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On a Local Hidden-Variable Model with Unusual Properties.

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Summary. – We show that a *local* hidden-variable model exists which violates Bell's inequality. The correlation function depends on the definition of the time of coincidence, are obtained for arbitrarily small times of coincidence.

It is not the purpose of this short note to show a model fitting very realistically the physical world. We are very less ambitious: our simple aim is to give evidence of how, starting from only roughly ondulatory assumption both with a definition of coincidence time, is possible to violate Bell's inequality (1).

This model is simple enough for an immediate intelligibility and is euristic for possible successive development. It is also « nonergodic » in the sense of Buonomano (2,3) because there is interaction or memory between consecutive measurements.

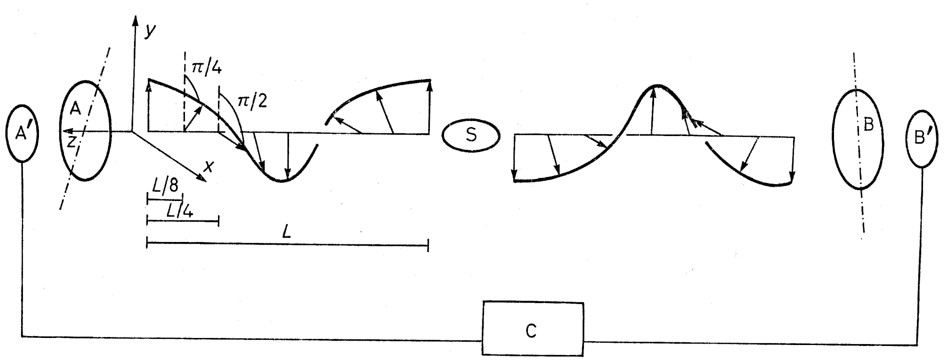

Fig. 1. – The helix model: A and B = polarizers, A′ and B′ = photomultiplies, S = source, C = coincidence counter, L = helix step; the little arrows represent the hidden variables of the process.

(1) J. S. Bell: *Physics*, **1**, 195 (1964).
(2) V. Buonomano: *Ann. Inst. Henri Poincaré Sect. A*, **29**, 379 (1978).
(3) V. Buonomano: *Nuovo Cimento*, **57**, 146 (1980).

The model does not use the corpuscolar concept at all; the wave is, in our argumentation, the principal information carrier as we recognize in the helix a faint resemblance to a circular polarized wave envelope.

A source S emits two correlated beams of « light » in opposite directions. For these beams the following classical model is assumed: each of them consists of a continuous ribbon which is helix-shaped and propagates in a direction parallel to its axis (fig. 1).

Passing through a « polarizer » with axis in the direction $\hat{a}$ means simply that the ribbon remains exactly the same as it was before, except for the fact that the directions $\pm\hat{a}$ are marked on the ribbon. A « photomultiplier » placed behind the « polarizer » integrates the energy contained in the ribbon, always starting from a marked direction and ending with the next marked direction.

The counter ticks only when two successive marked directions have entered it. We assume the counter to be blind at the initial piece of ribbon arriving before the first marked direction.

Therefore, a « photomultiplier » placed behind a « polarizer » ticks regularly every

$$\tau_0 = \frac{L}{2c}$$

seconds, where L is the step of the helix. We can always break the unpleasant rigid ticks regularity, but, as above mentioned, it is not our aim.

The correlation between the two ribbons produced by the source is such that the two vectors perpendicular to the axis and lying on the ribbon emitted at equal times are equal to each other.

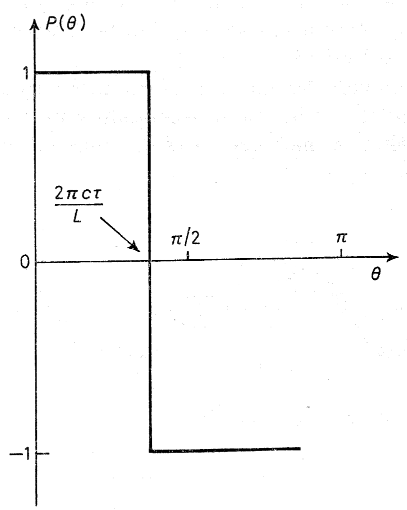

Fig. 2. – Correlation function for the helix model.

It follows that if the axis of the two polarizers are parallel the counters tick at identical times: there is then a total correlation between the two sets of counts. If the two polarizers axes are rotated of an angle θ the second ribbon will be marked a distance $(\theta/2\pi)L$ behind the position where the first ribbon is marked This means that the ticks of the second counter will take place regularly a time

$$t_0 = \frac{\theta L}{2\pi c}$$

after those of the first counter

Are there coincidences? This depends on the definition of time of coincidence τ. If $\tau > t_0$, we have $P(\theta)=1$, if $\tau < t_0$, we have $P(\theta)= -1$. The shape of the correlation function which is shown in fig. 2 depends obviously on the coincidence time.

Now it is easy to see that whatever is the inversion angle

$$\theta_0 = \frac{2\pi c\tau}{L}$$

(that is to say whatever is the coincidence time τ) it is possible to find polarizer's vectors $\hat{a}, \hat{a}', \hat{b}, \hat{b}'$, such that Bell's inequality

(1) $$\Delta = |P(\hat{a}, \hat{b}) - P(\hat{a}, \hat{b}')| + |P(\hat{a}', \hat{b}) + P(\hat{a}', \hat{b}')| \leqslant 2$$

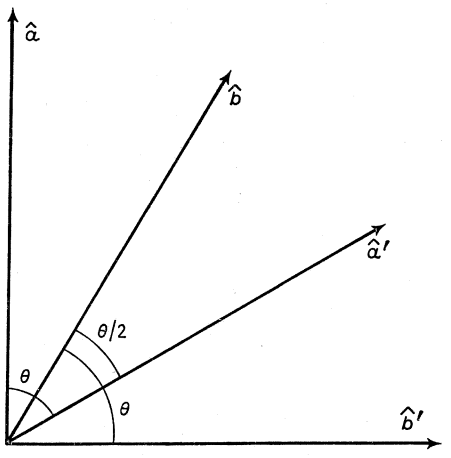

Fig. 3. – Example of choice for the relative polarizer angle.

be violated. In fact, it is possible to choose $\hat{a}$ and $\hat{a}'$ in such a way that they form an angle of θ_0. Also $\hat{b}$ and $\hat{b}'$ are chosen in the same way.

Furthermore, one chooses $\hat{b}$ along the bisectrix of the $(\hat{a}, \hat{a}')$ angle. Let the overall configuration be the one shown in fig. 3. One sees that all angles relevant to the inequality (1) are equal to $\theta_0/2$ except the angle $(\hat{a}, \hat{b}')$ which is $3\theta_0/2$.

But this simply means that $\Delta = 4$, so that the Bell's inequality is vioiated.