What is Bell's theorem actually telling us?

Johan Noldus*

September 30, 2015

Abstract

We point out that there is no contradiction between the results of quantum mechanics and consequences of general relativity.

1 What is all the fuzz about?

Recently, claims that a final Bell experiment has been performed excluding local realism (except for superdeterminism) are put into perspective. Years ago, I concluded that the *only* thing Bell's theorem [1] [2] is telling us is that the notion of locality of Bell can not be maintained for the microscopic world. While it works perfectly well for macroscopic objects (since they are not entangled in a way we would notice), something else seems to be going on for elementary particles. Nowadays, many people seem to think that at short distance scales our notions of spacetime must break down either because of the infinities arising in quantum field theory or for reasons inherently present in general relativity (that probing spacetime at such distances would cause the formation of microscopic black holes). Often, the point of view of a spacetime foam has been put forward. Now, the psychology of these authors is surprising, since most of them would refute the possibility of local realism. There are more conventional ways to be considered; that is, suppose that two entangled particles are connected by an Einstein Rosen bridge (better known as a wormhole) then it is possible for them to communicate at *effective* spacelike separated locations without exceeding the local velocity of light! Now, the Copenhagen interpretation of quantum mechanics does *not* require the wormhole to be destroyed after both particles were measured, it only tells that both individual particles are put into a definite state (and that both particles together do not form a state of zero spin anymore) which is good since otherwise we would need a new dynamics for spacetime given that general relativity does not know how to deal with topology change. The only conclusion we must draw here is that elementary particles are not such simple objects as most people believe, they do not only carry internal "quantum" numbers but also hidden variables relating them to other particles. Effectively such theory is of course nonlocal but there is no need to look for theories with signals exceeding the *local* velocity of light; one only needs to recognize that for elementary particles the assumed notions of spacetime do not uphold.

If one considers Einstein's thought that geometry and matter are influencing

---

*email: johan.noldus@gmail.com

one and another then one must come to the conclusion that the collapse of the wavefunction has a physical significance unlike when geometry is frosen. Now, the reason why we don't see such effects is because G as well as the mass of elementary particles are small. So there is a dynamically preffered frame in nature (call this the reinstatement of the arrow of time in general relativity) [3] just as is the case for causal set theory when one deals with finite posets (there however, this frame does not influence the physics!). Now, there is still a notion of causality in such framework (just as there is a notion of causality in Newtonian physics) but as mentioned before this does not need to be the effective notion of causality which is valid in the macroscopic world! The latter must dynamically arise when one considers interaction of macroscopic objects, so macroscopic Lorentzian geometry should have a dynamical origin. As far as I know, this idea has not been explored yet by causal set proponents but it is certainly a way to potentially avoid a lot of trouble with "quantization". In other words, for physics of elementary particles the *effective* Lorentzian geometry should break down (which does not of course imply that Lorentzian geometry breaks down).

Alternative ways to introduce nonlocality, such as a traditional nonlocal signalling in effective spacetime between two particles are all unplausible avenues since one can consider the Bell experiments to take place in isolated subsystems from a conventional spacetime point of view.

References

[1] Speakable and unspeakable in quantum mechanics, Cambridge University Press.

[2] A. Afriat and F. Selleri, The EPR paradox in Atomic, Nuclear, and Particle Physics, Plenum Press, New York and London.

[3] J. Noldus, Foundations of a theory of quantum gravity, arXiv.11015113.

[4] S. Weinberg, The quantum theory of fields, foundations, Cambridge University Press.