Facts about Bell-test Experiments

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Abstract

This paper is about two facts concerning Bell experiments that are generally being overlooked. The first is the meaning of the probabilities that emerge from the results of the experiments. The second is the fact that detectors detect pairs of entangled particles from opposite positions and so in opposite directions. This has extreme implications which have never been taken into account. Understanding and applying these insights makes it rather easy to explain the results of Bell-test experiments in a local-real way. Consequently this means that entanglement, considered as interaction at a distance, doesn't exist. Entanglement only means that particles have opposite properties.

In Bell experiments pairs of entangled particles are being detected. Entangled means that the particles have opposite properties: they move in opposite directions and they have opposite spin direction, which is random in space for each pair. Two detectors detect the particles of each pair. They are placed oppositely, on the line of motion of the particles, and so they detect in opposite directions. Detection of the spin direction of a particle boils down to the measurement of the deviation of a particle's trajectory, caused by a one-directional field gradient in a detector. This field gradient can be adjusted by rotating the detector around the line of motion of the particles. So the field gradient of a detector can rotate in a plane perpendicular on the line of motion and in this way be adjusted in a certain direction.

The spin direction of a particle is positive if the deviation of the particle is in the direction of the field gradient and it is negative if the deviation of the particle is against the field gradient. Entangled particles have opposite spin directions, so when the detectors are adjusted in the same direction they measure opposite spin directions for the particles of a pair. And when the detectors are adjusted in opposite directions they measure equal spin results. This really is being measured. As the spin direction of a pair is random in space, it is to be expected that for all the pairs in one run of an experiment, each detector will find 50 % of the total number of measured particles to have positive spin and 50 % have negative spin. Experiments indeed show these results, irrespective of the adjustments of the detectors. When the detectors are adjusted in the same direction they show 100 % opposite spin result and when they are adjusted in opposite directions they show 100 % equal spin result. There is no problem with this.

Problems arise when the relative angle of adjustments of the detectors (φ) is somewhere between 0° and 180°. One would expect an equally proportional correlation between the probability for equal or opposite spin result and the angle φ between the relative adjustments of the detectors. Bell also expected this and he based his calculations on this equally proportional correlation. However, this equally proportional correlation doesn't occur in experiments. In experiments a sinusoidal correlation emerges, which is also predicted by QM. So Bell's inequalities are being violated.

The sinusoidal correlation seems to be very difficult to explain. For this difficulty are two reasons. First it must be recognized that a Bell experiment is in fact a probability measurement. The probabilities, emerging from the experiments, should clearly be defined and described and it should clearly be understood how they come about. In order to understand the probabilities correctly, the reference frames of the particles must be taken into account. This is therefore the second reason why the sinusoidal correlation is difficult to explain.

Let us start with the probabilities in Bell-test experiments. The results of Bell experiments are measurement results of spin directions of particles of entangled pairs. As the particles of entangled pairs have opposite spin, the detectors show combinations of opposite spin results for every pair they detect if their field gradient (their adjustment) is the same ($\varphi = 0°$). When the adjustment of one of the detectors (B) is changed to an angle φ ($0° < \varphi < 180°$) in respect of the other detector (A) then B will measure the particles differently compared with the way it measured the particles before (when φ was 0°). So now it becomes possible for combinations of equal spin result to occur. This doesn't mean that the particles of a pair that showed a combination of equal spin result, both have the same spin direction. That is not possible because of the fact that they are entangled and so have opposite spin directions. So the results of the experiments don't represent numbers of pairs of entangled particles with equal spin (because they don't exist) but the results of experiments represent numbers of combinations of equal results for spin measurement, which is very different. A combination of equal spin result is only possible because the particles of a pair are being measured differently when the detectors are adjusted differently. The probability for a combination of equal spin result to occur, solely depends on φ but this doesn't necessarily mean that the probability is equally proportional to φ. In fact it is sinusoidal proportional to φ, as QM and the experiments show. In the next part it will be explained how this sinusoidal probability comes about. For this we need reference frames, projection directions, observation directions and detection directions.

This is about a phenomenon that everybody sees but no one ever thought about.

When someone is standing left of you and someone else is at your right hand side, both looking at you, the left one will tell you that your nose is at the left hand side and the right one will tell you that your nose is at the right hand side. So you hear contradictory, and from your perspective even false, remarks. This means that an object only can correctly be described from its own perspective. The situation in Bell experiments is exactly the same as the above described situation because in this regard a pair of entangled particles can be considered as one object. The detectors detect entangled pairs from opposite directions and not from a direction that is correct in respect of the particles' reference frames. I shall now show that in this way the detectors cannot possibly detect an entangled pair as being entangled, meaning that the particles of a pair have opposite properties.

Fig. 1)

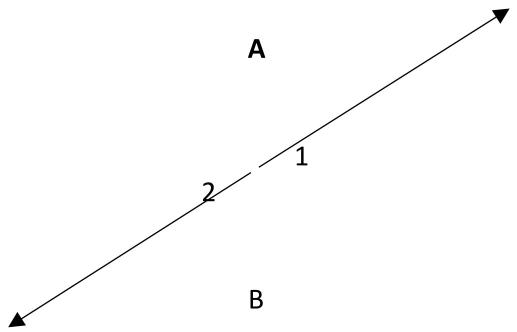

Fig. 1): The arrows (vectors) represent the spin directions of the particles 1 and 2.
The line of motion is perpendicular on the paper.
A is in front of the paper (at your position) and B is behind the paper (looking at you).
Spin directions are random in space.
Particle 1 moves towards A and particle 2 moves towards B.

Figure 1) shows the spin directions of two entangled particles: 1 and 2. Detector A, standing in front of the particles, detects particle 1 and detector B, standing behind the particles, detects particle 2. Before doing so they take a picture of the spin direction of their particle. Then B moves over to A to compare their pictures. The two pictures together don't show opposite spin directions so they don't represent the spin directions of an entangled pair. When A and B are at their detecting positions then what is on the left hand side to A, is on the right hand side to B and vice versa. So every time B moves over to A to compare the pictures, the spin directions appear on one side (see figure 2)).

Fig. 2)

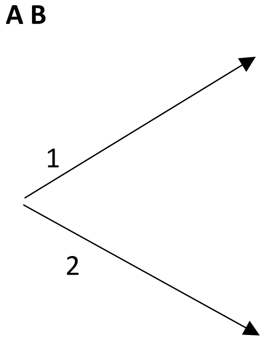

Fig. 2): B moved over to A in order to compare their pictures.

This means that entangled particles never can be perceived to have opposite spin directions when they are being observed from opposite directions. Entangled particles can only be correctly described from their own perspective / reference frame, so we have to determine their reference frames.

What is a reference frame? It is a composition of fixed directions in space. It can be composed by a line and a plane. A plane perpendicular on a line at a certain point of that line, determines a reference frame, and vice versa. So to establish a reference frame a line must be defined by a fixed direction or a plane must be defined by two fixed directions.

For the detectors the reference frame is defined by the direction in which they detect, which is the line of motion of the particles. The detection plane of the detectors is perpendicular on the line of motion, so this plane, together with the line of motion, makes their reference frame. The reference frame of the particles is defined by two fixed directions: one is the line of motion and the other is the direction of the field gradient that they experience when they enter a detector. These two fixed directions determine a plane and together with a direction perpendicular on this plane, the reference frame of the particles is defined. From this it is clear that the reference frames of the detectors and those of the particles don't correspond. In fact it is exactly the same situation as yours with the persons beside you, looking at you. To describe the particles correctly, they must be perceived from this perpendicular direction on the plane that is defined by the fixed directions for the particles, not from the direction in which the detectors detect.

When the spin directions of all the particles in the run of an experiment are being projected in this perpendicular direction, then the projection density of the projected spin directions (vectors) show sinusoidal proportionality to φ because in this direction the projection area changes sinusoidal proportional to φ. (This is demonstrated in [1]). This is the reason why QM's probability is sinusoidal proportional to φ.

QM's probability is a projection density per unit of area of spin directions (vectors) of entangled particles, projected in a direction that corresponds to the perspective of the particles (which is not the line of motion).

So QM's probability can be deduced by looking at the entangled particles from their own reference frames, that is: from a direction perpendicular in respect of the line of motion. This probability, however, cannot be measured directly by the detectors because the detectors detect in opposite directions and in this way they cannot detect entangled particles as having opposite spin directions. The combinations of equal spin result are therefore completely random but their numbers meet the deduced QM probability. So QM's probability only emerges after comparing the lists of results from both detectors afterwards.

All this has exactly been calculated in [1].

Conclusion

As QM's probability can be deduced in a logical way in agreement with local-realism, there is no need for immediate interaction at a distance. This means that entangled particles have opposite properties but they don't interact after the moment of their departure. The Universe can safely be local. Einstein was right after all.

Reference:

[1] Van der Ham, G; On the Relation between Bell's Inequalities and QM's Correlations in EPR-Bell Experiments
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