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Why Bell's EPRBA Experiment Is Meaningless

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Abstract

We demonstrate that a Bell type of experiment asks the impossible of a Kolmogorovian correlation. An Einstein locality explanation in Bell's format is therefore excluded beforehand by way of the experimental and statistical method followed.

Keywords

Bell's Correlation Formula, Basic Probability

1. Introduction

In 1935, Einstein Podolsky and Rosen initiated a debate about the foundation of quantum theory in [1]. Their work established what has been called entanglement. After EPR, many other researchers devoted their time to the topic as well. We are sorry for not including them. The most important reference, however, is Bell [2]. Because almost all researchers believe that Bell's experiment is valid, we are certain that the demonstration in this paper was not published before. Hence, our decision to include only those references that are needed to support our claim. The main point raised in this paper is about the statistical methodology of the experiment.

1.1. Bell Experiment

Bell EPRBA experiments need no further introduction. One can find a proper example in, e.g., Weiss's experiment of 1998 [3]. For convenience, a schematic representation is provided below.

$$\left[A(a)\right]\leftarrow\sim\cdots\sim\leftarrow\sim\left[S\right]\sim\rightarrow\sim\cdots\sim\rightarrow\left[B(b)\right] \tag{1}$$

Here, the $\left[A(a)\right]$ and $\left[B(b)\right]$ represent the two distant measuring instruments of Alice and Bob. The a and b are the unitary parameter vectors. They represent the setting parameters of the instruments. The $\left[S\right]$ represents the source of an entangled pair of particles. One can think of, e.g., photons. Note that we are allowed to employ the vocabulary: "spin of the photon". The quote: *A typical EPR-Bohm type two photon spin entangled state was predicted by Wheeler in the late* 1940*s and was proved by Wu and Shaknov in the early* 1950*s* ([4], page 40). For the statistic methodology we discuss here, it is not so very important which type of particle is employed. The spin and the statistical processing of its measurement are key.

Let's subsequently denote with, $x=\angle(a,b)$, the angle in the plane orthogonal to the direction of propagation. Because of the spin countings, it is easy to understand that the angle x is in the interval $0\le x<2\pi$. The positioning is orthogonal to the line of travelling of the two entangled particles from the source [S] towards the observations at Alice and Bob. The unity setting vector, a, refers to Alice's instrument. The unity vector, b, refers to Bob's instrument. For photons, it suffices to look at the orthogonal plane.

Suppose there are N number of entangled photon pairs in the experiment per x. During the experiment, the spins of both photons are measured.

Let us subsequently denote $N(x\,|\,eq)$ the number of (+, +) or (−, −) spin pair measurements in the total of N pairs under the angle, x. $N(x\,|\,eq)$ is equal to the sum of the countings $C(x\,|+,+)$ and $C(x\,|-,-)$. It is the frequency of occurrence of the statistical event "observation of equal spin under angle x".

The left "+" in (+, +) is Alice's measurement. The right "+" is Bob's. Similar for the other combinations. Moreover, with the assumption of perfect measurement the number of (+, −) or (−, +) measurements $N(x\,|\,neq)$, is equal to $N-N(x\,|\,eq)$.

1.2. Correlation

It is common practice in spin-spin entangled experiments, for a given $x\in[0,2\pi)$, to compute the Kolmogorovian Bell correlation [2] as a raw product moment (rpm) correlation

$$R(x)=\frac{N(x\,|\,neq)-N(x\,|\,eq)}{N} \tag{2}$$

Kolmogorovian, or classical probability, theory is given in the axioms established by Kolmogorov ([5], page 2). It is then easy to see, for a perfect measurement experiment that

$$R(x)=1-2P(x\,|\,eq) \tag{3}$$

with $P(x\,|\,eq)=N(x\,|\,eq)/N$. The rpm correlation is the experimental estimate of the Bell correlation formula ([2], Equation (2)) with $\rho(\lambda)$ the probability density of the hypothetical hidden variables λ. In the Kolmogorov sense, the Bell correlation is a classical probability expectation value of the product of two functions, *i.e.*, $E(AB)$. This implies that the experimental form comprises a Kolmogorov probability theory. If not, then the use of the correlation (3) and the use of inequalities derived from the Bell correlation $E(AB)$ have no ground in the experiment. The classical probability characteristic also refers to Einstein's idea of a return to classical causality [6].

Subsequently, we observe that the angle under the "eq" condition $X = x$ constitutes a *continuous* random variable. For the definition of a random variable in probability theory, the reader is, if necessary, referred to the basic literature, e.g., ([7], page 29). Only in the experiment do we have a number of discrete *x*-es; $x \in \mathcal{X} = \{x_1, x_2, \cdots, x_K\} \subset \mathcal{Y} = \{y \in \mathbb{R} \mid 0 \le y < 2\pi\}$. What is important here is that the probability of a continuous variable in a single point is zero ([8], page 121). Therefore, it is already wrong to call $P(x \mid eq)$ from (3) a "point" probability. There is no discrete random variable *X*. The random variable *X* is a continuous one because the angle between two unit vectors *a* and *b* is continuous. Let us then proceed as though $P(x \mid eq)$ can be called a probability but in the sense of an integral of a density function

$$P(x \mid eq) = P(0 \le X < x) = \int_0^x f(y)\mathrm{d}y \tag{4}$$

One can compare this approach with, e.g., the way a Gaussian probability is computed from its density [9].

1.3. Quantum Correlation

It is well known that the quantum correlation is $Q(x) = \cos(x)$. This can, via simple trigonometry, also be written like

$$Q(x) = 1 - 2\sin^2(x/2) \tag{5}$$

If we then want to know if it is possible for a Bell type correlation (3) to be equal to the quantum correlation (5) it follows that the classical Kolmogorov $P(x \mid eq)$ must be equal to $\sin^2(x/2)$. Can this be accomplished?

By definition, a function of one variable *x* on a subset of the real numbers, here $0 \le x < 2\pi$, whose increment $\Delta f(x) = f(x') - f(x)$ for $x' > x$ does not change sign, is monotone [10]. The $\sin^2(x/2)$ isn't a monotone function on $0 \le x < 2\pi$. It is *impossible* for a Kolmogorov probability $P(x \mid eq)$ to not be monotone in the interval $0 \le x < 2\pi$. A not monotone probability function induces negative probability. Negative probabilities violate the Kolmogorov axioms [5]. Hence, $P(x \mid eq)$ can not be equal $\sin^2(x/2)$.

2. Conclusion

In the paper, we looked deeper into the methodology of the EPRBA experiment. Especially we asked if it is possible that the estimated correlation in the EPRBA experiment can be equal to the quantum correlation. The result of the study is that it is not possible for a Kolmogorov probability $P(x \mid eq)$ to be equal to $\sin^2(x/2)$. This is because $\sin^2(x/2)$ is not monotone on $0 \le x < 2\pi$ while a probability $P(x \mid eq)$ must be monotone on the universe set $0 \le x < 2\pi$. Note $P(x \mid eq) = N(x \mid eq)/N$ is by definition a probability estimate, *i.e.*, frequency of an event, here "equal spin under angle *x*", divided by the total number of events measured, *i.e.* a Kolmogorov classical probability. It can *not* be not monotone.

It follows that the methodology of rpm correlation estimates disallows a Kolmogorov model to become equal to the quantum correlation in observations. The methodology excludes such a model beforehand from observation because $P(x|eq)$ cannot be equal to $\sin^2(x/2)$ on $0 \le x < 2\pi$.

Furthermore, because x is a continuous random variable, its probability density function is $\frac{\mathrm{d}}{\mathrm{d}x}P(x|eq) = \frac{1}{2}\sin(x)$. This is not a positive definite function for $0 \le x < 2\pi$. A Kolmogorov probability has a positive definite density function on the universe interval, $0 \le x < 2\pi$. The rpm correlation in (2) estimates the Bell correlation formula, which is based on Kolmogorov principles; *i.e.* probability density of hidden variables $\rho(\lambda) \ge 0$ and unity integral $\int \mathrm{d}\lambda \rho(\lambda) = 1$. The $P(x|eq)$ in (2) can not be anything else but a Kolmogorov probability.

We, therefore, are allowed to conclude that Bell's experiment is meaningless. It excludes by its statistical design, the data that the researchers claim to have investigated. A local causal explanation of entanglement is, therefore, still possible. In the recent past, the author, sometimes together with highly esteemed co-authors, gave some suggestive possibilities such as e.g., [11] and [12].

Declarations

The work was not funded. All data generated or analysed during this study are included in this published article.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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