A remark concerning Bohm's Theory

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Abstract

We investigate in this article a different version of Bohm's Theory which renders it compatible with what happens in the tunnel. It is a different picture where the wave and the particle are two phases of the same phenomena but are never simultaneous. We describe other quantum phenomena using this picture.

1 Introduction

Bohm's Theory In the classical undeterministic interpretation of the wave function, this function represents the probability of presence of a particle. Bohm's theory provides a "classical deterministic" interpretation of the wave function, which is : 1) the particle moves along geodesics determined by the wave function. This wave function ψ, determined by Shrodinger equation, is a guide for the particle, which once created, follows lines determined by ψ is such a way that the classical interpretation is never contradicted. Essentially, the trajectory of the particle is transverse and normal to lines where ψ is constant. 2) the results predicted by Bohm's Theory are exactly the same as the results predicted by the usual undeterministic interpretation. In other words, Bohm's Theory is a determininstic interpretation of ψ compatible with the predictions of the quantum Theory.

Tuneling Now, with the recent observations of the tunneling of particles, Bohm's Theory suffers a problem : in the tunnel, the particle cannot be guided anymore, because in the tunnel it propagates with infinite speed, it should be present at the same time all along its trajectory, which is impossible.

A new version of Bohm's Theory By reading very attentively the book [2], where the experiments of tunneling are described and explained in great detail, we imagined a different image for the particle and the wave. We could describe this image by being : Bohm's wave guide but with no particle at all. The reason for this is that we don't need the particle as long as it doesn't interact. To give a simple image, if we have a cell phone people can phone us and we can phone people wherever we are. The image would be this : suppose we just have a number and no phone. When someone calls this number, it creates a ringing phone in our pocket so we can take it and speak. When the conversation is finished, we can put the phone in our pocket again where it just vanishes. There would be no difference for reality in the second case and in the first case. We remark that in the second picture, if there are two successive calls, there are also two different but undistinguishable phones.

The particle in time In other words we abandon the principle of "the countinous existence of the particle in time". The simple concept of atoms, even like in the Democrite's description, shows to us that matter is not continous in space, matter is made of atoms but these atoms are seperated by huge distances only made of vaccum. Continuous matter as we see in our everyday life is just an illusion. But we still believe that matter is continuous in time, we don't imagine these atoms to exist only at very special instants, separated by huge intervals of time. So in our picture we want to abandon this picture. We want to admit that matter is no more continuous in time that it is in space. Special

Relativity has as a consequence the identity of nature of space and time. So if we know that matter is not continuous in space, it has no reason to be continuous is time either. That matter is continous in time would just be an illusion again.

Tuneling The non existence of the particle when it does not interact renders compatible this new version of Bohm's Theory and the observations of tunneling of particles. In our picture, in the tunnel, the particle doesn't need to be present everywhere only because its speed is infinite. The reason is that now there is no particle at all during this process.

Conclusion about this picture The particle would exist as a particle only during an interaction, and between two interactions, only the wave would exist. Then the wave is interpretated as an ability for interaction (in this picture interaction is the only reality). They are two seperate phases which are never simultaneous. The wave with no particle, then at the moment of any interaction, this particle would materialize, but not at a space-time point. The materialization of the particle would happen in a little region of space equal to λ and would take a little interval of time equal to $1/\nu$. After the interaction, the particle would disappear and transform into a wave again. We notice that this undertermination on the particle : $\Delta x = \lambda$ was already proved in [1] using the principle of Special Relativity and Quantum Physics.

2 The picture and experiments

2.1 Generalities

Symmetry Breaking The wave function is an ability to interact which means that there is no particle as long as there is a wave function. Our interpretation eliminates the probabilities : there is no probability of presence since there is nothing to be present. As well, this eliminates the wave guide : there is nothing to be guided. If two waves interact, particles are produced in some little region of space and at some little interval of time.

Where and when does this happen? We use the system of symmetry breaking to explain this kind of phenomenon. If a particle is observed at some detector and not at another we admit that the reason is a symetry breaking phenomenon, but the wave is still an ability to interact so the particle has still more chance to interact in region that the intensity of the wave is high that in region where it is tiny.

Double slit experiment When the particle materializes and dematerializes again, a new wave takes place but the physical quantities are still conserved during this process. For example in the double slit experiment, if there is no interaction at the slits, we have a wave and normal interference. If for some reason we force the particle to interact at one of the slits, we have a wave, then materialization of a particle at one slit, but in a region of space equal to λ, bigger that the slit itself so then a second wave, a diffraction phenomena with conservation of p and E. We emphasize that in this case the particle should arrive at the detector with a delay equal to $1/\nu = h/E$, the time the particle needed to materialize. We emphasize that in our picture there is no particle traveling inside the experiment apparatus, only waves travel.

Difference with Bohm's Theory Our interpretation gives the same results as Bohm's theory. Nothing is changed except that there is no particle to be guided instead of one. In Bohm's theory, during its travel guided by ψ, the particle never interacts so can never be observed anyway.To be really precise, the only difference would be the following : in Bohm's Theory, if we make an experiment about the position of a particle, and if it would be possible to make again the same experiment a second time instead of the first, we would find the same result. In our interpretation, we would find a different result. But this changes nothing, because it is just impossible to realize this thought and make a second experiment instead of the first : making a first experiment, anihiliting the reality of this first experiment and performing a second one is just self-contradictory. We emphasize that in our picture there is no particle, then no trajectory.

In the tunnel In the tunnel, Bohm's theory seems to fail : the particle cannot exist anymore, or it would exist all the way along the trajectory. Our interpretation poses no problem, as we already noticed : there is nothing to travel faster than the speed of light anyway, since there is nothing at all. Still we have to admit that everything which is a wave can travel at its "mathematical speed". In the tunnel the wave travels instantly, so with infinite speed and the wave is everywhere. What we say is that if we observe the particle at the entrance of the tunnel, and then at a space-like distance because of its travel in the tunel, if fact it's not the same particle we observed (just like in the picture of the phone, it's a second phone wich is created for the second call). Only the wave traveled not the particle. This situation confirms in fact our own interpretation. Because when a particle materializes some wave, existing in all space, is annihilated instantly so the particle takes place in λ and $1/\nu$. So our picture forces us to admit that the "information" contained in the wave disappears instantly. If we take a classical picture, suppose two people A and B are looking for a key they lost in a field. Once one of them, say A, finds the key, he knows instantly that B didn't find the key, he doesn't need to wait the light to come from B to A to have this information. In [2] section 5.6, non-locality, the authors explain that it's exactly what they observed. An information contained in the wave function can be displayed instantly at one point. So to sum up : now some experiments are available which shows that the information of the wave function can travel instantly, and we use this experimental fact to give a picture of a wave transforming into a tiny particle during an interaction. At the instant the interaction begins, an "order" is given to the wave function to collapse everywhere in space, this order being able to travel at infinite speed.

This picture is deterministic Our picture is as deterministic as Bohm's Theory. Suppose a particle created at one point, in a two dimensional experiment and suppose that we try to detect it after placing detectors all along a circle centered at this point. What says Bohm's theory? that there is an indetermination at the origin, the angle of the trajectory is undetermined. We notice : in two-dimensional classical theory also, when two particles collide, an angle is undetermined. What says our interpretation : the same, except that there is no particle between the point of creation (center of the circle) and the circle itself. There is no more indetermination in our interpretation than in Bohm's. Our theory says that if the experiment could be made again, the result would be different, but Bohm's theory says also that if the particle would be created again, it would have a different trajectory because of a different angle.

Schrodinger's cat The first principe we wanted to keep is : what we know can change the way we behave, can change the experiment we choose to make, but cannot change the result of a given experiment. Our interpretation fits with this principle. Schrodinger's cat cannot be dead or alive because we know it or not. Our interpretation is only a matter of interaction, not observation. The status of the interaction makes it dead for example, even if we do not know it. This is interaction and not observation which is at stake or in other words, there is no retroaction of observation on reality. The difference is that reality becomes only an ability to interact or interaction itself(there is nothing else in reality than interaction). The logical link is that no interaction implies no observation, but it's possible to have interaction without observation.

2.2 EPR experiment

We consider here the case of a pair of particles leaving the source, going to their Stern-Gerlach magnets A and B. We suppose we measure in each case the quantities : spin up or down along x, or along y. When the particles interact with the magnets, the wave function is the wave of two linked particles, so the ability of the particles to interact is the ability of two twin-particles, not two idependent particles. One particle cannot interact independently of the other. We reinterpret this experiment by postulating here symmetry breaking : even if the two particle interact at the same time with the magnets, by symmetry breaking one particle has to begin the process of materialization before the other, and at this time the "order" for the wave to collapse is given instantly. What happens? The order in this case is : the total wave function has to be rearranged in a way that it becomes the wave function of only one particle, the one which is still waiting for interaction. Then, this second particle interacts by a materialization given by this new wave function.

Measuring the same quantity We decide to measure the spin along x for both A and B. The new wave function (of the second particle, after the interaction of the first, and before the interaction of the second) is now such that the second particle knows "how to behave" to obey all conservation properties of spin.

Measuring a different quantity If we decide to measure spin along x in A and along y in B, again the second particle knows how to behave : its spin along x is fixed by the new function(the wave function available between the two interactions) and it can give any result along y. Can we deduce that each particle had a definite spin along x AND along y? Clearly not according to our interpretation. Even if the two particles were identical at the beginning, there are not anymore, once the first has interacted and while the second begins its interaction, so we cannot say anything about spin along y for particle A (the first one). And more : since experiments, according to our interpretation, are not reproducible, even without this argument, we would have no reason to believe we know for particle A the spins along x and y. We said that if we measure the spin along x, and if we could reiterate the same experiment, a second one, instead of the first : spin along x, we would not necessarily find the same result. So the measurement of the spin along y of particle B gives a fortiori no information of what we would have found if we had made the measurement of the spin of particle A along y.

2.3 Tunneling

Our interpretation fits also well with the tunneling experiments described in [2]. When the particle is not interacting, it appears as a pure wave so there is no underlying particle. When the particle interacts, it first has to materialize as a particle. This phenomenon needs the time $1/\nu$ and the space λ to take place (and to take time). This space λ explains why "a totally reflected beam is shifted against the incoming ray" (subsection 5.2.1 and fig. 5.21). Because this shift is equal to λ, it corresponds to the "space" needed to the materialisation of the particle. The shift in time $1/\nu$ corresponds to the time needed for the particle to materialize, and is always observed, even in the in the experiments involving tunneling. So at the entrance of the tunnel, the particle materializes in order to interact with the tunnel, and this phenomenon takes the observed time $1/\nu$ (corresponding to the universal relation section 5.8). After this interaction, the particle dematerializes and transforms into a wave, the wave predicted by quantum mechanics. In particular, inside the tunnel, this function is exponentially decreasing (imaginary time) but not oscillating. So a wave will materialize has a particle (interaction with the tunnel), a phenomenon taking the space λ and the time $1/\nu$ and then will dematerialize again to give another wave, described by quantum physics. If our particle is observed the other side of the tunnel, we should be aware that this particle has not travelled faster than the speed of light, it's just another particle materializing again to interact with the detector. In other words, in the Bohm's picture, the particle would always exist and would travel, guided by the wave function, and that means would travel at infinite speed in the tunnel. So this particle would be non-local and omnipresent in the tunnel. This image is strong enough to reflect the non-locality (section 5.6) and the infinite speed (zero time) in the tunnel (section 5.3.4). Our interpretations says exactly the same, except there is no particle in there, only a function (a matter field), the quantum wave function. So there is no "particle" travel and no "particle" non-locality.

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References

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