Which version of Quantum Mechanics is the right one?

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Abstract In this article we consider four versions of quantum mechanics (QM), which form four different theories and which have the same experimental consequences (one of them is the standard QM). We consider six fundamental problems as criteria for the evaluation of these theories. The most successful is the modified QM introduced in [1] and described in the axiomatic form in [2], which solves all six problems. The least successful is the standard QM, which does not solve any of considered problems. (It seems that the standard QM is unable to solve any of these problems.) Other two theories solve some of problems and did not solve some other problems. On the base of this result we recommend to abandon the standard QM and to accept the modified QM as the right QM, since both variants have the same experimental content and the differences rest only in theoretical considerations.

At this time there are at least four different theories which have the same experimental consequences as the quantum mechanics (QM):

(i) The standard QM (stQM) as is described axiomatically e.g. in [1]

(ii) The minimal non-realistic modification of stQM (n-rQM) - see [1]

(iii) The modified QM (modQM) - see [2] and [3]

(iv) The Bohmian QM (bohmQM) - see [4].

These are different theories with the different theoretical consequences but with the same experimental consequences.

At first we discuss the differences among these theories

- (iv) is different from (i)-(iii) by its structure (i.e. trajectories of particles in (iv))
- modQM is different from stQM and n-rQM since modQM does not contain the concept of the measurement among its axioms (instead of this, modQM contains the concept of an observation, see [3] and [2],
- stQM is different from n-rQM and modQM since it contains $\mathbf{Ax}_{vN}$ which contradicts to $\mathbf{Ax}_{avN}$ contained in n-rQM and modQM.

Thanks to these differences it is clear that at most one of possibilities (i)-(iv) can be true. It is necessary to state the criteria by which we can evaluate theories (i)-(iv).

Our analysis will be based on the evaluation of the following six problems.

(P1) The problem of Bell's inequalities: the problem is how to ensure their non-derivability (since they contradict to the experimental results)
(P2) The non-locality problem: the problem rests on the fact that the Special Relativity is fundamentally local (see [6])
(P3) The problem of the Collapse Rule: this immediate change has no clear mechanism, ant it contradicts to the standard unitary evolution
(P4) The measurement problem
(P5) The problem of having the concept of a measurement among axioms
(P6) The problem of the non-unicity of the decomposition of mixed states into individual states.

Now we shall evaluate theories (i)-(iv) with respect to these six problems. In the evaluation we shall use the convention:

Yes means that the problem exists and is un-solved
No means the either the problem does not exists (in the given theory) or it is solved (in the given theory).

	stQM	n-rQM	modQM	bohmQM
Bell inequalities (P1)	Yes	No	No	?
non-locality (P2)	Yes	No	No	Yes [1]
Collapse problem (P3)	Yes	Yes	No	?
Measurement problem (P4)	Yes	Yes	No	No
measurement among axioms (P5)	Yes	Yes	No	No
non-unicity of the decomposition of mixed states (P6)	Yes	No	No	No
summary	6× Yes	3× No 3× Yes	6× No	3× No 1× Yes

Conclusions.

- stQM does not solve any of these six problem
- modQM solves all these problems
- n-rQM does not solve three problems connected with the measurement
- the main handicap of bohmQM is its explicit non-locality

As the conclusion we can say that the replacement of stQM by modQM would solve all these (in stQM un-solvable) problems.

Which changes are necessary?

(i) to reject $\mathbf{Ax}_{vN}$ and to accept $\mathbf{Ax}_{avN}$

(ii) to reject axioms describing the measurement (axioms **Ax6**-**Ax8** from [1]) and to accept axioms describing the observation (axioms **Ax6**-**Ax8** from [2])

After many years (even decades) of the study of stQM, it seems that problems (P1)-(P6) are not solvable in stQM. All these problems are solvable in modQM.

The experimental success of QM *does not imply* that stQM is a true theory. All considered theories have the same experimental support. At most one of (i)-(iv) may be true. It may happen that (e.g. stQM) containes (up to now not recognized) inner contradiction.

The choice among variants (i)-(iv) has to be done on the base of theoretical considerations, namely on the possibility to solve problems (P1)-(P6).

[1] BohmQM is explicitly non-local

References.

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