A new interpretation of non-relativistic quantum mechanics.

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Abstract

We propose a new interpretation of quantum mechanics without the observer and thereby solve the micro-macro problem. Our proposal goes beyond Bohm-de Broglie theory but is as far as it stands mathematically isomorphic to it.

1 Introduction

A reinterpretation of quantum mechanics is only useful if it proposes a new direction of research, a deviation from the standard path laid out by other proposals and potentially also a conflict with competing interpretations. The Copenhagen interpretation is minimalistic, but leads to a number of paradoxes such as the particle-wave duality and the measurement problem. Indeed, this approach does not reveal anything about which observable actually corresponds to a macroscopic apparatus, when a measurement takes place and even if a measurement should occur. Questions as what happens to the particle after a position measurement has been done are dismissed as complete metaphysics[1] until a new experiment has been done. Moreover, the theory never really makes precise what a measurement is, so that one must come to the conclusion that it ultimately must take place in the mind of the observer. Such mind boggling statements were indeed made by pioneers such as Von Neumann and I find it hard to swallow that someone who arrives at such idea does not look for the weakness in his own assumptions. An extension of quantum physics was proposed in the early days by de Broglie and some 25 years later by Bohm; they concluded that as well the particle as the wave exist and that the wave is a real physical wave guiding the particle. Since the advent of special relativity, it is hard to imagine that particles provide the ultimate answer since it might be desirable to explain how they are created and annihilated just than merely stating that it happens. Up to this date, we do not have a satisfactory relativistic quantum theory and it might be that the absence of hidden variables in such formulations ultimately are responsible for their problems. My bet is in that particles in the sense of irreducible representations of the Poincaré group, are not the fundamental constituents of nature but merely effectively describe phenomena which occur in our experiments. Therefore, it is entirely logical that

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[1] This is an example of how to turn a weakness of your theory into a virtue.

we build our theories upon them and only start to wonder when experiment speaks differently or when our theories bounce at inconsistencies. This novel interpretation just intends to offer a glimpse of inspiration as where to look for such new ideas if that turns out to be necessary. Given the absence of mathematically sound relativistic quantum theory, it is still legitimate to pretend as if particles are the fundamental constituents of nature and limit ourselves to the non-relativistic case. The need for a realist interpretation of quantum mechanics has also been recognized by Sorkin who builds a new interpretation based on the path integral; our interpretation does not really depend upon the picture one works in (path integral or Schrodinger wave) but the path integral offers a neater way of how to interpret the wave than the Schrodinger equation does and indeed I would look for a novel theory rather in that direction. Our interpretation is more flexible than Bohm-de Broglie [2] since it leaves open more possibilities; as such a minimalist might dispend of it as too liberal, but on the other hand the adventurous researcher might discover possibilities never envisioned. As with all interpretations of quantum mechanics I will be vague at certain points (albeit by far not as vague as the Copenhagen interpretation) but at least one can construct more specific models and certainly one does not face the problem that particle wave duality is the final answer.

2 Our proposal.

As mentioned in the introduction, we assume particles to be real albeit probably not the fundamental constituents of nature. Quantum mechanics speaks about particles and has nothing to say beyond that; those researchers who may wish to make that generalization are responsible for the consequences. Quantum theory also does not really reveal whether particles are points or not, the only thing relativistic quantum theory assumes is that they may interact in points which is not the same thing. Also in string theory, the string is just a way to construct specific representations consisting of an infinite number of conventional particles and in my mind, it is certainly a wrong idea to think that we will ever observe a string. A realist theory beyond quantum mechanics would probably contain the idea that a particle is an extended object but we will content ourselves with point like descriptions. In [1], an attempt was made to build a consistent relativistic particle theory (without fields) and as far as it stands it is unknown wether it is consistent or wheter some modification of it is (without really changing any of physical ideas). Without going into that particular proposal, one conclusion of it has remained with me over the years: at any point of spacetime, the information (wave function) about matter in the whole universe is present and potentially available. It is nothing new to regard the wave function as information, but then as information available to the *observer* of the system; what that work seemed to suggest is that it was also available to elementary particles! If this were so, then we would no longer need the observer, whatever it is but it becomes impossible to substain that elementary particles are "simple" objects. Indeed, in what follows, we do not consider them to be simple at all and we maintain that nature has for all practical purposes an infinite complexity at those scales (I remain ignorant about what happens for example at the Planck scale). So we propose that a particle is an information processing entity where the wave function (of the particles) is the temporary *result* of that process. For ease of presentation, let us look at the case of an individual quantum particle, then I propose that the information *actively* available to it (meaning information with which a computation is made) concerns the spacetime configuration of "nearby" objects. Here, I don't specify nearby and leave this open to the model builder, but conceivably deviations from standard quantum mechanics are expected here since there *all* information is taken into account. In a double slit experiment for example it is natural to assume that the particle "knows" that both slits are there, I leave it open wheter it should also know that there is a screen behind the slit. Let me describe now what I imagine such particle does on its trajectory from particle gun to the screen. As long as it is in the gun, information about the outside world is irrelevant and as such its wavefunction does not contain yet the plate with double slits; if you would "ask" the paricle what it "knows" about the world outside the gun, it would probably "answer" not much. Nevertheless, inside the gun, it moves according to the information available to it; this is how we interpret the Bohm-de Broglie current as the "flow" of information. When it is about to leave the gun, the information about both slits becomes available and even if it were "unaware" of the screen behind it, it would calculate the information behind the double slit based on the *assumption* that nothing is there. So, we get a preliminary interference pattern; if the particle arrives behind the slit and merely receives the information of the screen, then it *updates* its information which might even result in repulsion if for example the screen were negatively charged and likwise so for the particle. Suppose now that the particle comes into the immediate vicinity of a lot of particles, then this information becomes primordial and its history becomes irrelevant. Unlike Bohm-de Broglie I do not need to assume that the "detector" will have a macroscopic response to the arrival of the new particle in order for its state to "collapse"; the collapse of the wavefunction here is just an update of information and the particle doesn't need the detector for just doing that.

Now, what about multiple entangled particles then? Obviously, particles know about other particles even if they do not directly "interact". The only way I can imagine such thing to happen is if they have a private communication channel, something akin to a wormhole connecting them. Of course it is also possible that particles do not make these computations after all and that nature does it from a holistic point of view; then "nature" is of course "aware" of everything in the entire universe and just dictates what the flow of elementary particles is. The whole world can then be regarded as a hologram of some kind where spatial extensions are irrelevant for information processing. In that vein, the particle would be guided by the information flow instead of just calculating it itself. The matter of limited or omnipotent information can be decided upon experimentally, by making setups over extended spacelike distances (with "shielded" components) and one must see if interference effects still pertain in the same way as they do in the standard theory; particularly suited are Elitzur-Vaidman bomb type experiments. Coming back to the wormhole, we must conclude then that *total* information (the multiparticle wave function) is a *resultant* of more complicated information flows, a grand harmonization between distinct particles. The collapse of the wave function does not constitute any problem here since modifications of *individual* information are immediately "known" to other particles. I wish experiment would guide us more in order to further specify some of the details above; it would certainly help us looking for a more unified theory.

3 Conclusions.

As promised, we have presented an interpretation, or better possibilities of interpretation, which allow for further experimental testing. Especially, the hypothesis of limited information can lead to clashes with all other known interpretations and it is worthwhile to verify this in experimental setups where one could imagine some part of the setting to be "shielded" from the particle. The reader may have noticed that the word measurement apparatus or macroscopic event was of no importance in our interpretation; one simply does not need such constitution in order to have an information update. Also, our interpretation(s) pointed towards unconventional views concerning the fabric of spacetime and as such provided more information than was a priori asked for. Moreover, they gave a direction for a more fundamental view of nature, which is one of information and information processing, rather than one of particles moving in a background spacetime; this is where our approach differs significantly from the Bohm-de Broglie theory. How this picture as well as local Lorentz invariance can be derived from the more conventional one is of course an open question.

References

[1] J. Noldus, Foundations of a theory of quantum gravity, Arxiv:1101.5113

[2] J. Bell, Speakable and Unspeakable in Quantum mechanics, Cambridge University Press.