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

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


## Abstract

Bell's theorem prescribes that no theory of nature that obeys locality and realism can reproduce all the predictions of quantum theory. However, Bell's theorem presupposes that particles that are distanced from each other become spatially disconnected. Yet studies have never experimentally confirmed the possibility of *spatial locality* between distanced particles. Here, I show that Bell’s theorem cannot forbid an infinite set of local-deterministic relativity theories that violate Lorentz's contraction for distancing bodies. This result in itself cannot guarantee a theory from this set of theories to successfully reproduce the predictions of quantum theory, but until the spatial locality loophole is satisfactorily closed, experiments should be decided the fate of such theories.



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


Bell's theorem[1-2] prescribes that no theory of nature that obeys locality and realism can reproduce all the predictions of quantum theory. However, Bell's theorem presupposes that particles that are distanced from each become *spatially disconnected*. Yet studies have never verified the possibility of spatial locality between distanced particles. Here, I demonstrate that an infinite number of local-realistic theories which predict that spatial locality between distancing bodies could be sustained are conceivable. For this purpose, consider a system in which two particles A and B are distanced from each other along the *x* axis with normalized constant velocity β. Denote the radius of particle B in its rest frame by $\Delta x^0$.

For an inertial system as the one described above, the relativistic distance transformation is given by

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

where $\Delta x$ is the length of particle B along the x-axis in the reference frame of particle A, and $\Lambda_x(\beta)$ is a distance's transformation factor. Now consider the set of all continuous and well-behaved local and deterministic relativity theories in which $\Lambda_x(\beta)$ satisfies the following conditions:

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

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

$$\Lambda_x(\infty) = \infty. \qquad \text{.... (4)}$$

The condition in (2) ensures the invariance of $\Delta x^0$ 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 $\Delta x^0$ of particle B, along its movement relative to particle A, will continually "stretch" with β, approaching ∞ as β approaches ∞. Because the Lorentz invariance contradicts quantum theory itself, [3-4] objecting to its violation by conditions (3) and (4) (for distancing bodies) is hard to justify.

In theories of the above defined type, local entanglement becomes feasible even when temporal locality has been eliminated, as accomplished in many experiments.[5-9] to various degrees of success. Note that for any distance *d* between A and B, conditions (2)-(4) guarantee the existence of a critical velocity $\beta^*(d)$ above which the *relativistic stretch* of particle B in A's frame is larger than *d*.

In summary, we argue that Bell's theorem does not consider a possible spatial locality between distanced particles, and that tests of the theory were only successful in closing the loophole of temporal locality, leaving the loophole of spatial locality wide open. Moreover, we demonstrated that Bell’s theorem cannot forbid an infinite set of local-deterministic relativity theories that violate Lorentz's contraction for distancing bodies. This result in itself cannot guarantee that a theory in this set of theories will successfully reproduce the predictions of quantum theory, but until the spatial-locality loophole is satisfactorily closed, experiments should decide the fate of such theories.

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