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Peer Review

Review of: "On the Unreasonableness of the Quantum Nonlocality Debate"

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This paper has the purpose of shedding some light on the debate about quantum nonlocality.

I agree with the author that the debate on quantum non-locality is often unclear and often lacks precision. This largely derives from the use of different concepts under the same name, as also happens with the definition of realism. Unluckily, I am afraid that the present paper, in several parts, adds further elements of confusion, even if some of the presented “fallacies” are correct.

Let’s start with the concept of non-locality. An important point is that non-locality has different meanings in different contexts, and in the discussion on the foundations of quantum mechanics, they are often interchanged.

One could refer, for instance, to [1,2,3,11] for a discussion of these several meanings. Although I cannot, in a referee report, describe all these questions in detail, I can mention at least three different definitions of non-locality:

- A “generic” one, as the definition 1 of the present paper on page 1 (“*A theory is nonlocal if it predicts that what happens in a region of space has an immediate and instantaneous influence on another separate region without allowing a time delay for the propagation of the effect.”)*
- The signalling, i.e., the possibility of transmitting a signal at a speed larger than the velocity of light in a vacuum (which violates special relativity).
- Bell locality, which establishes a factorization of the joint probability of measurements with a precise mathematical definition (see [1,4,5] for details)

These differences are not well clarified in the paper.

Concerning the discussion on Bell's theorem, in synthesis, Bell's theorem has three main hypotheses:

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Bell non-locality, existence of predetermined (by a hidden variable) outcomes (that one can call the realism hypothesis), and free choice of the experimental settings.

The measured experimental violation of Bell inequalities implies that one of these hypotheses is violated (not which one). Also, this does not emerge clearly from the paper. Nonetheless, it must be mentioned that the discussion on non-locality in quantum mechanics and its meaning largely extends beyond the violation of Bell inequalities (and related issues) and would require a wider discussion.

The concept of realism is rather vague and differs in different contexts as well; what is intended in this paper should be clarified better.

When discussing the emergence of incompatible experiments, some statements are misleading. For instance, the author claims: “Any argument requiring the simultaneous measurements of incompatible quantities contradicts orthodox quantum mechanics and should be immediately dismissed without further ado, be it the Bell inequality or the Stapp inequality.” Of course, what quantum mechanics asserts is that, due to the Heisenberg uncertainty principle, one has a limit on the precision with which incompatible observables can be measured on the same state. As reported later in the paper, weak measurements allow for a joint or sequential measurement of incompatible observables (of course with a large uncertainty), as described by Mitchison, Josza, Popescu [6] and in [7], and experimentally realized in [8,9] and many others later.

Finally, other sentences are also rather confused. For instance, the author claims that Ref.21 is not a test of Bell inequalities. As described in Ref.30 of the paper, this assertion derives from an author's interpretation of what Bell inequalities are and of what was done in the experiment, which is not correct. I do not come back to this issue, since the reader can find the discussion in Ref.30.

Furthermore, the Bell argument that the author reports concerns projective measurements, since at that time, weak measurements had not yet been introduced.

In conclusion, although agreeing with the author that several discussions on quantum non-locality (as more in general on foundations of quantum mechanics [10]) are confused, and on several of his fallacies, nonetheless I am afraid that this paper adds somehow further elements of confusion due to the imprecision of the presentation in various points.

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Declarations

Potential competing interests: No potential competing interests to declare.