On the two possible interpretations of Bell inequalities.

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Abstract

It is argued that the lesson we should learn from Bell inequalities (BI) is not that Quantum Mechanics (QM) is nonlocal, but that QM contains an error which must be corrected.

The two interpretations of BI discussed here are the following

The standard interpretation: the non-locality of QM (see [1])

The modified interpretation: the need of a correction of QM.

Quantum theory (QT) is the theory describing the quantum phenomena and it has two parts

(i) QM

(ii) Special Relativity (SR)

i.e. QT = QM + SR .

The basic problem of the contemporary physics is the fact that QT seems to be inconsistent. It is known that the inconsistent theory is fundamentally wrong.

Now we shall give the arguments for statements written above.

In the case of the standard interpretation the procedure contains the following steps (see [3, p.3], [4], [5])

(i) We shall assume the locality of QM

(ii) From this we shall derive BI

(iii) BI contradict to QM

The non-locality of QM contradicts to SR, so that we obtain the inconsistency of QT. Thus the standard interpretation implies the inconsistency of QT.

Let us analyze the modified interpretation.

The consistency of QT implies the locality of QM. Then it is possible to derive BI and the inconsistency of QM. As a result we obtain the inconsistency of QT.

The inconsistency of QT is the main contemporary contradiction in the physics and it must be solved.

In the 20th century there were many developments in the science based on the discovery of the inconsistency (examples are written below).

The typical example is the case of the Russell's paradox and the consequent discovery of the Zermelo-Fraenkel set theory.

The procedure consists of the following steps

(i) the discovery of the contradiction

(ii) the discovery of the assumption which is wrong and its rejection

(iii) the introduction of the new assumptions replacing the previous one

(iv) the analysis of the consistency of the new theory

In the case of the set theory the problem was the Cantor (naive) set theory.

(i) the inconsistence is given by the Russell's paradox based on the following definition of a set R

$$R = \{M | M \text{ is not an element of } M\}$$

(ii) The wrong axiom: the non-limited use of the definition of the set by the property (so-called axiom of the comprehension]

(iii) The postulation of the limited comprehension axiom (only subset of a given set can be constructed by the property) and the postulation of other axioms for the construction of new sets

(iv) Analysis of the consistency: the proof of the consistency of the Zermelo-Fraenkel set theory is not possible, but the arguments leading to the Russell's paradox cannot be used in the Zermelo-Fraenkel set theory (the definition of the Russell's set R is impossible in the new theory)

The application of the four steps described above to the case of QM

(i) the inconsistence: BI (BI are the analogs of the Russell's paradox)

(ii) the error may be in SR or in QM (or in both). There is no reason to change SR, thus one can assume that the error is in QM. With respect to the results of [2] the appropriate candidate for the error in QM is the principle of superposition. In [2] it is shown that in the modified QM it is possible to show that using the principle of anti-superposition it is impossible to derive BI.

(iii) Instead of the principle of superposition it is necessary to assume the principle of the anti-superposition which make impossible the derivation of BI.

(iv) To prove the consistency of SR + modified QM is probably difficult, but possible derivations of the Bell inequalities are impossible in the modified QM, since in the modified QM the so-called EPR principle of reality is not true.

As a conclusions we can say

(i) QM must contain the basic error (see also [6, p.4])

(ii) This error is contained in the principle of superposition

(iii) The principle of superposition must be substituted by the principle of anti-superposition

(iv) This means that the standard QM must be substituted by the modified QM introduced in [2]

(v) It is possible to show that the modified QM is consistent and local

(vi) It is possible to show that the modified QM introduces the minimal changes into the practical application of QM – all practical results of QM can be reproduced in the modified QM (see [2])

We can say that the standard interpretation of BI (BI implies the non-locality of QM) is wrong, since

(i) it does not solve the inconsistency of QT

(ii) it introduces the non-locality of physics in such a way that the unique examples of the non-locality are BI and the EPR correlations (no other examples of non-locality is known), [3, p.4].

(iii) The standard rule states that the mistake is in the theory and not in the reality – i.e. not the non-locality of physics, but the error in QM.

There are many cases, where the inconsistency was the main origin of a discovery:

Topic	Problem	Solution
Black body radiation (before 1900)	The infinite energy for high frequencies	The Planck's law (Planck 1900)
Photo effect (before 1900)	The law of the photo effect	The discovery of the photon (Einstein 1905)
The inconsistency between Maxwell theory and Newtonian mechanics (before 1900)	In-compatibility of these theories	Special theory of relativity (Einstein 1905)
Cantor's (naive) set theory (before 1900)	Russell's paradox	Zermelo-Fraenkel set theory (Zermelo 1908)
The inconsistency between Special Relativity and the Newton's gravitation theory	The finite velocity of the spreading	General relativity (Einstein 1915)
Radioactive decay (Beckquerel 1896)	Non-conservation of the energy	Neutrino (Pauli 1931)
EPR correlations (1935)	The local explanation of EPR correlations	?[1]
The finite range of weak interactions	Massive W-boson and the calibration invariance, the renormalization of Salam-Weinberg model	Salam-Weinberg model (Glashow, Salam, Weinberg 1967), Higgs mechanism (Higgs, Englert, Brout 1964)
Bell inequalities (1964)	Inconsistency of QT, non-locality of QM	?[1]
The structure of hadrons	Form factors and symmetry of hadrons	Quarks (George Zweig, Murray Gell-mann 1964)
Quark model	The confinement of quarks	The asymptotic freedom (Frank Wilczek, David Gross, David Politzer 1973)

There are other benefits of the modified QM:

(i) the locality of physics

(ii) the complete solution of the measurement problem in the modified QM (see[2])

The main conclusions:

(i) it is necessary to get rid of BI - the modified QM offers the way how to exclude the possibility of the derivation of BI.

(ii) The standard interpretation says: to preserve BI, but to sacrifice the locality of QM (preserving the inconsistency of QT)

(iii) The modified interpretation says: to preserve the locality of QM, but to make a correction in QM.

[1] The modified QM is a possible solution.

Remark. Our considerations clarify the role of BI. Russell's paradox has no positive content, it only indicates the inconsistency of the theory. The same is true for BI: BI have no positive content, they only indicate the contradiction inside QT. The contradiction requires a change in QM such that in the new theory BI cannot be derived. Our approach is based on the analogy between Russell's paradox and BI.

References:

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