A solution to the Einstein's EPR puzzle in the modified quantum mechanics

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Abstract. In this note we show that in the modified quantum mechanics EPR correlations can be explained locally. We show also that the claim on the quantum nonlocality is in the modified quantum mechanics false.

Einstein's problem with the EPR correlations consists in the fact that the result of Alice' measurement (seemingly) influences the result of Bob's measurement since these results are perfectly anti-correlated (see [3] - but with the Bohm's modification).

We shall show that this claim is false and that in the modified Quantum Mechanics (QM) there exists a local explanation of the perfect anti-correlation of measurement results. Modified QM was introduced in [4] and in [5] its axiomatic formulation was given.

The construction of the EPR state will be decomposed into four steps such that each of these steps is a local operation.

(i) Let us consider systems **S** and **R** which are in the standard entangled singlet state

$$\psi = 2^{-1/2} \left(|S1\rangle \otimes |R0\rangle - |S0\rangle \otimes |R1\rangle \right)$$

(ii) We transport the system **S** to the region of Alice and we transport the system **R** to the region of Bob

(iii) Alice connects its measuring system **A** to the system **S**. Then Alice applies (in her region) the measuring transformation (which is a unitary map) to the systems **A** and **S**.

(iv) Bob connects its measuring system **B** to the system **R**. Then Bob applies the measuring transformation (which is a unitary map) to the systems **B** and **R**.

All steps contain only local transformations where no nonlocal connection between Alice and Bob is created. Details will be described below.

Then the (purely mathematical) calculation is done and it follows that only anti-correlated results are possible since for probabilities we necessarily have

$$\text{Prob}(A0, B0) = \text{Prob}(A1, B1) = 0$$

Since this state of system **A** + **S** + **R** + **B** was obtained through four steps each of them is a local operation, the resulting state must be local.

The correlation between **A** and **B** is analogous to the classical correlation between two bits with the probability distribution given by $\mathrm{P(A0, B0) = P(A1, B1) = 0}$ and $\mathrm{P(A1, B0) = P(A0, B1) = ½}$. This classical correlation is local. It can be modelled with pairs of gloves when from each pair one (randomly selected) is transported to Alice and the other to Bob. This anti-correlation is a consequence of the previous interaction and is clearly local in the classical sense.

The specific feature of QM consists only in the fact that in QM this classical correlation is obtained for each orientation Φ of measuring systems **A** and **B.**

It is important to understand that the perfect anti-correlation between measuring systems **A** and **B** does not imply the same perfect anti-correlation between individual systems **S** an **R**. The perfect anti-correlation between **S** an **R** exists only on the level of ensembles but not on the level of individual systems. All this is explained in details in [4].

In the modified QM the measurement process is decomposed into two steps

(i) The measuring transformation which is applied to the measured system **S** and the measuring system **A** and which is an entangling unitary map
(ii) The observation of the individual state of the measuring system **A** – the observation can be interpreted as a trivial measurement done on the measuring system **A**

Now we shall describe details of this construction.

The measuring system **A** has the basis $|A1\rangle$, $|A0\rangle$ where these two states are individual states and let us assume that in the standard (von Neumann) measurement the state $|A1\rangle$ is linked to the state $|S\Phi 1\rangle$ of the measured system **S** and the state $|A0\rangle$ is linked to the state $|S\Phi 0\rangle$ (where Φ denotes the orientation of the measuring systems). The system **S** has individual states $|S1\rangle$, $|S0\rangle$ and states $|S\Phi 1\rangle$, $|S\Phi 0\rangle$ are not individual states but collective states, i.e. states of ensembles. The same for Bob, i.e. $|B1\rangle$, $B0\rangle$, $|R\Phi 1\rangle$, $|R\Phi 0\rangle$ and Bob`s measurement links $|B1\rangle$ with $|R\Phi 1\rangle$ and $|B0\rangle$ with $|R\Phi 0\rangle$.

Alice connects her system **A** in the state $|A0\rangle$ to the system S and applies the measuring transformation to the system $\mathrm{A + S}$ following the linking described above – we then obtain the state described in the eq. (3C12) in [4]. This process is local since it connects only systems A and S which are localized in the region of Alice.

Then Bob connects his system B to the system R and applies the corresponding measuring transformation; the resulting state of the system A+S+R+B is described by the eq. (3C13) and (3C14) in [4].

Now one can do the mathematical calculations represented in eq. (3C16) and (3C17) with the result described by the eq. (3C18) from [4]. Then eq. (3C18) implies the perfect anti-correlation of the outputs of **A** and outputs of **B** as it is expressed in eq. (3D1).

In this way we have obtained a local explanation of the EPR correlations different from the explanation based on the pre-determination (see [1], [2], [3]).

To make the locality of the modified QM possible it is necessary, moreover, to show that Bell inequalities (see [2]) cannot be derived. This was shown in [6].

As a conclusion we obtain that claims of the type: "… non-locality is a necessary feature of any theory which shares the empirical predictions of QM" (see [1]) and similar claims are invalid.

References

[1] T. Norsen, Quantum Solipsism and Non-Locality, http://www.ijqf.org/wps/wp-content/uploads/2014/12/Norsen-Bell-paper.pdf

[2] J.S. Bell, "On the Einstein-Podolsky-Rosen paradox," Physics 1 (1964) 195-200; reprinted in J.S. Bell, Speakable and Unspeakable in Quantum Mechanics, 2nd ed., Cambridge, 2004.

[3] A. Einstein, B. Podolsky, and N. Rosen, "Can quantum-mechanical description of physical reality be considered complete?," Phys. Rev. 47, 777–780 (1935)

[4] J. Soucek, The principle of anti-superposition in QM and the local solution of the Bell's inequality problem, http://www.nusl.cz/ntk/nusl-177617, available also at http://vixra.org/abs/1502.0088

[5] J. Soucek, The restoration of locality: the axiomatic formulation of the modified Quantum Mechanics, http://vixra.org/abs/1503.0109 , available also at http://www.ijqf.org/wps/wp-content/uploads/2015/06/201503.pdf

[6] Jiri Soucek, The Hidden Error in the Standard Quantum Mechanics, http://vixra.org/pdf/1507.0083v1.pdf