elementary particles, the atomic clock, the laser, the superfluid Helium, and many more systems are understood by means of Quantum Mechanics, the theory of the microscopic world. This theory is tested hundreds of times per day in different laboratories all around the world and is consistently found to be successful and accurate.

On the other hand, Classical Mechanics (and the beautiful classical *Weltanschaung* we were describing before) was proven to be wrong in the subatomic world, were Quantum Mechanics must be used instead.

This specific point needs a little clarification. It is customary to hear plain sentences like: 'Classical Mechanics is wrong' or 'it is superseded by Quantum Mechanics'. These statements neglect the validity of Classical Mechanics on non-atomic (macroscopic) scales and also give a slanted view of the scientific progress that lead to the birth of the Quantum Theory. As we said before, most of our technology and science is still based on Classical Mechanics – a theory that has an enormous range of applicability. Most engineers still do calculations with Classical Mechanics in a great variety of applications; it would be a foolish exaggeration to treat the stability of a bridge by using the complex formalism of Quantum Mechanics.

Secondly, a lot of the conceptual apparatus of Classical Mechanics was actually included in the Quantum Theory (Analytical Mechanics, just to give an example). It is however true that Quantum Mechanics is a conceptually new theory with a much deeper insight in the fundamental field of the atomic and subatomic world. In practically all realistic atomic and subatomic systems that we can consider, Classical Mechanics would fail and Quantum Mechanics would be successful in describing their behaviour. Wow!

Now the point is that Quantum Mechanics has some properties that seem to force us to take a clear position in the positivism/realism debate (at the epistemological level, see also [3] for an excellent discussion of the subject).

This fact was firstly noted already at the beginning of the Quantum Theory itself and has a strikingly beautiful exemplification in the famous Einstein-Bohr debate. All originates from the fact that Quantum Mechanics is an abstract formal theory that has a non-trivial interpretation.

6. Quantum Mechanics and Bell's inequality

In the Quantum Theory there is no trivial correspondence between its formal objects and the physical quantities that the theory allows to predict. Physical quantities are represented by (highly non-intuitive) linear operators in abstract (Hilbert) spaces and there are concepts (like the wavefunction) which have no clear correspondence with the physical world we perceive. This fact was the base of the Einstein-Podolsky-Rosen (EPR) criticism to the theory and of Einstein's viewpoint on Quantum Mechanics. Roughly speaking, these critics [4] required that concepts of the theory be put in correspondence with elements of physical reality; according to them physical reality was existing irrespective of the act of measurement, the conceptual (realistic) viewpoint of Classical Physics. Niels Bohr responded for the opposite side arguing that physical quantities only 'come into existence upon measurement'. One cannot speak of a physical quantity without reference to the measuring device and the measurement process. This positivistic viewpoint is called Copenhagen interpretation – put forth by Bohr and many others at the beginning of the 20th century and is considered (even today) the orthodox interpretation of Quantum Mechanics.

In analyzing the Einstein-Bohr debate, one can clearly interpret it as a realist/positivist debate. For instance, in reference [4] (the original EPR paper) it is explicitly said that Quantum Mechanics has to be confronted with an "*objective reality which exists independent of our theory"* .

Using the language of reference [3], the Copenhagen interpretation, on the other hand, insists that the reality of the physical states that can be measured is defined by the nature of the interaction between the particles and the measuring apparatus. This unresolved epistemological point about the interpretation of Quantum Mechanics did not prevent the theory from having its tremendous experimental success.

In 1960 John Bell [5] put the question on quantitative grounds devising an inequality that would hold true only if Quantum Theory were a realistic one. In other words, Bell's inequality assumes the existence of physical microscopic quantities (e.g. an electron spin) independent of any process of measurement (we recommend reference [3] as an excellent place to learn about all this). The relevant point is that Bell's inequality could be tested experimentally and was proven to be **violated** in a series of famous experiments (first performed by Alain Aspect and collaborators [6]). This experimental test has convinced the vast majority of the Physics community of the validity of the Copenhagen interpretation. From the philosophical viewpoint, they strongly indicate that it is not correct to think about the existence of the electron spin in itself, without performing a measurement.

In other words, to the best of our knowledge of today, we cannot really speak about physical quantities in the atomic world; we should always be speaking about physical quantities in relation with ourselves as observers. It is precisely in this sense that modern science favours the positivistic interpretation.

7. Another victim of the quantum revolution - strict determinism

Incidentally, another victim of Quantum Mechanics is pure determinism [1]. This theory clearly shows that repetition of experiment at the atomic level does not lead to the same results. What remains the same (upon repetition of the experiment under the same initial conditions) is the probability of a given outcome to occur. But the predictive power about the outcome of a single experiment is in general lost. This is often expressed by saying that Quantum Theory is an irreducible statistical theory.

We will not elaborate any further this concept, since it does not lie in the mainstream of our reasoning. We will return instead to discussing the philosophical implications of the positivistic quantum-mechanical view of reality.

8. Western spirituality, Oriental philosophies and Quantum Mechanics

In the western approach, there appears to be a strong distinction between the subject and the object. As we have seen, according to this idea, the human being is a distinct subject that treats whole nature as an object without (obviously) soul and divine imprinting. Nature as a whole can be appreciated as being created by God and must be accordingly respected. However, nature remains a somewhat worthless, soul-less 'inert material substrate' upon which the action of man can be exerted.

The subatomic world is instead telling a story of subject and object that cannot be separated, since we cannot speak (at the subatomic level) of the object without the subject. It is precisely for this reason that the eastern theological approach appears more suited to confront us with this fundamental aspect of modern science.

It is in fact interesting to note that in a vast part of the oriental philosophical and spiritual approach, the distinction between the subject and the object fades. One of the very goals of oriental religiosity (consider for instance the related practice of meditation) is precisely overcoming this distinction, which is in general not considered to be a fundamental one. One of the consequences of this weakened (or missing altogether) subject/object distinction in eastern religiosity is a different ontological consideration of nature. Nature is, in the eastern approach, at the same level to the one of mankind, the difference in awareness being only **quantitative** in character (as opposed to a **qualitative** difference in the western thought). According to this view the subject/object separation is (at least in part) an illusion of our senses, an artefact of *maya*. This is nicely illustrated, for instance, in references [7, 8].

Now, and this is the crucial point of this paper, it is for this reason that we deem eastern thought as being in greater harmony with Quantum Mechanics, a science that considers the observer as an integral part of the physical situation under consideration, a science that is giving the clear message that it seems impossible (at least at some level) to make the subject/object distinction.

9. Western ontological view of reality - the synthesis of revelations and Greek thought

All of this is at variance with the predominant Western view of reality which is generally in agreement with a sharp subject/object separation and a (realistic) existence of the Universe. To better understand where the problem comes from, we should back up a little bit.

We should first remember that Western religions are based on revelations (directly and/or indirectly) made by a personal God. Truth is revealed by prophets (Moses, Muhammad) or God (Jesus) and in any case represents the faithful view of the God and in itself an absolute and objective Truth.

The distinction between subject and object was (ontologically) introduced in the theological view much later, e.g. by Christian thinkers, in their effort to harmonize Christian revelation with Greek and Ellenistic philosophy.

While the viewpoint of revelations is (ethically and morally) the very clear statement that nature is at man's disposal, nothing was actually said in those revelations about the ontological level, which was instead discussed in the context of Philosophy in a very different (Ellenistic) context. Therefore, it is only when we apply to revelations the categories of Greek philosophy that we can possibly build up the subject/object distinction that has characterized much of Monotheistic inspired thinking during several centuries.

By the same token, western thinkers claiming today that human reason has metaphysical power are facing the very same problem of dealing with the quantum mechanical effects. Human reason would tend in fact (and this is the 'common sense' mechanism at work) to make the subject/object distinction and to assign realistic existence to the Universe, leading to conflict with modern science at some level.

In a single sentence, the believe in reason's metaphysical power or in the complete harmony between ancient Greek thought and monotheistic revelations leads to a subject/object distinction which is in epistemological contradiction with the findings of modern science.

10. Caveats

There are of course biases both personal and professional which are embedded in this work. It is useful (to the extent that I am able to detect them) to enumerate them and possibly to answer to some objections.

1. Physicists tend to think that Physics is the ‘main Natural science’ and therefore tend to use the word ‘Physics’ as a synonym for ‘Science’. This is clearly arbitrary and in general not correct. However it cannot be negated that Physics is a science with a great predictive power which is able to investigate nature at the current limits of space and time. I claim this fact is sufficient for the goals of this paper.
2. In this work I have also used a reductionist approach. This is of course arbitrary. However, even if there are good reasons to criticize reductionism, what I am claiming here is only that Quantum Mechanics is telling us something fundamental. It seems to me very likely that this claim can also be defended in the light of a more holistic view (while, I am not going to conduct such apology here).
3. Quantum Mechanics itself is not considered by many scientists to be a completely self-consistent theory. For instance, conceptual and technical problems arise in the description of macroscopic bodies, in the classical limit, in the measurement process, in the phenomenon of decoherence. For all these reasons (at least) we cannot go on claiming that Quantum Mechanics is the ultimate theory of everything in Physics. However, in this paper I am only claiming here that Quantum Mechanics is a theory which has more conceptual and predictive power than any other theory in the fundamental subatomic world.
4. I am of course aware that other physical theories can have ontological implications, like Classical Chaos or Quantum Chaos, to name only two (this is related to question 2). I will not be elaborating this subject. As before, I am only claiming Quantum Theory is telling us something fundamental about us and the reality in mutual interaction.
5. I am of course aware of other possible extreme neo-platonic schemes that can be used to describe reality. The following reference [M. Tegmark, Los Alamos preprint archive: arXiv:gr-qc/9704009] is a rather technical example of this approach. However, these schemes in general arbitrarily assign real existence (ontological role) to any of our conceptual (mathematical) ideas and as such I consider them viable but rather extreme.
6. We have used philosophical considerations taken from Quantum Mechanics (and the Copenhagen interpretation) as it is today. Of course this is not the end of Science (nor of Philosophy), and future progress can always give surprises. Certainly our ideas will seem naïve to our nephews. Therefore we cannot (in spite of all current efforts of today) rule out the possibility that some future super-theory will supersede Quantum Mechanics and have at the same time some different structure, maybe in lesser conflict with western subject/object distinction. However, in this paper I am only

claiming that the ontology of oriental philosophy is in better agreement **today** with Quantum Mechanics.

7. The realism/positivism debate has mostly been considered at the epistemological level. While I believe my conclusions apply also to common sense realism, I am not claiming it naively applies to other more sophisticated forms of realism. In this paper I am more concerned with Science and religion than with Philosophy.

11. Self-consistency issue

The careful reader would have noted that I have used sentences like 'description of reality' throughout the paper. I am aware that this is logically inconsistent if one wants to take a positivist viewpoint (one should perhaps say 'description of reality interacting with us as observers' instead). I have however used this (perhaps in part incorrect) language because of superior simplicity.

12. Conclusions

I believe Quantum Mechanics cannot be neglected in discussing subject/object relation today. This modern physical theory forces upon us a series of philosophical considerations (see for instance references [3] and [9]) that seriously challenge the western distinction between object and subject (as well as strict determinism). This subject/object distinction was however introduced at the metaphysical level not as a basis of Christian Revelation (or other western revelations, Hebrew or Islamic) but as a subsequent theological and – most of all **-** metaphysical speculation.

Since this subject/object distinction is in disagreement with Quantum Physics, it seems that we have sufficient grounds to seriously doubt this metaphysical attitude.

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