Refuting the refutations of the Wigner-Neumann interpretation in quantum mechanics

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Abstract

One of the most controversial interpretations in quantum mechanics is the Wigner-Neumann interpretation, according to which the superstitions collapse only when a conscious observer observes the quantum system. In general, there is much opposition against this specific interpretation and the reasons are more philosophical than purely scientific. By refuting a specific refutation of the Wigner-Neumann interpretation postulated by Anderson and Carpenter, this paper shows how cancelling the Wigner interpretation is simply not possible at least with our current understanding of the cosmos. What is more, a brief overview of the philosophical dogmas underlying the opposition against this specific interpretation are discussed. The debate is more philosophical than scientific and if science wants to progress it should reunite with philosophy and start asking the simple questions once again and with a clear mind.

Tags: quantum mechanics, Wigner-Neumann, observation problem, decoherence, superposition, quantum mechanics interpretation

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1. The problem

The interpretation of quantum mechanics (QM) has been a field of strong debate for many years now. Since the era of Bohr and Einstein, scientists have been trying to agree on the underlying philosophy governing the quantum world without a consensus being possible in the near future.

There are more than ten possible interpretations of QM currently and not one of them had gained the unive

rsal acceptance of the scientific community as of now. One interpretation of all others however has been quite successfully in stirring hostile reactions from a majority of physics today, and that is the Wigner-Neumann interpretation.

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1.1 Wigner-Neumann interpretation

According to that interpretation, the collapse of the superposition of a quantum system is the result of the observation by a conscious observer. This interpretation puts humans in a central role regarding the wave function collapse. In summary, the argument was that since a quantum system is always in interaction with other quantum particles or systems, there is no reason to have superposition at any point in time. A conscious observer however makes the difference and causes the electron to hit the sensor in a specific point when it is observed.

1.2 Objections to the Wigner interpretation

As one would expect there are many objections against that view, following various other possible explanations: the collapse can be simply caused by the interaction with other material not necessarily conscious, with the instant generation of multiple universes every time a wavefunction collapses et cetera. The need for consciousness as a reason for the superposition collapse is an unnecessary assumption that does not offer anything except problems.

The reasons for the hostility against this way of thinking have their source in specific philosophical dogmas transcending through modern scientific community for the last centuries or so. These will be analyzed later.

2. The Anderson-Carpenter argument

First, let's examine one example of refutation of the Wigner interpretation. By exploring it we can get a glimpse of the problems the opponents of Wigner interpretation face, along with the problems of that interpretation as well.

In 2006 Anderson and Carpenter published a paper where they tried to refute the Wigner interpretation of quantum mechanics. The paper was titled 'The death of Schrödinger's cat and of consciousness-based quantum wave-function collapse' and was published in Annales de la Fondation Louis de Broglie, Volume 31, no 1, 2006. (rf. to https://fondationlouisdebroglie.org/AFLB-311/aflb311m387.pdf)

The argument Anderson and Carpenter tried to make can be summarized as follows: The authors tried to create an experiment where the 'Schrodinger cat' (two hammers in this case) inside a box was observed by two observers instead of one. The trick was that each observer only had knowledge of one piece of the information needed to describe the final state of the system. They created a box with two hammers inside. If a decay event took place in a specific device inside the box, then hammer A would be released. If no decay took place, then hammer B would be released. The release of each hammer caused the release of a ball that was attached to the hammers. This ball read 'decay' or nothing. Then an observer could go and see which ball was released from the box. There was a catch though: a random process determined which ball would be attached to which hammer. Observer A would decide based on the output of a random number generation whether the 'decay' ball would be attached to hammer A or hammer B. In that way, this meant that when Observer B would go to check on the ball released by the apparatus (the box) he would be in no position to know whether a decay event took place or not, because he wouldn't know where the 'decay' ball was placed by A. So Observer A had the knowledge of whether the apparatus of the experiment would show a true or false result, while Observer B had the knowledge of the apparatus result (i.e. whether or not we had a decay event thus killing the 'cat' or letting it live, in our case hammer A or hammer B being let go to release a ball in the apparatus). Only after they spoke to each other could they know what actually happened in the box, i.e. only after they spoke the superposition of the events in the box would be collapsed and a certain result would present itself to the world. The researchers conducted the experiment ten times and in all these instances they observed whether anything changed inside the box when A and B spoke to each other to deduce what had happened in the box. They never observed anything. This meant that any superposition inside the box was already collapsed well before A and B conversed to understand what had happened.

So, Wigner was wrong.

3. Refutation of the refutation

However original the method Anderson and Carpenter used was, they did not manage to overcome the main problem any attempt to refute Wigner interpretation has.

That problem can be summarized as follows: How can we know anything without observing it? It does not matter if the observation is made by one or two observers or if it consists of many observations. At the end (or the beginning actually), any knowledge we have about anything stems from our knowledge for that thing.

Sounds tautological in nature. And it is.

In the case of the experiment described above, the observers A and B might not have the full knowledge of the incident, but they do have that full knowledge after they speak to each other. At that point the observation is complete and according to Wigner any superposition collapses. The authors said that they checked and found no changes happening when A and B talked to each other ('*In all repetitions, we found that neither the state of the ball nor the state of the truth-card changed upon Observer A becoming conscious of the true output of the Geiger counter. In addition, the state indicated by the ball/ truth-card combination always agreed with the state of the hammers within the box*.')

But how did they check that? With videos from inside the box? If they checked the videos after A and B conversed then the collapse had already happened (by the conscious observers A and B) and this collapse could have also affected the videos they used to check the events that took place inside the box. If they checked before A and B discussed and before B viewed the ball, then essentially the collapse of the superposition happened due to that observation (again by a conscious observer). And it would only be logical that B saw what he saw based on the collapsed system's state. If they checked before A and B discussed but after B had viewed the ball, then one can again claim that the collapse happens because of the observers of the video. So Wigner is still alive in this case as well. The video would of course need to be aligned with what A did (and knows) and with what B saw. But one could also claim the the collapse of the superposition affected what A knows and that B saw as well. Transactional theory allows for example connections in time where the future affects the past. (rf. to https://plato.stanford.edu/entries/qm-retrocausality/ for more on retrocausality in quantum mechanics) What is more, our limited knowledge of how decoherence works could make the problem seem unsolvable while it is not: for example the collapse could happen gradually, with the observation of Observer B only affecting a part of the 'reality' of the system. If the checking of the video happened at exactly the same time with when A and B conversed with each other then we are free to choose any of those observers (A and B, or the observers of the video) as the ones who caused the superposition to collapse.

3.1 Can one know what he does not know?

In all the above possible scenarios, one thing is for certain: there is no way someone knew what had happened in the box without someone knowing what had happened in the box. If this someone is one person, two persons or one person viewing a video it matters not. To

disprove Wigner's interpretation, one must show how the system under examination was at any specific state (i.e., that the situation did not contain any non-collapsed superpositions) without observing it, in any way. And that is simply impossible. So regardless of which scenario we choose, regardless of when a conscious observer came into play (e.g., when the video was being watched, when A and B exchanged information etc), one simply cannot use what we believe we know that happened in the apparatus as an argument, simply because in order for us (or anyone) to actually know he/she would need to… know, i.e. to act as a conscious observer of the system.

3.2 Unknown details that are not details

To add on what is mentioned above, it is important to state that the details on how this collapse is happening and what are the effects of the collapse are still under debate, so we cannot use any assumption here as an argument for or against any possible solution (the only thing everyone agrees on is the final result from a statistical point of view after everything has collapsed and the 'dust has settled'). I already mentioned the example of events affecting past events. This is something unacceptable in Newtonian physics, but something possible in quantum mechanics. Also, the authors took for granted that the observers of a system are stable and cannot change. So since we had Observer A and B we should stick to them to deduce any conclusions. But that is not necessarily true. The ones who observed the apparatus (with video or whatever other means, it matters not) during the experiment to make sure nothing changed when A communicated with B were also observers of the system. And from what it seems from the description of the experiment, most probably they were the ones who caused the superposition to collapse. It depends on what they did actually know. If they saw the apparatus and they know which hammer struck, then they had all the information needed and they were the ones who caused the collapse. Last but not least, the nature of the superposition and the inner workings of decoherence could include elements we haven't thought of as yet. Meaning that we cannot truly reach a safe conclusion without making sure that all our assumptions are correct. For example, the authors of the paper take for granted that the situation includes one superposition that can collapse either completely or not at all. But what if the superposition can collapse gradually and in stages? (e.g., the observation by B collapses the part related to the ball outside the box) It would be wise not to reject possible interpretations based on unproven assumptions; the best way forward would be to document all the assumptions each interpretation needs and slowly work our way forward while trying to reduce the assumptions.

Since the details on what happened after the collapse are yet to be defined, one cannot use this lack of knowledge as an argument in favor or against a specific interpretation. These details (which are no details at all) are also unknown when it comes to other interpretations as well. How the superposition collapses with the interaction of the system with another lifeless system? If that is the case, why don't we have constant collapses in all quantum systems? Since everything in the cosmos is interconnected, the suggestion of the authors of the paper that an interaction with inorganic material causes decoherence would imply that we should have no superpositions anywhere.

4. Assumptions

We should pause and take a breath here. And avoid rushing into conclusions based on what we want to believe.

Given that any interpretation currently needs assumptions, we should stay with what we know for fact: no one can know something before knowing it. So, refuting the Wigner-Neumann interpretation is destined to always hit a wall since at no point can say researcher claim anything for the state of the system without knowing the state of the system.

Is it weird and surely irritating, but Bohr wouldn't be discouraged to use this argument anyway. I can only imagine asking 'So what?' to anyone trying to argue that such an argument is essentially not scientific since it cannot be overcome in any (humanly possible) way. Whether we like it or not, it is what it is.

5. The extra experiment

In the Anderson-Carpenter paper another extra experiment was conducted: Observer B tossed a coin to decide how he would interpret the results of the experiment. This twist to the whole set up was added to make sure that a superposition did not exist. Observer A still had the knowledge of whether the ball 'decay' would be put in hammer A or B, but now Observer B would toss a coin to decide how he interpreted the results he would see in the apparatus. So, in a hypothetical scenario where A put the ball 'decay' in the true hole and there was indeed a decay, then the ball would be in the true hole. But then B comes and tosses the coin. This results in head or tails and based on this B would decide what the result of the experiment is.

So, if B tossed tails, that would mean (according to arbitrarily selected definitions that B made before tossing the coin) that the ball is absent. But the actual ball would be there. Here it's a bit tricky. Observer B would not be able to deduce a definite outcome without talking to Observer A. But B, according to the paper never reveals the result of his coin toss to A, thus leaving 'alive' any superposition related to B. If such a superposition existed then the result of the experiment could not be known since that would be known only after A and B conversed. But the authors claim that the result of the experiment can be known if we know what A did and if a decay happened or not in the box. They even put the readers of the paper in the analysis, by claiming that if the readers also know all the facts of what happened then they would know, even though any superposition related to B still lingers in the air.

5.1 The same problem again: How can we know?

Again, we are touching at the very heart of the problem with the Wigner interpretation (a problem that is also its greatest strength): If one does not know what happened, then there is no observation and there is no way to tell what happened. If we can tell what happened, then the collapse happens because of us who know what happened. In the case of the paper

if even the readers of the paper know what happened (while B is still in the limbo of a superposition that has not yet collapsed) then the readers are the conscious observers who made the superposition collapse.

In essence, when someone claims that an interaction with a non-conscious something can cause the collapse of a superposition, he needs to observe that something to make sure the collapse has happened. So, he puts himself in the process and there is no way of telling what the situation was before he intervened.

5.2 'Most likely…'

The details of how decoherence works are still under analysis so any conclusions regarding that process need to be based on assumptions. How the superposition is established, what it consists of (all events, only some of them?), how it can collapse (gradually or all together), how decoherence can then affect other events, what is the effect of the collapse of the superposition (does it affect what others have observed already?), where the system transcends from microscopic to macroscopic etc, are all important topics (some of them a bit philosophical, but with great implications on our discussion) that we cannot take for granted and when we are forced to do (to write a paper) we need to state these assumptions explicitly and not take them as a given truth. (One can spot such assumptions hidden behind key words like 'very likely', 'maybe' etc used at the conclusion sections of papers, like in the results of the Anderson and Carpenter: *Our results are consistent with the idea that a measurement from the Geiger counter is sufficient to collapse the quantum state, most likely because the counter involves amplification processes that are irreversible*)

6. All interpretations have problems

To put it simply, there is nothing so extreme that cannot be explained with the Wigner-Neumann interpretation if we add one or two assumptions needed to the main logical argument of the interpretation. (The same of course goes for all other interpretations as well) At least nothing more extreme than the things other interpretations need to answer from their side.

Surely the Wigner-Neumann interpretation has many important questions to answer. But so do the other interpretations. With the first and most important question being essentially the result of the experiment mentioned by Anderson and Carpenter: if the authors are correct and the interaction of the quantum system analyzed with the things inside the box (some of which we call them 'measuring devices' for some reason only known to us, but not to the particles involved in the experiment; the definition of what is a measuring device being another problem the non-Wigner interpretations need to answer) made the superposition to collapse, then the same would happen to all quantum systems everywhere and we wouldn't have any superposition whatsoever. The double slit excitement also poses questions that both interpretations need to answer (if the election superposition collapses through the interaction between lifeless particles, then we should always have a collapse, on the other hand if a

conscious observer makes the difference, then why do we have different results and the electron can behave as a particle or as a wave while in both cases at the end a human does observe the experiment?)

But we do have superpositions.

Why do they happen still remains a mystery.

And yet, so many are eager to exclude one possible answer from the table: Our own self.

What is the reason for that?

7. Reasons for hostility

The Wigner-Neumann interpretation is touching at a sensitive subject from a philosophical point of view. A subject that is almost a taboo in today's society: The importance of humans in the world. You may see it mentioned as the anthropic principle in more scientific terms, but the gist is just the same. Modern humans like to see nature and its objective reality as the sovereign force in the cosmos (rf. to the paper Kakos, Spyridon (2020). Religion as the single foundation of Science. MCDSARE 4, for more on the belief of modern science in an objective reality and how that is related with religion), while themselves are just dust in the wind. A tiny unimportant speck in a huge cosmos as a renowned astronomer says. How could we play any role in the definition of reality? Thinking something like that is purely heretical for modern materialistic science.

Consider the paper we just examined. Now try to imagine a similar paper trying to refute any other interpretation. Would it be accepted for publication based on arguments of the type 'This happens most likely because…'? Would three pages suffice to put a candidate interpretation out of the game? Especially when there are so many unanswered questions regarding essential parts, like what is consciousness, how decoherence works, what exactly is the superposition etc? No, one cannot imagine of something like that.

7.1 Modernity and contemporary philosophical dogmatism

This is not a conspiracy. It is just the result of modernity and the mainstream way of thinking in science today. Since the French revolution all scientists in the West have been eager to exclude God from any discussion. And after killing God (something that we did quite successfully in our eagerness to take His place) then came the turn of our own self. Modern humans cannot philosophically accept anything that puts them in an important role. Humans must be unimportant. (This is related to the Copernican principle, read the related paper Kakos, Spyridon (2018). From Galileo to Hubble: Copernican principle as a philosophical dogma defining modern astronomy. International Journal of Theology, Philosophy and Science 2 (3):13-37) Because the lifeless cosmos is important.

Modern times are based on a more materialistic philosophy that cannot accept the role of anything else than pure matter in anything scientific. What we need to keep in mind though is that materialism is a dogma and not a scientifically proven proposition. Refuting other ideas based on other unproven ideas is not good philosophy and certainly it is not good science.

But we live in the era we live in.

That is why you will see three-page papers refuting the Wigner interpretation but at the same time you would see pages upon pages discussing the possibility of the multiple universes interpretation, an interpretation that is equally if not 'weirder'. (and I being very mild here) Don't get me wrong. A sound experiment and a sound reasoning would potentially need even only one page. But there are so many things still shrouded in mystery regarding quantum mechanics that spending three pages to refute a possible interpretation without even mentioning the open point that are still under debate, is a bit extreme on its own right. What is more important is that there is a trend here. Any refutation of the Wigner-Neumann interpretation consists usually of either small papers or, in most of the cases, very small sentences inside books simply starting that 'this theory cannot be true'. For most scientists the wrongfulness of the Wigner theory is so obvious that the do not even care explaining why.

At the same time though, as already mentioned above, the same people who so easily deny the possibility of Wigner being right, are very flexible in entertaining many other ideas as long as they do not contain any 'forbidden' anthropocentric ideas.

8. Does it matter?

As a fellow philosopher told me when we discussed the matter, since the final result of the experiment does not change based on the interpretation we follow, then all this discussion might be moot. But if that is the case, then the hostility against the Wigner-Neumann interpretation makes even less sense. And the dogmas underlying this opposition become even more apparent.

Bohr was objective enough (I am not saying correct, since I do not personally agree with his stance of ignoring the philosophical implications of quantum mechanics; the philosophical questions are for me far more important than the cold calculations any computer can perform) to not speak about things he could not speak of. He and other proponents of quantum theory focused on the results and their statistical verification and avoided any discussion regarding the how and why of the phenomena called superposition and decoherence.

Perhaps for science that is the best way forward. To leave behind any discussion for the explanation of what happens and to concentrate on the equations as Diraq used to say. The philosophical questions that the Wigner interpretation has to answer seem unsolvable for the time being. With the main one being the most obvious one: is consciousness a manifestation of the behaviour of lifeless particles anyway? Current understanding gives us no clue on what consciousness actually is (rf. to the paper Kakos, Spyridon (2018). Consciousness and the End

of Materialism: Seeking identity and harmony in a dark era. International Journal of Theology, Philosophy and Science 2 (2):17-33). Needless to say though that our lack of knowledge on what consciousness is, is a problem for the other theories as well; If you do not know what consciousness is how can you be certain that it doesn't play any role? Unanswered questions exist everywhere and affect any other possible solution to the mystery at hand.

But we cannot stop searching.

Science cannot stop searching for the underlying reality behind the phenomenal we observe. If it did, it would just be void of any substance, just a dry set of equations based on our observations. If science wants to truly be the major tool of humanity for progress, then it should reunite with philosophy and start being serious about anything philosophical that is related to the theories it creates.

We need to keep on asking questions.

What is the answer we cannot know now.

But we hope one day we will do know.

And that is reason enough to go on…

Anderson and Carpenter posed some interesting questions in a clearly original way, giving the debate a new stir that was much needed. For this we need to thank them. The paper you are reading addresses no argument they posed in a definite manner. Instead, it provides possible explanations of the experiment and an alternative possible way of thinking.

Perhaps at the end Bohr was right and we should not speak for things we cannot speak of. Silence sometimes contains wisdom.

I see you. You see me

Let's open the box.

And take a look at the cat.

It matters not if it is alive or dead.

I will always love her.

And guess what.

We all die at the end.

(The cat never cared for you or me…)

REFERENCES

Any references needed are included in the main text of the paper. The main arguments of the paper are described in the text and there is no need for external references to add substance to the arguments documented. But I was indeed thinking of adding references at the end. Perhaps in another universe this possibility materialized and references do exist there.