A Realist Interpretation of Quantum Mechanics that rules out Determinism

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Abstract

We indicate how pursuit of a realist interpretation of Quantum Mechanics, starting from a simple and plausible physical principle and established Quantum Mechanics, leads to a physical picture almost as counter-intuitive but which among other things would if true confirm that the quest for a deterministic model of Quantum Mechanics is doomed to failure.

Contents

1 Introduction

Theoretical physicists can be broadly classified into instrumentalists, the majority who expect and demand no more of physics than algorithms and recipes that make correct predictions, and realists, with aspirations to find ontological explanations based on "what is really there". Using an industrial metaphor, one might compare the first with black box testing, where the inner workings of the box are unknown and perhaps, in the circumstances, unknowable.

Instrumentalism is undoubtedly the only practical approach in the early stages of discovery, and was essential for example to get Quantum Mechanics off the ground. But, like a religious dietary observance, what starts commendably, as making a virtue out of necessity, can become in the light of further progress no more than an arbitrary token merely to identify the faithful.

Indeed, the effort required to accept quantum postulates without further explanation has something of a religious character, an act of faith, and this no doubt accounts for much of the antipathy and scorn, and even incomprehension, which instrumentalists typically have for realists.

However, realists face an obvious problem: By definition, in so far as they are not wearing their instrumentalist hats, they are seeking models based on physical facts and principles beyond current, or perhaps even conceivable, observation. So, lacking God-like insight, their only recourse is to start with informed guesswork.

Typically, their approach is to devise and study idealized "toy" models, such as unconventional logic systems or cellular automata, and attempt to find aspects of these that mirror established physical principles, in other words to make contact with the latter.

I have ventured in the opposite direction, by starting with the established principles, and a plausible conjectural principle, and attempting to "read between the lines" and identify by circumstantial evidence, or fuzzy inference, an underlying physical process or model that would account for all these.

The present paper is an initial "stake in the ground", intended to sketch the model and how it has been inferred. Further studies will be needed to elucidate how it works.

Although the author would concede that in its present descriptive conceptual form it could be technically (if rudely) classed as "not even physics", it is closely argued and forms what seems a broadly coherent whole.

Also, although clearly speculative in parts, several aspects draw on recent studies by others, including Stephen Hawking (future backreactions [6], [7]), Gerard 't Hooft (virtual black holes [3]) and S Kalyana Rama et al (black hole fuzzballs [4]).

So, however preposterous the resulting picture may appear at first sight to readers not well versed in the latest speculative physics, it is in many respects no great departure from ideas already being studied by others, and is thus to some extent merely "joining the dots".

2 Summary

For the reader's convenience, the following few subsections briefly summarise the salient points of our model, after which key aspects are expanded in the remaining couple of sections.

2.1 Superposition as View of Distant Future

Our basic new physical principle, and logical starting point, is that quantum superposition is a characteristic of a system which could potentially persist in its present state into the distant future, and is a kind of window offering a transformed and speeded up view of that future.

This state is memoryless, in that decoherence can be introduced and removed at will, for example by varying the temperature of liquid helium.

Semi-stable systems such as neutrons and high-energy particles, which in normal conditions rapidly decay, seem to be exceptions, and the Quantum Zeno Effect is even more troubling; but arguably these involve composite systems in which intrinsic instabilities disguise the effect, analogous to flaws in a crystal obscuring the view through it.

Further support for our assumption can be tentatively inferred as follows: As is well known, distant objects are seen in their past, as opposed to a fictitious present they would be viewed if the speed of light were infinite. So if a large amount of space is associated thus with the past, is it so surprising if a sufficiently microscopic view, involving a small amount of space, is into the future? In the same vein, travel into black hole, where space is also restricted, is also a voyage into future from the standpoint of an external observer.

2.2 Quantum Probabilities from Death and Rebirth Process

We also argue, backed up by other recent studies and by general tenets of Quantum Mechanics, that quantum probabilities are characteristic of a dynamic "death and rebirth" physical process which underlies and gives rise to the wave function in any given system.

2.3 Black Hole Evolution in the Distant Future

Based on our starting principle, we assume that this "dissipation and regeneration" process reflects one that occurs in the distant future, and therefore involves essentially only black holes and their decay products, as these will be all that by then exists.

The bizarre but inescapable implication is that superposition and hence, because this is ubiquitous at suitable scales, present reality in its entirety, is a transformed and immensely speeded up image or projection of black hole evaporation and reformation in the distant future.

The next couple of sections explain how this would be to a great extent unavoidably random, and how it could work and continue stably for innumerable black hole generations.

Note that virtual black hole evolution at Planckian scales is by now a fairly commonplace idea in physics, following the pioneering work of 't Hooft [3] among others. It is then but a small step to imagine, as we do, that these holes are an extremely foreshortened speeded up view of macroscopic black hole evolution in the distant future, viewed down the wrong end of a time telescope so to speak.

2.4 Black Hole Evolution is not Deterministic

Although black hole evolution in the manner just sketched sounds deterministic, like a somewhat messy cellular automaton, unfortunately the opposite is true: Randomness is introduced by N-body interactions, due to gravity and electromagnetism, and even more so by random walks of black holes over their lifetimes due to Hawking radiation recoil (which extends over a volume of the order of its initial event horizon radius squared [5]).

2.5 Black Hole Death and Rebirth Process

Once mass/energy falls into a black hole, it will go nowhere outside for a very long time. So our original physical principle, of potentially long endurance being associated with superposition, indicates that black hole interiors must be among the most quantum environments of all, and thus comprise not a singularity but a fuzzball in a state of superposition which fills the volume inside the event horizon. As several recent studies have explored this [4], the idea even if still speculative is not beyond the pale.

On that assumption, we propose that by the Uncertainty Principle fuzzballs "leak" marginally superluminal lobes of space outside the event horizon. These accelerate, reducing their negative energy toward zero. Interacting lobes emitted by two black holes mostly condense to form "dark matter" (of positive mass/energy), and the remnant further accelerates and diffuses to form throughout space an apparently uniform negative energy field which manifests itself as dark energy.

In short, we conjecture that dark matter is formed by pairs of black holes and is the seed material of new black holes that would form from it over aeons and at sufficiently low temperatures (probably much lower than the cosmic background temperature today).

One can envisage that the further apart the black holes are, up to a point, the more efficient and complete the condensation of tachyonic space lobes into dark matter and therefore the less the excess left over for dark energy. Combined with gravity, this could provide a neat self-regulating mechanism for the required fantastic degree of stability of average black hole density and its uniformity over innumerable black hole generations.

2.6 The End and the Next Start

At very late times, perhaps due to slight cosmic expansion and dropping temperature, average black hole size declines and the recreation rate speeds up until no pairs are close enough to form a new generation, whereupon runaway expansion occurs.

The conventional view of Big Bang inflation is that it diluted existing inhomogeneities. But our model indicates that the opposite is true: they were not diluted but, in their absence, searched out so to speak by rescaling, and inflation was halted by their first appearance in the dual future "view".

This does make the initial low entropy problem worse; but the fact that entropy was initially lower than now is a problem anyway. So it seems natural to assume that it was not just low but extremely low. As the saying goes, one may as well be hanged for a sheep as a lamb!

2.7 Shades of the Epkyrotic Model

One can also think of present and its backreacting future (as sketched above) as two fuzzy "branes" that start out close during inflation. Then one recedes into the future, and projects its transformed black hole evolution images back onto the other. These projected images, as we have argued, are the inhomogeneities that curb inflation. This is reminiscent of the epkyrotic "clashing brane" scenario, but with inflation.

At very late times the present brane catches up with the future brane, and the cycle repeats at a new scale. Perhaps it is a time-like analog of how we propose pairs of black holes evolve new generations, taking into account their fuzzball interiors.

2.8 Aside - Operational Explanation of Holography

The stable death and rebirth process we have sketched would give an operational explanation of holography: If a closed boundary and the space and fields it encloses correspond via some suitable transformation to a vast cloud of black holes and their evaporation products, constantly reforming in alternation, then every aspect or degree of fredom of a region is faithfully played out on its surface as the two are simply different manifestations of the same thing.

2.9 Aside - Quark Asymptotic Freedom and Confinement

Were it not for the fact that gluons are massless, one might almost believe that asymptotic freedom and confinement of virtual quarks operates in much the same way as the reproducing black holes as sketched above. As non-perturbative QCD remains still almost a complete mystery (ref), this possibility would be worth bearing in mind.

3 Quantum Superposition and Decoherence

As is well known, quantum decoherence of a system in quantum superposition is caused by interaction of the system with its environment. So superposition is maintained while the system is effectively isolated from external interactions.

Because an isolated system stable for a reasonable time (by everyday standards) is likely to persist so for a long time while it remains isolated, it seems a small step to think of superposition as a property of a system which could, in that state, endure for a long time. Indeed, this is almost a tautology.

In a rather larger step, albeit supported by other considerations, including studies by various prominent physicists, one is then led to wonder if superposition may be a manifestation of physical processes occurring in the distant future, and that the conditions where it becomes apparent are in some sense opening a window to this future.

If so, this must be a "memoryless" process, which constantly reiterates itself and becomes manifest or is suppressed depending on the changing state of the systems. For example, a quantum state can be induced or destroyed at will in supercooled helium by simply lowering and raising the temperature. So in a way, on this assumption, lowering the temperature is "tricking" the system into behaving as if it will endure for a long time, as befits a very low temperature.

Of course, backward propagation of the effects of future events is potentially problematic and suspect; but if these occur sufficiently fast and jumbled up then causality need not be threatened.

4 Quantum Probabilities

In [1], one finds the following quoted results:

'The Gauss-Lucas theorem assert that the convex hull of the zeros of any nonconstant complex polynomial contains the zeros of its derivative.'

'Further, by a result of Schur and Cohn, all zeros of a self-inversive polynomial P(x) lie on T [the unit circle] if and only if all zeros of P'(x) lie inside or on T'

(The paper defines a "self-inversive polynomial as a scalar multiple, of modulus 1, of a reciprocal polynomial.)

That suggests intuitively that at a quantum system is a constantly evolving process, in which the possible measurement outcomes are physical "nodes" in some sense that interact to produce new "derivative" nodes while at the same time (if one might use that word) dissipating and vanishing.

Note that this is broadly consistent with the Schrodinger equation, or suggestive of it if one squints, because does that equation not basically equate one quantity with its derivative?

The Schrodinger equation applies only in configuration space, and this suggests that the proposed death-and-rebirth process, although physical, also operates in some comparable abstract space. This would also be necessary to allow non-local effects such as entanglement.

Note that recent studies in biology, such as [2], have also claimed to find quantum probabilities in population dynamics.

The death-and-rebirth process must operate extremely fast by normal standards, so that the possible states which the nodes represent are for all practical purposes in superposition between measurements, in accordance with QM.

Also, and this is a key point, the "blurring" bloats the probability zone relative to a classical "static" configuration.

5 Conclusion

In this note we have attempted to sketch a coherent picture of an "operational" model of Quantum Mechanics which, if true, might account for many of its well-known counterintuitive aspects, or at least replace these by mere vast profusion of entities behaving in a rather more familiar classical manner which may be more manageable both psychologically and formally.

6 References

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