A conceptual explanation for nonlocality.

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A simple explanation is given for the continuation of the singlet state over large distances in an EPRBA experiment. The paper answers this question with clocks ticking in synchronized frequencies that can be carried by the particles. The connection is an expression of relativity of the clock variables that represent the distant separated spins.

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I. INTRODUCTION

The discussion about the explanation of entanglement started with the EPR paradox¹. Key in the discussion was and is: how is it possible that particles remain connected over long distances. Subsequent to Einstein, David Bohm changed the EPR paradox into entanglement of spins arising from a singlet state². Then, Bell³ asked if the entanglement between spins can be explained with the use of classical statistics. From Bells formula, inequalities were derived and experiments were proposed⁴, fine-tuned to experiment⁵ and performed⁶.

The author acknowledges many other experiments and apologizes for not mentioning them here. The experiments showed that the selected inequality can be violated in nature. This result urged many researcher to claim that Einstein's view on entanglement was wrong. Hess and Phillip⁷, however, tried extension of possibilities to, in the end, explain the existence of the singlet state over distance. However, their point was raised against the background of Bell inequalities. Recently, the present author questioned the mathematical validity of the argument behind the Bell inequalities⁸. The reader is challenged to check his or her obvious disbelief.

In the present short communication the author is, hence, no longer bound to explain the connection over long distances by referring to a Bell inequality. In the following section a short *conceptual* explanation will be given for the continuation of the singlet state over long distances.

II. CLOCKS

A simple conceptual solution to the paradoxical correlation is the following. When the particles split, two independent spins arise from the singlet state. Keep in the back of your mind that simultaneity is key in, for instance, the CHSH experiments. So why not have a clock mechanism changing each dt unit of time, the direction of spin. E.g at t , spin up, at $t + dt$, spin down etc.

Suppose, the spin going towards A starts, with spin up. The one to B, down. This is a singlet state that can e.g. be found in positronium. Suppose the spin carrying particles are still in a bounded singlet. Suppose they are a dt time unit away from leaving the singlet. Then, dt later, they separate. There is no longer a bond between them.

This means only the carried clock can drive the change in dt . In one dt from singlet, the spin to A changes to down and the spin to B changes to up. Then looking at the next dt . This gives, the spin to A becomes up again and to B becomes down etc. This continues until both spins are measured simultaneously at A and B. No need for incompatibility nonlocality or multiple universes to explain the correlation or "why do the spins of the separated particles remain connected". The spins are not connected. The synchronized frequency maintains the singlet. The measurement parameters, a and b, for A and B respectively, therefore produce correlated measurement results. The distance traveled is translated to ticks of the clock. So the up-down are synchronized. If the spin of the particles started in the up-down singlet relation the synchronized clock frequencies will keep them in the singlet, via, each dt a spin change.

A. Non-destructive in flight changes in one wing.

When for instance in the A-wing a not destructive change in the spin of e.g. a photon occurs, then, we can say that a physical change occurred in the A wing that did not occur in the B wing. How can a clock mechanism like the one proposed here explain this. Suppose x is that distance between A and B. In relativity, $s^2 = x^2 - c^2 t^2$ is invariant under Lorentz transformation. If, in the A-wing the time is Lorentz transformed, i.e. the clock shifts dt so that $t' = t + dt$, there must be a relative change in x such that, $x' = x + dx$, because,

$$s^2 = \{x'\}^2 - c^2 \{t'\}^2 = x^2 - c^2 t^2. \quad (1)$$

This implies the following relativity explanation for the entanglement. Namely, similar to relativistic time contraction:

Hypothesis: H1 *Each physical non-destructive activity on the spin (like a spin-flip) in one wing of the experiment, induces $t \rightarrow t' = t + dt$, with $dt > 0$.*

The spin-flip Lorentz factor is equal to

$$\gamma(dv) = \frac{1}{\sqrt{1 - \frac{(dv)^2}{c^2}}}.$$

Hence $\left(\frac{dt}{t}\right) = \gamma(dv) \left(1 - \frac{xdv}{tc^2}\right) - 1$. If x is the distance between A and B, then a relativistic change of the distance $x \rightarrow x' = x + dx$, with, $\left(\frac{dx}{x}\right) = \gamma(dv) \left(1 - \frac{tdv}{x}\right) - 1$, is induced. Solving

the s^2 invariance in (1) to dx , we find, noting,

$$2x dx + dx^2 - c^2(2t dt + dt^2) = 0$$

that, with $t > 0$ and $dt > 0$,

$$dx = -x + \sqrt{x^2 + c^2(2t dt + dt^2)} \quad (2)$$

This leads us, together with the following hypothesis, to the preservation of the singlet.

Hypothesis: H2 *Measurement synchronization is in spacetime distance $s^2 = x^2 - c^2 t^2$.*

With a dt shift by a non destructive A-wing spin-flip, the distance between A and B shifts dx and the singlet (synchronous spin clocks) is, therewith, preserved.

B. Light-like s^2

If, $ct = x$, $x > 0$, then, $s^2 = 0$ and the previous formulae have a simple explanation. First let us rewrite dx/x and dt/t . It shows

$$\begin{aligned} \frac{dx}{x} &= \gamma(dv) \left(1 - \frac{dv}{c}\right) - 1 \\ \frac{dt}{t} &= \gamma(dv) \left(1 - \frac{dv}{c}\right) - 1 \end{aligned} \quad (3)$$

Secondly, for $c > |dv| > 0$ and $dv < 0$, the two equation are simply

$$\frac{dx}{x} = \frac{dt}{t} = \sqrt{\frac{1 - \left(\frac{dv}{c}\right)}{1 + \left(\frac{dv}{c}\right)}} - 1 = \sqrt{\frac{1 + \left(\frac{|dv|}{c}\right)}{1 - \left(\frac{|dv|}{c}\right)}} - 1 \quad (4)$$

The equation (2) written as

$$\frac{dx}{x} = -1 + \sqrt{1 + \left(\frac{ct}{x}\right)^2 \left(2\frac{dt}{t} + \frac{dt^2}{t^2}\right)} \quad (5)$$

and noting, $ct = x$ together with, (4), is then correctly observed. Hence, under those conditions the dt shift of a spin-clock, in a Lorentz transformation relativistic framework, appears to be mathematically allowed.

III. CONCLUSION

In this short communication it was demonstrated that a conceptual simple explanation for the existence of the singlet condition over long distances, can be given with synchronized clocks. This simple conceptual explanation suffices because Bell inequalities are intrinsically flawed⁸. However, even if one refuses, unreasonably, to believe the mathematical truth of that claim, then still the synchronized clocks driving the spin-flips, thereby maintaining the singlet, can be accepted.

It is noted that the clock we are talking about is a quantum phenomenon. This is a necessity because of possible dipole energy losses when the particles leave the singlet at $t = 0$. The author acknowledges prof Nordén for this remark. For instance, an electron bound in a hydrogen atom does not emit radiation energy when in the ground state. In an overview article, Nordén⁹ presents a way that Einstein possibly was thinking. The claim made here is that the second possible viewpoint of Einstein could be valid without violation of special relativity. This is because the clock extending the singlet state of the two particles is a quantum phenomenon.

It is argued that the instantaneous change of a spin-flip in one wing is a dt shift of the spin clock. This shift is claimed to be a relativity phenomenon, similar to time contraction. Hence, the two spin clocks remain synchronized in a light-like relation, even if one of them is changed.

REFERENCES

- [1]Einstein, A.; Podolsky, B.; Rosen N. Can the quantum-mechanical description of physical reality be considered complete? Phys. Rev. 1935, 47, 777 - 780.
- [2]Bohm, D. Quantum Theory, D.R. Bates, Ed., Acad Press, N.Y. 1962.
- [3]Bell, J.S; On the Einstein Podolsky Rosen paradox,Physics, 1964, 1, 195-200.
- [4]Clauser, J.F., Horne, M.A., Shimony, A. and Holt, R.A., Proposed experiment to test local hidden variable theories, Phys. Rev. 1969, 23, 880-884.
- [5]Aspect, A. Proposed experiment to test the nonseparability of quantum mechanics, Phys. Rev. 1976, D14, 1944-1955.
- [6]Hensen, R., Bernien, H., Dreau, A., et al; Loophole-free Bell inequality violation using

- electron spins separated by 1.3 kilometres. *Nature* 2015, 526, 682 - 686.
- [7]Hess, K. and Phillip, W.; A possible loophole in the theorem of Bell, *Proc. Natl. Acad. Sci. USA*, 2001, 98, 14224-14227.
- [8]Geurdes, H. Nagata, K., Nakamura, T. and Farouk, A.; A note on the possibility of incomplete theory, arXiv 1704.00005, Geurdes H., A probability loophole in the CHSH, *Res. in Phys.* 2014, 4, 81-82, Geurdes, H. Lecture at QB16, Vaxjo, 2016, to be published in: *Advances Interdisciplinary Mathematics Research*, Springer.
- [9]Nordén, B., quantum entanglement: facts and fiction -how wrong was Einstein after all?, *Quart. Revs. Biophys.*, 2016, 49, 1-13, doi:10.1017/S0033583516000111.