Selected Problems in Realist Interpretations of Quantum Mechanics and a Novel Suggestion

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Abstract

In this short paper I suggest a few properties a good realist interpretation of quantum mechanics ought to have. Then I canvass several interpretations, most of which do not have these properties, and further suggest problems specific to each one. Then I give a reference to a novel interpretation that solves all of these problems.

Selected Problems

Why will we be concerned exclusively with realist interpretations? That a realist interpretation is needed is perhaps 'not obvious but nevertheless self-evident'. When I first heard this locution I didn't like it: I thought is was a fudge-term that philosophers could use to get out of anything. But I think it applies to this situation. When one becomes mired in trying to understand quantum mechanics it becomes not-obvious that the theory must describe a well-defined reality. But upon reflection we are reminded that s*omething exists*—and that this is indeed self-evident.

First I will call attention to certain specific problems most realist interpretations face. By no means is any claim of comprehensiveness being made.

1. It not clear why intermediate (quantum) states should depend on what appear to be counter-factuals. For example, suppose Schrodinger's Cat is alive when put in the box at the beginning of the relevant experiment. The Cat enters the state [psi> = [alive> + [dead>. But now suppose that when the experimenter opens the box at the end of the experiment the Cat is still alive. Then the Cat has been alive the whole time and it's not at all clear why the intermediate (quantum) states should depend on the cat being in a dead state.

2. Amid all the controversy there is one thing we can say about Schrodinger's Cat: it's lazy. So we want an interpretation that is *unequivocally* parsimonious.

3. A realist interpretation should give some account of when/why an observation/measurement/collapse happens.

4. A problem that most of the interpretations canvassed below share is that they do not say what a superposition *is*. Of course, a superposition is given by a vector in a Hilbert space by a certain kind of sum of vectors with complex coefficients. But, generically, interpretations do not specify (nor justify) what a superposition is *ontologically*, or indeed why there should be such things as Hilbert spaces with states modeled by state-vectors and observations modeled by operators in the first place, as opposed to some other mathematical formalism.

5. A problem with most interpretations is that they are very brittle. Suppose we realized tomorrow that the laws of physics are radically different than what we think they are today. Then, in almost all realist interpretations, the interpretation—in spite of whatever virtues it has—would most likely need to be discarded and a new one sought. The old interpretation might not even be definable in the new

formalism. This is an unsatisfactory situation since we want reality to lead to the description of the observable phenomena and not the other way around.

6. All interpretations to date arguably have a very *ad hoc* flavor. Additionally, no interpretation stands out as the most plausible. None of them is decisively better than the others, and indeed none of them are well-motivated to begin with. One may arbitrarily pick an interpretation, but only one that appears 'least un-likely'. But this is a totally unsatisfactory state of affairs.

7. If quantum mechanics describes a realist world, then the automatic default position is to assume that quantum mechanics describes an objective realist world, or perhaps a realist objective world. But there are problems with such an assumption. There is a progression of gedankenexperiments that show that an objective interpretation (one in which (at least) a collapse happens if and only if it happens for all systems in the universe) would be difficult at best. These include 1. Schrodinger's Cat, 2. Wigner's Friend, and 3. the Frauchiger-Renner scenario (theorem), and results after it.

So we are stuck with wanting a *realist* account of the Cat that does not seem to lend itself to an *objective* account. One is led to the question of whether there are interpretations that are some combination of objective *and subjective* (or perhaps entirely subjective) that are nevertheless realist. Note that we would be after an interpretation that has *subjective* components that are nevertheless *real*. The subjective components must be an essential and irreducible part of a complete description of reality.

8. Obviously we want an interpretation that takes into account *all* of the empirical data available to us. The extent of this data should include physical things *and* give some account of the phenomenal.

9. Instead of incorporating the lessons of quantum mechanics and going from there, most interpretations try to mitigate the lessons and return us to a classical worldview as much as possible. It could be argued this is going backwards in theory development and is a mistake.

Selected Interpretations

I'll canvass several realist interpretations, adding and subtracting problems as appropriate. No claim of comprehensiveness is being made.

1. Retrocausality. Retrocausality does not solve any of the above problems. In addition, it has problems of its own (again, no claim is being made for comprehensiveness). In retrocausality a present experimental outcome of a quantum measurement is at least partly a function of the outcome of a *future* experiment. But that future outcome in turn is dependent on outcomes in *its* future, and so on—giving an infinite regress. The upshot is that this interpretation supposes an infinite amount of information from the future to explain the outcome of a single experiment in the present.

2. Superdeterminism. In superdeterminism it is supposed that all correlations in the universe were created at the big bang. The size of the universe at (or just after) the big bang was not larger than the Plank length to an absurd degree (before inflation). Thus if our universe were superdeterministic we would find stronger-than-quantum correlations all over the place (both metaphorically and literally). But we do not. Thus superdeterminism has already been falsified.

3. GRW. As far as I know, there is no relativistic formulation. But it doesn't solve the above general problems in any case except for problem (3).

4. Modal. There are at least two modes and a privileged observable. Two modes for the sake of having a classical mode indicates that retaining the classical model is not the right thing to do (general problem (9)). Further, a privileged observable in this context is untenable as it adds too much arbitrariness.

5. Bohmian. This postulates a litany of metaphysical baggage; commits one to a picture that is not necessarily implied by the standard formalism; it is exceptionally non-local; it assumes a position basis (or at least a privileged observable); it adds yet more unobservable quantities to the theory; it has wildly excessive elements (waves that do nothing *after* an interaction); it breaks Newton's third law. These are too high a price to pay for an attempt at a return to a partially-classical worldview.

6. Many-Worlds. 1. This interpretation is important to think about as it represents an extremal point among possible realist interpretations. But it carries so much ontological baggage that as a proposal for how the world actually is it is *silly*. 2. It doesn't have even the hint of a mechanism for how new universes (worlds) are created at each measurement. 3. It should be emphasized that it doesn't say what a superposition *is*. It only attempts to say what happens at a measurement. 4. It gives only rational real numbers of probabilities at measurements. It has a very difficult time accounting for unequal and irrational probabilities. (Sebens et al. 2014). 5. Another objection might be called methodological. It basically just adds epi-cycles. It starts by trying to hold onto what is basically a classical universe (as opposed to a universe that is quantum in the first place). Then it adds more and more classical universes to refine the picture until it accounts for (some) of the quantum probabilities. This is ridiculous.

There are three interpretations that fair better under the pressure of the general problems.

7. One realist interpretation that solves problems (2) and (7) is the ever-more-popular Relational interpretation. In fact, it is arguably a minimal such solution and as such is refreshingly parsimonious. In fact it takes into account a philosophical principle: that *x* appreciates (so to speak) *y* (in a realist sense) in virtue of the parameters with which the two systems interact. It is important that this is a plausible philosophical principle *independently* of the *ad hoc* scaffolds used in attempts at interpreting quantum mechanics. It also suggests a solution to (3): a collapse occurs when and only when two systems come to interact with each other.

1. In spite of some of the literature, it is not clear (to me at least) that this gives a satisfactory account of non-locality. The interaction of two systems can show that non-local interactions (in some sense) *had occurred* before interaction. 2. Another drawback is that, at present, it is not a complete or filled-out interpretation, but more of an (attractive) framework. But this invites further development.

8. Chalmers' M-property interpretation. This interpretation says that a mental property (M) causes the collapse of the state function. Some will regard this as a negative: it requires the phenomenal to be included in the ontology. But I would count this as a great virtue: we want an interpretation that makes use of subjective realism (problem (7)), and it is perhaps not obvious but nevertheless self-evident (to use the phrase again) that we do indeed *have* the phenomenal, so it addresses general problem (8) too.

One apparent drawback is that it assumes a causal role for 'the mental'. For example, it could be that collapse happens when and only when a certain amount of complexity (or perhaps something else) is

reached in a system, and that this level of complexity is the minimum that is correlated with subjective (realist) experience.[1] But this would make the mental causally superfluous again.

But we want, in the case of an M-property interpretation, a (realist) notion of the mind or qualia or the phenomenal, one that causes physical collapse over-and-above their physical correlates. Some researchers would consider this unlikely. But it has certainly not been ruled out. Here are two arguments that the mental is in fact causal.

A. The freedom of choice of the orientation of apparatuses in Bell experiments. This freedom is required (in some sense) for the violations of the Bell inequalities. 2. It's often pointed out that without this freedom science would be impossible since everything would be pre-determined and no independence of variables could be used to infer physical laws. 3. *It's curious how most philosophers of mind assume the causal closure of the physical, while most physicists assume that an experimenter's choice of apparatus orientations is not a function of events in the experimenter's past lightcones (nor past Bell correlations, presumably).*

B. If the mental were not efficacious in anyway that is over-and-above the efficatiousness of its physical correlates, then it is not clear why a human would have mental experiences that are better (more coherent, etc.) than those mental experiences that are correlated to a physical system of similar complexity *chosen at random*, since in this latter case the physical (human) system would solve all of the evolutionary problems for promulgation anyway. In this way the fact that our mental worlds are *not random* is evidence of the causal efficaciousness of the purely mental.

C. It might (might) be a good definition of 'over-and-above the physical' to suppose that the mental can be changed (to some extent) without changing the physical, and vice versa. It might (might) further be that the only such subjective (mental) states are those that we experience as free will. I've written more on this elsewhere.

9. Causal Sets. This is at least an attempt at taking phenomenal time seriously. In this way it is pointed toward the realism of (arguably) subjective elements, addressing general problems (7), (8), and (9).

But it does have its own problems. These include 1. it is not complete—it is only the beginning of a proposal, 2. it rests on 'causality'. But causality adds a whole new level of arbitrariness, complication, and mystery on top of the quantum formalism. In quantum mechanics it's not even clear what causality *is* nor (I would contend) if there *is* such a thing. 3. It suffers from what I would contend is a naive conception of time (see below)—though one that is probably better than that of many other interpretations.

Where does that leave us in getting to a good interpretation of quantum mechanics? There are a few temporal clues that we have to guide us to one. I would like to highlight some of these.

Clue 1: collapse does not preserve the (physical) conservation of energy (Carroll et al. 2021). In virtue of Noether's Theorem this implies there is something wonky going on with time at collapse (though the authors themselves did not draw out this conclusion).

1 By using 'correlated' I am, of course, assuming Dualism: there is a physical system that is correlated to every mental system and *vice versa*. This is not the only philosophical theory (or even the only plausible philosophical theory), but it is sufficient for discussing this interpretation.

Clue 2: a scientist can *demonstrate* an experimental outcome to me *only* in our mutual present. We can talk about and theorize about outcomes all we want, but a literal *demonstration* occurs only in our mutual present. If you believe the block-world interpretation of time you would be tempted to tell me that you can give me (or have given me) a demonstration 10 minutes in our future, for example. But then you are *talking*—not *demonstrating*. (Actually, you would be demonstrating—but only that you can talk, not an outcome of the (quantum) experiment in question.) If you claim there are many presents in which one could give demonstrations of experimental outcomes you are, again, making a verbal claim and not demonstrating. I would go so far as to argue that every scientist should be a presentist.

Clue 3: manifest time—a source of *empirical data* for us—is not time-reversible.

Clue 4: One dimension of time cannot be modeled by just one temporal series. Two temporal series are required to model one dimension of time (see McTaggart 1908). For example, first, we may note that the big bang was 13.8 billion years ago. Then a later time of 5 billion years ago was reached. Then an even later time of the present epoch was reached. So time goes from 'past to future' or, more accurately, from 'earlier times to later times'. Meanwhile, however, dinner tonight is first in my future, then in my present, and then in my past. So time *also* goes from 'future to past'. (The problem of anthropocentrism is solved by panpsychism. I've written about this elsewhere.) The former is the B-series and the latter is the A-series. This, along with Clue 3, shows that *two* series are required to model *one* dimension of time.

Clue 5: Bell inequality violations happen, and they happen *instantaneously* in some sense, in spite of relativity. Therefore for single-outcome realist interpretations there must be *some* kind of coordination between time and non-locality.

10. I will merely mention that a novel but as yet unpublished interpretation that meets all of the general objections, incorporates elements from the three better-fairing interpretations, and incorporates all of the temporal clues, has already been put forward, in (Merriam 2021a, 2021b, 2021c, 2021d).

Conclusion

Many realist interpretations of quantum mechanics are beset with serious problems. Some of these problems are shared by many interpretations, and some are specific to the interpretation. There are a few interpretations that fair relatively well: Relationalism, M-collapse, and Causal Sets. Happily, there are also clues from time about where to look for a better interpretation. An as-yet-unpublished interpretation avoids the problems, involves elements from the three interpretations mentioned above, and follows the clues. The novel interpretation is not given in this paper but can be found in the references.

References

If there is anything written on my tombstone it will be that 'he couldn't track down references no matter how hard he tried'. I can only protest this paper was not meant to be a comprehensive academic-quality survey but rather just some notes. Anyway, I can only assume all necessary references can be

found in SEP, Google Scholar, arXiv, PhilSci arxiv, PhilPapers arxiv, and journal articles refereed to in these.

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