Not all local-realistic theories are forbidden by Bell's theorem

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Abstract

Bell's theorem prescribes that no theory of nature that obeys locality and realism can reproduce all the predictions of quantum theory. However the theorem presupposes that particles which are distanced from each become *spatially disconnected*. The possibility of *spatial-locality* between distanced particles has never been considered neither in Bell's theorem, nor in its experimental tests. Here I show that an infinite set of local and deterministic relativity theories cannot be forbidden by Bell's theorem.

Keywords: Bell's Theorem, Entanglement, Relativity, Locality, Realism.

Bell's theorem[1-2] prescribes that no theory of nature that obeys locality and realism can reproduce all the predictions of quantum theory To prove that an infinite number of local-realistic theories cannot be forbidden by Bell's theorem, consider a system in which two particles A and B distance from each other along the $+x$ axis with normalized constant velocity β. Demote the radius of particle B in its rest-frame by Δx^0.

The distance transformation of any relativity theory for the system described above should be a function of β, such that:

$$\Delta x = \Lambda_x(\beta)\, \Delta x^0 \qquad \dots (1)$$

Where Δx is the length of particle B in the reference-frame of particle A and $\Lambda_x(\beta)$ is the respective theory distance transformation. Now consider the set of all continuous and well behaved local and deterministic relativity theories, in which the transformations of distance $\Lambda_x(\beta)$ satisfy the following:

$$\Lambda_x(0) = 1 \qquad \dots. (2)$$

$$\frac{\partial \Lambda_x(\beta)}{\partial \beta} \geq 0, \text{ for all } \beta \geq 0, \text{ and } \frac{\partial \Lambda_x(\beta)}{\partial \beta} < 0, \text{ for } \beta < 0 \qquad \dots. (3)$$

$$\Lambda_x(\infty) = \infty \qquad \dots. (4)$$

The condition in (2) ensures the invariance of Δx^0 if the two particles are stationary with respect to each other. The conditions in (3) and (4), contrary to the Lorentz contraction, prescribe that the spatial dimension Δx^0 of particle B along its movement relative to particle A, will continually "stretch", approaching ∞ as β approaches ∞.

The above defined set of relativity theories, excludes Special Relativity. Nonetheless, it is perfectly legitimate. In fact the distance transformation for moving bodies obeying the above restrictions mimics the Doppler Effect[3] observed for waves emitted from moving bodies.

In the framework of such theories, entanglement due to spatial-locality, even when temporal-locality has been eliminated[4-8], becomes feasible for any distance between A and B. For any distance *d* between the two particles, the conditions (1)-(4) guarantee the existence of a critical velocity, $\beta^*(d)$, above which the *relativistic stretch* of particle B along its travel access will be greater than *d*.

I have argued above that Bell's theorem does not pay regard to a possible spatial-locality between distanced particles, and that tests of the theory so far were only successful in closing the temporal-locality loophole, while leaving the loophole of spatial-locality wide open. Thus, it is fair to conclude that until the spatial-locality loophole, which was unnoticed by Bell, is satisfactorily closed, the hopes for a near-death of locality[8] are greatly exaggerated. Meanwhile,

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