The ineffable *now* in physics

Abstract While physicists know how to use quantum mechanics, there is no consensus on what quantum mechanics is a mechanics *of*. The aim of this paper is to introduce the beginning of what might turn out to be an interpretation of quantum mechanics—one that leaves all calculated probabilities intact. The basic idea is that quantum mechanics describes the objective world, but there must be added to it ineffable variables, one of which is the temporal 'now'. Ineffable variables are not 'hidden variables'.

1. Basic Idea There is no consensus on what quantum mechanics means. Evidently, to get a meaning, either something must be added to it or something must be subtracted from it (or both). We take the former option. To standard quantum mechanics we will add ineffable parameters. An 'effable' parameter is one for which different systems agree exists and agree is capable of taking on a system-independent value. Examples include position, momentum, energy level, and spin. An 'ineffable' parameter is one which a system may use in describing its own state, but which is not part of the description of the state as given by another system.

There are extremely good reasons to think (section 2) that a complete description of a system must include ineffable variables. In this paper we will be mostly concerned with one particular ineffable variable, that aspect of time that is described by the '*now*'. A simple case works like this. Alice describes her own (quantum) state with parameters x_A, t_A, and now_A. The effable parameters are x_A, and t_A. The ineffable parameter is now_A. Thus, Bob will describe Alice's state using only the parameters x_A, and t_A. For Bob, there is no such variable as now_A. Conversely, Bob will describe his own state with parameters x_B, t_B, and now_B. Alice will describe Bob's state only with the varibales x_B, and t_B, there being no such variable, according to her, as now_B. That is the basic idea.

2. Panpsychism I am conscious, I have subjective experience, and this is certain to a degree even greater than the certainty that there are physical laws. There is in some sense nothing special about my composition—I'm made of electrons and quarks etc. Thus there is good reason to think that the basic elements that make up my brain are accompanied by the basic elements of subjective experience—qualia. One is lead to the conclusion that an electron is accompanied by a quale—a subjective experience—for example, the color green. Perhaps a positron is accompanied by a blue quale. There is an enormous amount that has been written about this idea but the basic idea is clear enough and is called (Dualist) Panpsychism. [1]

Now, I cannot communicate to you what my subjective experiences are. I can demonstrate to you 1 meter of distance, but not my experience of green. So these qualia are said to be 'ineffable'. The physical aspect of a system may be described by effable parameters x_1, x_2, … But the complete description of a system must also include ineffable parameters y_1, y_2, … A complete description is given by both kinds of variables, $x_1, x_2, \ldots, y_1, y_2, \ldots$

3. Time Famously, McTaggart [2] identified two different notions of time. There is the A-series, in which an event is future, then present (i.e. *now*), then past. And there is the B-series, in which events are either before or after each other. The values of the A-series change whereas the values (order) of the B-series are permanent.

A complete description of a system must incorporate both series. How is this to be done? The B-series is what physicists normally use: all systems agree that a time of 1 sec. on a watch comes before a time of 2 sec. on the watch, etc. General relativity preserves the order of events on a time-like worldline. The idea will be to incorporate the A-series as a different ineffable variable *now* for each system.

4. Simultaneity It's worth looking at this in the context of the relativity of simultaneity. Suppose Alice remains at the Milky Way galaxy, and that Bob rockets off to the Andromeda galaxy, turns around when he gets there, and comes back to the Milky Way. Also suppose that Charlie is at a galaxy off the Milky Way-Andromeda route. For some configurations, a state of Charlie will be in the past (future) of Bob and when Bob turns around Charlie's state will then be in the future (past) of Bob. It is said that the plane of simultaneity of Bob has changed. So far so good.

However, "But (bringing the subject into the story) my Now advances along my trajectory at one second of my personal experience for each second that passes on my watch, which follows the same trajectory as I do. And your Now advances along your trajectory at one second of your personal experience for each second that passes on your watch, which follows the same trajectory as you do." [3], p. 33. But we don't need to go the the extremes of QBism to use this. Alice's *now* advances along her worldline at a rate of one second of personal experience for each second that passes on her watch. Also, Bob's *now* advances along his worldline at a rate of one second of personal experience for each second that passes on his watch. In addition, Charlie's *now* advances along his worldline at a rate of one second of personal experience for each second that passes on his watch.

The *now* is empirically known to be a feature of all systems and can't be ignored just because it's inconvenient. Happily, the situation can be resolved. Alice, Bob, and Charlie may all agree on the order of their watch's ticks along each person's worldline—this is the B-series information. This information is effable. Yet Alice, Bob, and Charlie may experience their *own* senses of *now*—this is the A-series information. This information is ineffable. For example, Bob's description of Charlie includes the order of ticks on Charlie's watch, but does *not* include Charlie's *now*. Otherwise, Charlie's *now* would be all over the place (temporally speaking), in contradiction to the empirical facts.

5. Double slit This furnishes us with an interpretation of the double slit experiment. Suppose that, in laboratory time, an electron is fired from a gun at $t = 0$ seconds and lands on the screen at laboratory time $t = 10$, at which time the experimenter in the laboratory checks the screen to see where the electron has landed. It's quite obvious that from $t = 0$ through $t = 10$ the experimenter experienced a *now*, I'll call now_L, that informed him of the watch-time at which he was actually existing.

For the experimenter, the electron also went from watch-time $t = 0$ to $t = 10$ (assuming non-relativistic speeds). But for the experimenter, there is no variable now_e indicating where in its A-series these electron events were. So at some laboratory time, say, $t = 8$, now_e may have been, for example, at watch-time $t = 2$ or watch-time $t = 5$... now_e does not have to be at the same watch-time as now_L. Nevertheless, for the electron now_e is a parameter and events advance normally through its A-series, though for the electron now_L is not a parameter of the laboratory.

This strategy can be employed in interpreting the delayed-choice quantum eraser.

6. Path integrals For the transition kernel K one has

$$K(x_f, T; x_i, 0) = \int_0^T [Dx(t)] \exp[\frac{i}{\hbar} S(x(t))]$$

Notice there are two different notions of time. There is the laboratory time going from 0 to T, and there is the time t in the action of the system under study. These times don't have to be equal because t ranges over B-series information only.

7. Ontological Models The Ontological Models framework makes many things in realist interpretations precise and allows for rigorous theorems. To prove the PBR theorem (that quantum mechanics is psi-ontic) it is assumed that “the ontic state space of a composite system should be a Cartesian product of the ontic state spaces of the subsystems”, [4] p. 104. The generalization to the ontic state space of two subsystems each with ineffable parameters is more complicated.

For example suppose Bob may parameterize Alice's ontic state space with the effable time variable $0 \leq t \leq 10 = O_A$ (informal notation). Then, according to Alice, her ontic state space is parameterized by an ontologically privileged time now_A together with the states parameterized by t. The now_A take on each t value at some point, so she gives her ontic state space as (isomorphic to) the Cartesian product of O_A with O_A. Similarly for Bob. It might then be that the ontic state space of the Alice-Bob composite system is the Cartesian product of O_A with O_A with O_B with O_B. But there are subtle issues here whose discussion unfortunately lies outside the bounds of this paper.

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References

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