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Article

A thinking on Quantum Physics and common sense

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Abstract

The author attempts to answer the questions there are in the title of this paper. These questions are questions that scientists and philosophers have been asking themselves for many decades since Quantum Mechanics was formulated to explain the phenomena of the atomic and subatomic world. First of all a short but complete historical review of the transition between Classical Mechanics and Quantum Mechanics there is. It is preceded by some of the methodological premises that fit a certain vision of science. Then the author examines the issues and debates that have occurred on aspects of quantum mechanics such as realism, non-locality and probabilism (in contrast to determinism of Classic Mechanics). In doing this author llustrates the foundations of the various interpretations of quantum mechanics which, in an attempt to resolve these problems, have been given. The absurdities, and conflicts with the common sense, of quantum mechanics are shown to be largely apparent. In doing this, we examine the analogies of classical physics, as well as those of everyday life. Recent experimental results are taken into consideration. It is concluded that Quantum Mechanics presents elements of rupture more with Classical Physics than with the everyday experience.

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Quantum physics; interpretation of physics; physics models; probabilism; realism

Introduction

When we talk about quantum physics or contemporary physics in general in any context and especially in dissemination, it practically always happens that we use or hear words such as strange, counter-intuitive, apparently absurd, and abstract. Some have stated and maintain that in Quantum Mechanics (henceforth QM), the cause-effect principle does not apply. Others have stated that an objective reality independent of the observer no longer exists, while others have used QM to build New Age visions of reality. But are these really the facts? Is QM really such an odd theory and so far from common sense? In this article, we will see that this is not really the case.

When starting a complex discussion, it is good to establish a starting point. The author has written books on what science or rather the scientific method is (Artemi 2012, 2024). Starting from the apparently banal fact that science is not a set of statements but is, above all, a method (the only one that has proven able of greatly expanding our knowledge of reality), it is necessary to clarify, as stated and reiterated by the author, that science, and especially physics, while making observations, measurements and experiments on phenomenal reality, does not work on phenomena but on models of reality. Examples of models are the material point, the uncompressible fluid, the ideal gas, as well as the models used in the study of the economy

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and society. The validity of a model is not linked to its beauty or to its logic but to its ability to describe and organize experimental facts in a unitary way, and its ability to reduce many phenomena to a few causes. The material point is an absurdity: how is it possible that an object that has no dimension can exist and have inertia? The rigid body model is absurd because its ability to move, even if the force is applied only to one part of it, implies interactions propagating with infinity speed which is against all common sense. In Relativity, the rigid body is not even studied (Goldstein, 1971). A different model, Born Rigidity, needs to be introduced (Born, 1909)

This work with models involves space-time too. Newton, as is well-known at the beginning of his *Principia*, writes about a "true, absolute and mathematical" space and about a time that "flows independently of what happens." As Mach understood centuries later (Mach, 1901) ,these statements are metaphysics, and they are ideas. Mach stated that absolute space and absolute time are not measured, whereas the distances between objects and the time intervals between events are. If the author had lived in Mach's time and could have answered him, he would have said "Dear Mach, the fact that objects exist at a certain distance from each other demonstrates that this happens in a certain environment which is the one in which we live. The mathematical description of this environment is something completely different. The model of Euclidean, continuous, three-dimensional space with a temporal dimension independent of the phenomena attached is a model that is very good in Physics. If, from the study of the perihelion of Mercury or of the ether wind and other phenomena, we will see situations and phenomena requiring a new model of space-time, for example, discrete or non-Euclidean or 5-, 6- or 10-dimensional space, a new model will need to be adopted.

A Bit of History

Summing up entire books on the history of science, we can say that QM was born when it became evident that microscopic systems, electrons, atomic nuclei and atoms had behaviors that could not be explained by the models of Classical Physics. They behaved according to the situation, such as appearing to involve two deeply different models of Classical Mechanics (henceforth MC), the material point (corpuscle) model and the wave model. The electrons in cathode ray tubes are the material points. In beam collision experiments, they present diffraction and interference phenomena. Inside the atoms are standing waves on a wire or on a circular surface. This dual behavior accounts for an impressive series of phenomena including the light spectra of atoms. From a mathematical point of view, the Schrodinger equation, the Heisenberg matrix formalism and then Dirac's unitary vision explain all of these behaviors but there has been a discussion about the physical meaning of this. Some have argued for its inability to explain things and see the quantum state of a system as little more than a mathematical idea, an element of a Hilbert space. This is the standard or Copenhagen interpretation, which is the most adopted. Some have hypothesized the existence of phantom hidden variables (like viruses in ancient Rome which we will discuss) that influence the behavior of quantum systems, an interpretation formalized in particular by Bohm (Bohm,1952). Some have hypothesized the existence of many universes or many worlds, and that the measurements of a quantum system have made it possible "to jump" from one world to another (Everett, 1957).

Each of these interpretations obviously has strong and weak points (Rovelli, 2020). For example, the standard interpretation associates a wave function ψ with each quantum system such that the value that its square modulus has at a point in space-time given the probability density that the system has when it is observed at that point in space-time. One can argue that it is not clear what meaning the wave function of the entire universe can have, and that it is not clear what the wave function of a macroscopic system includes for the observer (for example, the Milky Way). The above formulation seems to highlight the need for each quantum system to have an observer who can measure its position using all philosophical problems this creates. Furthermore, the standard interpretation is probabilistic as is clearly evident when the temporal evolution of the system is analyzed by the mathematical formalism of the path integrals created by Feyman. We need to focus on this.

First of all, let's see what is meant by deterministic theory and probabilistic theory. A theory describing certain phenomena is deterministic if, given the initial state of a system at time t1 and knowing the conditions that will exist between t1 and t2, it is able to predict precisely what the state of the system will be at time t2. The theory will be probabilistic if it is only capable of predicting the probability that, at time t2, the system will be in one of the certain states, even infinite ones. We also tell what local and non-local theories there are. We will need these definitions later. Simplifying but not distorting things, we can say that a local scientific theory is one in which, beyond a certain distance, objects no longer have an influence on the system under examination. Obviously if the opposite is true, the theory will be not-local.

We return to Feyman who, in 1942 for his thesis work (Feyman, 1942) attempted a different approach than his predecessors to QM. The starting idea of Feyman's new approach derives from the least action principle. It is a principle that has been rigorously stated in the last years of the eighteenth century by Lagrange and is a practical method for describing the motion of a point alternative to Newton's laws. In practice, a function called Lagrangian, the difference between kinetic energy and potential energy, is considered and its stated trajectory that a point follows to go from the starting position to the arrival is the trajectory that minimizes the integral of the Lagrangian density (called 'action') that is calculated along the same trajectory. This proves that this principle is equivalent to Newton's laws in the sense that the principle is derived from Newton's laws and that Newton's laws are derived from the principle. It should be underlined the introduction of the least action principle, perfected and expanded on in the nineteenth century by Hamilton and others, caused a debate at the time (Glick, 2023) because the question was asked, "How is it possible that at instant t1, the object knows where it will be at instant t2 and above all, how does he know the values of the integral on all trajectories?" This shows that even in CM discussions, there have been doubts. Feyman modified the least action principle, arriving at the path integrals method. The idea is that a particle does not travel on just one path (having a wave-like, i.e. extended, nature) to go from one point to another in space-time. It travels every possible one: each with a probability that depends on the value of action on that path. So the particle, or in general the quantum system, will go from the initial state to the final state with a probability given by the sum (integral) of the action on all possible paths. In this way, Feyman rediscovered the Schrodinger equation.

The probabilism of QM has aroused strong doubts in many scholars including Einstein himself who uttered the phrase, "God cannot have played dice when he created the Universe." Bohr responded by saying "Who are you to say to God what should he do?" Neglecting this exchange, Einstein was convinced that QM was an incomplete theory in the description of nature, with this incompleteness quantified by the Heisenberg uncertainty principle. He invented the EPR paradox which has been, for decades, the most insidious criticism of QM or rather, of its standard interpretation. We will return to this very important paradox later.

The microscopic objects constituting matter have a dual behavior and the nature of light also appears similar. The nature of light had been the subject of speculation since ancient times and from Newton to the nineteenth century, there have been two opposing views on light and similar radiations that were discovered in the nineteenth century: the corpuscular theory and the wave-like one. In the nineteenth century, the discovery of the phenomena of birefringence, interference, polarization and the measurement of the speed of light in water led to the abandonment of corpuscular theory for wave theory. But this theory had an enormous problem: in classical physics, a wave must be the mechanical vibration of a medium and for light, the existence of the luminiferous ether was assumed, an imaginary medium that filled the entire universe and was 100,000 times more rigid than steel but did not hinder the motion of the planets. Despite this, early 20th century physicists were convinced that the luminiferous aether was real to such an extent that a citizen geologist scientist tried to trace the force of gravity back to the aether-matter interaction (Del Pretto, 1904).

Even Maxwell's discovery of the electromagnetic nature of light did not lead to a change of ideas. Maxwell found equations for electric and magnetic forces and found the solutions of these equations to be similar to those that described waves. The speed of these electromagnetic waves was equal to light speed, and this could not be a coincidence. However, Maxwell's equations were derived from the hypothesis of the luminiferous aether and from some formulas of classical mechanics (Braccesi, 1968). It was the unlikely properties of the ether, the experimental difficulties of finding evidence of the ether-matter interaction (Resnick, 1969), and the affirmation of Relativity that led to abandoning the idea of the ether.

Further research on the photoelectric effect, on fluorescence, on the Compton effect and others brought in evidence of the corpuscular behavior of light which made the ether hypothesis useless, highlighting the dual nature of light too. After the 1930s, the need arose to unify QM with Relativity to be able to treat the quanta of light and matter in a single way. All of this was achieved thanks to the Feyman mechanism with the quantum field theory or second quantization (henceforth QFT) which led to modifying the dual wave-particle model which arrived from Einstein and his collaborators. The strongest criticism of QM and the Copenhagen interpretation was the EPR paradox (Einstein, 1935) which paved the way for the phenomenon of quantum entanglement. To understand quantum entanglement, we start from a classical analogue cited by Wikipedia, used in educational videos (Baldi, 2022).

Two friends have two balls, one white and one black, and they divide them at random without looking at them. One then leaves and goes to a place very far from Earth, it could be Mars or the Andromeda galaxy. As soon as one of the two looks at his own ball, he instantly knows which ball the other has. There is a distant link between the two balls but this is not absurd because whoever looks at the ball looks at the result of a choice that has already done some time before on Earth. Let's move on to the quantum case. Here, we have a well-defined initial system, which produces two quantum systems that have momentum as a property. Let's assume that initially, the momentum or, rather, a component of the momentum along a chosen axis is zero. By momentum conservation law, if one of the objects created has momentum directed upwards, the other will have it directed downwards. The two quantum objects head in opposite directions, and after some time, they reach two observers who are very far from each other (one on Mars and the other on Venus). The time taken to measure the component of the impulse is less than the time light takes to travel from one observer to another. Here, the observer who is on Mars, having made his measurement, will instantly know the result of the measurement made on Venus but with a big difference compared to the classical case. The result of the measurement process is determined at the same moment as the observation and the value obtained does not pre-exist the measurement itself.

It almost seems as though there is a "spooky action at distance," words used by Einstein, that connect the two systems. This connection has been called entanglement but it is in contrast to relativity. The criticism refers to a simple system but is very targeted and puts the supporters of QM, or rather of its ability to describe reality, in a position of great difficulty. Bohr initially responded that the criticism was right but the experiment was impossible to carry out (Bohr, 1935). In the following decades, experiments similar to the one proposed by Einstein were carried out, (Aspect, 1982; Colciagi, 2023; Freedman, 1972) and it turned out that entanglement really exists and some of its practical uses have been proposed (Piveteau,2023). Obviously, the suspicion may arise that even in the quantum case, the states are decided at the departure of the two objects perhaps with a probabilistic distribution of the results. Bell (Bell,1964) found and published inequalities that should have been tested for if indeed the results were random but predetermined. Very recently (it can be seen a list of these experiments in wikipedia.en issue " Bell tests "), experiments have been carried out in which Bell's inequalities have been disproved while the QM predictions have been confirmed. It therefore seems that ghostly action at a distance is real and we will return to this point.

Regarding the second quantization, we follow an argument made in (Tung, 2021)). Let's imagine observing a single particle and decreasing the inaccuracy Δx with which we measure its position. We can imagine using increasingly precise tools. Obviously, due to Heisenberg's uncertainty principle, the particle will acquire an impulse Δp and therefore an increasingly greater energy. A certain point will be reached in which the energy will be sufficient to create other particles due to the mass-energy equivalence. So if we want to combine Relativity and QM, it is not possible to consider single particles but rather fields of particles.

Then there is another problem. Let's start with a seemingly banal question. Why is every electron the same? Equal electric charge, equal spin, equal sensitivity to forces, equal mass. Yet among electrons (we could say the same thing for protons, quarks or neutrinos), there are objects that have had a completely different history. Some have been produced billions of years ago in a distant galaxy, and others have been produced a few minutes ago in particle accelerators. This cannot be explained but if we admit that we are dealing with quanta, with fundamental elements, and with small pieces of a field that has existed since the Big Bang and extends over the entire Universe, then it is obvious that the smallest pieces of the same field are equal . From a formal point of view, to achieve quantization of the fields, we operated on the Lagrangians and it was discovered that Schrodinger and Dirac's equations could easily be interpreted as equations of matter fields. The existence of antimatter is easily explained too because if the matter field is vectorial and therefore has several components, then some of these correspond to ordinary matter (electron) and others to the corresponding antimatter (positron). Using Feyman's formalism, it is possible to describe the interactions between particles very well and very precisely, creating what is today called the standard model of particles and forces.

Some thinking

So far, we have engaged in a historical summary, albeit a very brief one, of the changes in the models used to describe reality from Classical Mechanics to QM. It is time to explore some reflections to answer the questions that are in the title of this paper. Let's start with the alleged "absurdities" that exist in QM. We have already said that the material point model, which is fundamental in CM, contains absurdities. Let's consider the very well-known formula of the gravitational force between two points:

$$F = Gm1m2/r2$$

This is the formula explaining almost all motions in the sky, the movements of every object that man has sent into space, and the force of weight with all of its consequences in the calculations of engineers. However, it can be seen that:

a) the gravitational force of the point on itself is infinite, and this recalls the singularity of the Schwarzschild metric, which is the basis of the theory of black holes.

b) infinite energy needs to detach part of the material point from the rest.

c) the gravitational force between two points is never equal to zero whatever the distance, with the language used above in Newton's theory of universal gravitation being non-local.

Just to give an example, if you calculate the gravitational acceleration that people feel of a small household appliance placed at a certain distance, you will find a value that is comparable to the acceleration that the same people feels by the Andromeda galaxy. To put in some numbers, if the household appliance mass is 1 kg, the distance between me and the household appliance is 10 meters, the mass of the Andromeda galaxy is 10^{12} solar masses, the distance between me and Andromeda is 2 million light years, paired with the data for the mass of the sun and the conversion light years – meters and the cost G, we have the following:

For acceleration due to Andromeda, $3.3*10^{-13}$ in MKS system units.

For acceleration due to the appliance, $1.3*10^{-13}$ in MKS system units.

It is clear that the effects that distant masses can have on daily life can be neglected not so much because of their low value (there are millions of galaxies that weigh as much as Andromeda, not to mention the stars of our Milky Way that are less heavy but closer and more numerous). The fact is that these far effects add up as vectors, so then the two effects with same intensity but in opposite directions cancel out, therefore a non-local theory in practice becomes a local theory. We can think the same thing happens to quantum entanglement because if an electron that makes up my body can be connected to an electron of a hypothetical inhabitant of Andromeda, it can also be connected to an electron of a hypothetical inhabitant of the Magellanic Cloud, and the two effects cancel each other out. There are two very strong indications that this is happening.

Since the first experiments on cathode rays, which are electrons, which took place 150 years ago, observations and measurements have been made of quantum systems in millions of cases, and the anomaly that can be explained by disturbing effects due to the entanglement of the system with far systems has never been observed. Furthermore, millions of macroscopic devices have been produced which base their operation on QM (lasers, superconducting magnets, tunnel diodes, electronic microscopes, and don't forget all electronic components based on transistor or optoelectronic components related to the photoelectric effect), and an anomaly created by entanglement has never been observed. In short, someone who claims to base New Age visions on QM and who doesn't sleep at night thinking about its possible connections with living beings who knows where (Rovelli,2020 B) is simply wrong.

There are those who think that entanglement_signals can be sent at instantaneous speed, therefore contradicting Relativity and introducing a contradiction within Contemporary Physics. There are many informative books and videos (Balbi, 2022; Brown, 2002) where it is explained that entanglement_signals cannot be sent, Here, we can limit ourselves to observing that in measuring the impulse of an electron connected to another, I do not "write" a message that can reach the other electron and in any case, some time passes from the departure of the connected electron until the moment in which I measure its property. Any signal would still have a travel time. If we think about the "spooky action at distance" that seems to really exist, it is enough to read Newton's *Principia* to realize that the Newtonian theory of gravitation admits, and indeed predicts, action at distance. A historical reminder is needed here. Before Newton, Descartes (Descartes, 1644/Ferlin, 2020) had already formulated a theory of gravity in which it was thought that the Solar System was filled with a fluid and that vortexes of the liquid generated the motions of the planets, without any remote action. As Voltaire testifies in English Letters, this vision was the most widespread in continental Europe at the beginning of the eighteenth century. Voltaire writes (Voltaire , 1734) "whoever goes from Paris to London leaves a full Universe and finds an empty one."

Remote action is therefore an integral part of CM. It was put into a state of crisis by the studies on electrical, luminous and magnetic phenomena which led to the concept of field in the nineteenth century. Einstein's relativity then excluded remote action and placed a limit on the interaction's speed. So the non-locality of QM almost seems like a return to CM, and perhaps this annoyed Einstein. Furthermore, the same discussion that we made above for gravitational attraction due to distant masses can be applied to entanglement with one addition. If the force of gravity cannot be shielded from entanglement in a certain sense, then it can be canceled out because the particle in its motion clearly interacts with other particles and it will be intertwined with them too. The intertwined states are therefore particular states that are very "delicate" and susceptible to being canceled out. This must be considered in experimental checks. In fact, the non-locality of entanglement is not operational for practical purposes. On the other hand, the QFT vision of particles such as the quanta of fields that clearly extend throughout the Universe and have existed since throughout the Universe and have existed since the Big Bang is a non-local vision and it must be taken into account that even space-time, referring to General Relativity, can be seen as the field of gravitational forces. Moving on to the leap between determinism and probabilism, this is a real leap but we can ask ourselves, is it a leap compared to CM or is it compared to everyday reality? Is the cause-effect relationship invalidated?

Let's start with the cause-effect relationship, and we can immediately see that it still exists. We consider a quantum event as the production and then detection of the Higgs boson in a particle accelerator. We have a proton-antiproton pair that "collides" (cause), we have the kinetic energy of the couple higher than the energy corresponding to the rest mass of the boson (contributing cause) and obviously we can see that the standard model is valid (another contributing cause). The production of the Higgs boson is there (effect). If there is no cause or one of the contributing causes, the effect does not occur. The difference with the classical case is that if I collide a very high number of pairs (billions), only in a very few cases will I have the Higgs boson particle in the final state. I will be able to have the final states of other already known particles, perhaps with the top quark or the intermediate vector bosons, or even events in which nothing happens because the proton and antiproton simply exchange part of the momentum (elastic collision). This is because the phenomena is probabilistic, therefore there is a certain probability (cross-section) that there is a Higgs boson, an intermediate W vector boson, a top quark etc. Obviously, the peculiarity remains. From the same well-defined cause, there can be effects that very different and the same effect can have different causes.

Now we move from a quantum event to a political event, and find a practically identical situation. Party X increases their votes from 3.5 to 25% of the votes, which is a notable increase. This is an effect that can even be measured with absolute precision because the number of votes is a natural number. To understand the cause, we did an opinion poll of a representative sample of the new voters and asked explicitly why they voted for that party. The experience of daily life tells us that we can have all kinds of answers, such as patronage (election promises), sympathy (for the leader or a candidate), adherence (to the general program or some of its points), protest (it is the only opposition party) or random (I didn't know which to vote for, I chose randomly) and more. One effect can have several causes and we certainly cannot forget the observation done in one of the articles by the great Italian physicist Ettore Majorana: (Majorana, 1942) "In a perfectly deterministic world, man's free will would make no sense."

Therefore probabilism breaks with CM but not with everyday reality. Probabilism is a guarantee of man's freedom. Let's get to the most important point, that reality is independent of the observer. We have already said that the characteristics of this reality, which has been measured, are one thing, while the existence of a phenomenal reality isn't created by the observer but influences him even if unobservable. We can then speak about a reality independent of the observer. Entire books can be written on what "reality" is and what the observer is (Rovelli, 2020). It is necessary to repeat some things. At the time of the ancient Romans and in the European Middle Ages, one would not suspect that microbes or viruses existed. Despite this, infectious diseases existed and caused many deaths. This is an unobservable reality, a hidden variable one might say, that exists and has influenced people. On the other hand, the vast majority of objects constituting the Universe were not visible to the ancients, nor they could influence their lives, but we certainly cannot think that in inventing the telescope, man created galaxies and stars not visible to the naked eye, or the planets.It is trivial to say that reality may appear different to multiple observers but it is useful to remind using some examples to understand how this diversity can be strong.

The measurements of a characteristic quantity of a system done by different observers can give different results like the measurement of the frequency of a wave emitted by a source done by two observers, where the results (Doppler effect) are different. The state of motion of an object depends on the observer because motion is relative. With examples taken from everyday life, this is taught in he first year of physics in high school. The color of an object can vary depending on the angle at which it is looked from because the reflected light can have a different spectral composition than the transmitted one. The author remembers having observed, when he was a student, a thin vinyl record which, when looked at in a reflection, was blue-violet and when looked at in transparency, was red.

The simultaneity between two events can be judged differently by two moving observers. There is an important example by Einstein (Einstein, 1981) which is reported here with a slight modification because it can have an important variant. Let us consider (see Figure 1) the carriage of a train of length L, measured when it is motionless, as well as people O motionless on the station platform and people O1 inside the carriage. Both observers are equidistant from the ends.

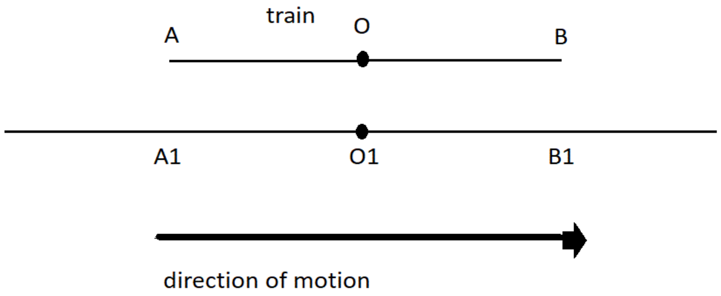

Figure 1. Einstein example

Suppose that, when the train is stationary, two bolts of lightning strike simultaneously and strike points A and B of the carriage respectively, which correspond to points A1 and B1 of the platform. Both observers agree that the two events occurred simultaneously because the light from the lightning had to travel the same distance. If instead of light the two observers had listened to the sounds of two gunshots, then nothing would have changed. Let us now imagine the train was moving at a constant speed v towards B, with reference to the observer on the ground (the inertial reference system is the platform). Just when the two observers are in front of each other, two bolts of lightning strike the ends of the carriage. Let's also assume that for O1, the lightning bolts that strikes the ends of the carriage are simultaneous, therefore he perceives them at the same time. Observer O states that the lightning at B happened first. This is explained because the observer is moving towards B and away from A, therefore the ray of light emitted at point B reaches O before that of A. If the two observers had been blindfolded and had to judge only by the sounds, then nothing would have changed. If instead of the train we put one of them on a plane traveling at supersonic speed, then the observer on the plane would never have been able to hear the sound coming from A, and the two observers would have disagreed not only on the simultaneity but even on the existence of two events. On the other hand, as seems to be very important to the author, since the 1950s to today, individual atoms, i.e. a quantum system, have been photographed (see Figure 2) by electron microscopes (Jacoby,2005), obtaining photos such this:

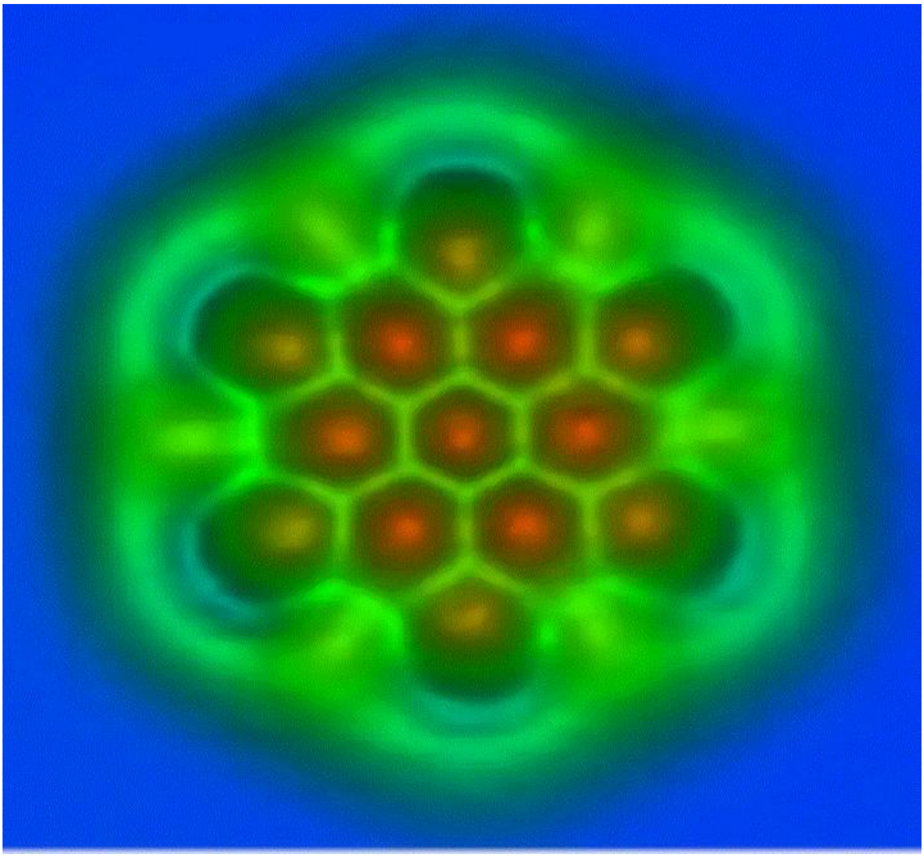

Figure 2. Example of a photo of atoms

Recently, atoms have been photographed at the moment at which they exchange an electron to carry out a chemical reaction (Kiesewetter, 2018). Using electric fields and lasers, we are able to move individual atoms in a way to make a word appear (Eigler, 1990). We can even put them in a line by creating a magnetic field meter (Schaffner, 2024). Now I can photograph and manipulate a real object, not an idea or an element of Hilbert space. I can photograph a beautiful place or a beautiful people but not the beauty itself, therefore quantum objects are real objects, not abstractions.

In recent times, it has become possible to photograph wave-particle dualism (Verstraten, 2024) and quantum entanglement itself (Zia, 2023). Because of its importance, let us describe the scheme of the experiment in which the dual behavior of the individual atoms was photographed by verifying the validity of Schrodinger's equation too. They cooled lithium atoms to temperatures close to absolute zero using lasers to extract their energy. Then they trapped them in an optical lattice, a bit like a complex game of ping-pong where the balls are the atoms and the rackets are beams of light. Having trapped them, they turned the lattice off and on periodically, observing the atoms move from the particle state to the wave state. More precisely, they saw the individual atoms make apparently random shifts with respect to their equilibrium positions. They derived from these shifts a position probability distribution, and they found a perfectly identical function, within the limits of experimental uncertainties, related to the solution of the Schrodinger equation. For the potential corresponding to the atom-light interaction, there is a potential practically equal to the harmonic oscillator potential. This result was highlighted by a series of images (see Figure 3), one of which was placed on the cover of Nature magazine which announced the result.

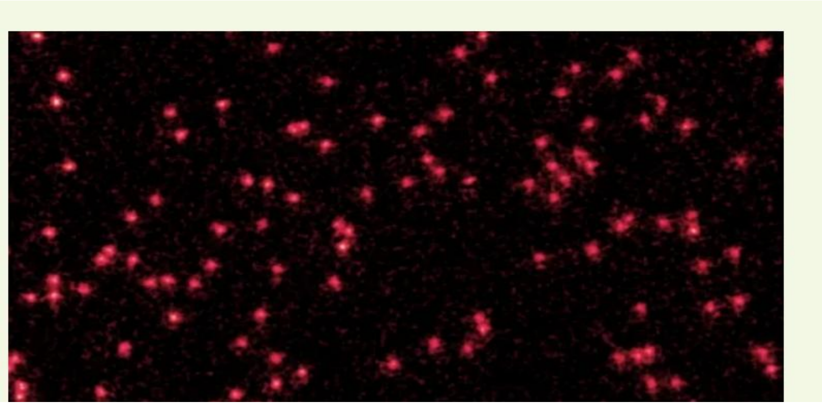

Figure 3. Photo of atom in wavw corpuscolar behaviours

This is just the beginning. Physicists predict that this imaging technique can be used to study even more complex systems.

Conclusion

Let's try, using everything that has been said, to answer the questions in the title of this article. Summing up, we can say that: The existence of an objective reality such that its laws aren't influenced by the observer (the first postulate of Relativity) and such that it is not created by the observer, is not denied by QM. What is reiterated and expanded is that reality is more complex than CM tells us because the evolution of reality is probabilistic. Elements of non-locality appear in the laws that regulate it. Quantum non-locality, like that of universal gravitation, does not have any effects for practical purposes. The probabilism of QM, far from creating problems, could be both a guarantee of man's free will and a link between the natural sciences (physics, chemistry, biology, etc.) and the so-called human sciences (sociology, political science, economic and legal studies), possibly using non-linear physics as a "bridge" because the great majority of physical models used to describe socio-economic systems are non-linear. Quantum systems are neither abstract entities nor unobservable, and they can even be photographed. The measurement of the individual quantities that characterize them is obviously influenced by the uncertainty relations. A cause-effect relationship between events continues to exist but it is more complex than classical logic and CM. QM therefore does not appear to the author to be either very strange or counterintuitive. Even elements such as the existence of antimatter, spin and virtual particles, with the associated Casimir effects, which were not discussed in this paper, can be framed in a logical and simple way by the second quantization. If we enter the model of the vector particle that of a single quantum system, i, it is obvious that the v electron vector has components that have two verses. In the case of the electron, the two components are the electron of ordinary matter and the positron of the antimatter.

Declarations

Acknowledgments: At the end of this paper, I would like to give special thanks not to particular people or to an institution but to the Internet. The author is not an academic. He does not work for a university or a research center but, through the Internet, he has obtained and continues to obtain updates on recent experimental results, information contained in articles produced by colleagues, the possibility of contact with organizations and research centers, etc. All of this has allowed the author and others in the same conditions to be open to the scientific community, and everything that derives from it.

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