WHO TOLD YOU THAT NATURE IS NONLOCAL?[1]

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Shortly after the Nobel Committee awarded its 2022 Physics Prize to Alain Aspect, John F. Clauser and Anton Zeilinger "for experiments […] establishing the violation of Bell inequalities […]", the popular press went abuzz with stories about Albert Einstein having been wrong in his firm conviction that Nature is both local and realistic according to his *Principle of Locality*, which he stated as follows in his autobiography:

> On *one*[2] supposition we should, in my opinion, absolutely hold fast: the real factual situation (the state)[2] of the system S_2 is independent of what is done with the system S_1, which is spatially separated from the former. [1]

Einstein's position was shaken after John Stewart Bell proved in 1964 that some predictions of quantum theory are incompatible with *local hidden variables* [3]. Soon thereafter, it appeared to be untenable after experiments, performed in particular by the 2022 Nobel Prize laureates, confirmed those predictions. Does it follow that Nature is nonlocal? Did the Nobel laureates tell you so?

In an interview with the CBC radio programme *Quirks and Quarks* immediately after the Nobel announcement, **John Clauser** said this: "The truth is, I didn't know what the result was gonna be. I was betting on Einstein. […] I was very sad because I thought Einstein was right but, unfortunately, I did disprove his point of view." [4]

In his Nobel banquet speech, **Alain Aspect** claimed that "The conclusion is now clear: Einstein's view on physical reality cannot be upheld." In his 7 June 2023 Nobel podcast, he said: "I could not imagine how Einstein could be wrong, […] but I have to accept the result.''

We see that both Clauser and Aspect believe that Nature is nonlocal since this is indeed what they mean by "Einstein was wrong". What about **Anton Zeilinger**? In a personal communication [5], he told me that "All the experiments tell us is that nature cannot be described by local properties in the sense

[1] A full version of this version will appear elsewhere.

[2] The word "one" was not emphasized in Schilpps's translation [1] and the parenthetical addition "(the state)" was omitted. Yet "einer" is emphasized and "(Zustand)" appears in Einstein's original version in German [2].

of Bell (and extensions).” This is absolutely correct. Then, he added “But to say that nature is nonlocal is going too far in my eyes.” I applaud this nuanced opinion.

Indeed, Einstein's Principle of Locality has *nothing* to do with Bell's notion of locality, which is based on local hidden variables. It follows that “establishing the violation of Bell inequalities” can*not* be used to argue that Nature is nonlocal, only that it is nonlocal *in the sense of Bell*, exactly as Zeilinger stated so aptly. Could there be another way for Nature to be local and realistic?

It turns out that David Deutsch and Patrick Hayden discovered a quarter of a century ago how to explain all the predictions of quantum theory in a local realistic universe [6]. Subsequently, Paul Raymond-Robichaud proved that local realism and nonsignalling are equivalent when the dynamics is reversible [7]. Therefore, *no* experiment whose purpose is to vindicate quantum theory can serve as evidence that Nature is nonlocal!

So, who told you that Nature is nonlocal? A great many people indeed, including two Nobel Prize laureates, but their arguments for this claim are empty. As usual, Einstein prevails. :-)

ACKNOWLEDGEMENTS

I am deeply indebted to decade-long discussions on this topic with (in alphabetical order) Alain Aspect, Charles Alexandre Bédard, David Deutsch, Nicolas Gisin, Renato Renner, Paul Raymond-Robichaud, Lev Vaidman and Anton Zeilinger, even though some of them do not share my perspective. More recent discussions with Samuel Kuypers and Taha Skiredj were also illuminating. It was Paul Raymond-Robichaud who was the first to make me aware that experimental violations of Bell inequalities cannot be used to argue that Nature is nonlocal. It was in 2012 that, in a matter of minutes, he changed my entire view of the Universe. Thank you Paul. I am forever indebted to you.

Research supported in part by the Natural Sciences and Engineering Research Council of Canada, NSERC (RGPIN-2022-04341 and ALLRP-578455-2022) and by and Québec's Institut transdisciplinaire d'information quantique (INTRIQ).

The original photograph, from which the portrait was developed by Belgian architecture firm LIGNES, was taken by Hatim Kaghat.

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