Conceptual QM and its Practical Consequences

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The usual way of looking at quantum mechanics lacks a good conceptual structure. I don't mean that I am unsatisfied with what QM *tells* us about the world–as a physicist I can (and should) look beyond that–but I am dissatisfied with how quantum mechanics chooses to *represent* the world. A more conceptual theory would be more clear about what is out there and what its properties are. Note that this would not imply those objects actually exist, that is not the point or relevant (that is *metaphysics*); the use for such **a conceptual structure would be more practical**, and this in at least the following two ways:

- **For getting approximations:** concepts can be played with and hence are robust under approximations of the abstract equations. More concretely, more conceptual theories are easier to create approximations to. Still, despite the non-conceptuality of orthodox QM, we have approximation schemes (e.g. Born-Oppenheimer approximation, or mean field) but the problem is that we do not have an easy quantitative measure for how good our approximation is in certain cases (or even more harshly: there is no *justification*), and this because the approximation typically introduces new concepts, e.g. a two-body QM system is sometimes approximated as a point particle interacting with a one-body QM system. Suddenly we introduced the concept of a physical particle, and this is a conceptually discontinuous jump accompanied with a qualitative difference from the exact equations which cannot be put into a quantitative difference (unless one calculates specific numbers that one can measure in the end, but that creates a mess and is too case-specific). A more conceptual way of representing predictions is pilot-wave theory, where one has point particles from the start, and indeed in this case the proposed approximation scheme can be made quantitative on the level of fundamental equations (i.e. *justified*).

- **For expanding the theory:** non-conceptual theories are not very limber and it is hard to see how one can modify the theory and which predictions would change if we modified it in a certain way. Or even more basically, before we try to expand a theory, we try to fully grasp what the theory is telling us, but this is hard to figure out without well-defined concepts. An example could be: say one wants to understand what exactly entails "the mass-giving Higgs mechanism" (in the bigger picture of "mass", i.e. how we should understand it in QM, how it relates to relativity, etc.). We know from relativity that we can create mass by adding kinetic energy, and we know there is also rest mass, and one could wonder whether both are different origins of mass or in the end the same. It seems that the Higgs mechanism is a mechanism for rest mass and fundamentally distinct from kinetic energy, *however* it is hard to properly analyze this because even the concepts of mass, energy, kinetic, ... are too obscure in QM for them to be talked about in such a context, let alone compared to concepts we know from relativity. We are left without a strategy to attack.

Two theories with the same predictions might differ vehemently on the level of concepts. Custom dictates that we should not make a distinction between the two theories (at least on a scientific level), but as I argue they can differ greatly in the two aspects discussed above, and since these are quite practical in nature one can wonder if these could not count as (extra) criteria for judging a theory's worth. I feel that up until now this has hardly been done: we have relied solely on the strict yes/no of hardcore predictions, and neglected, say, the success and justification of approximations which after all form most of science.