On the Detection of Direction

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Abstract

Basically detection of direction is a comparison of a direction with a known or a defined direction. A known direction is a direction in a reference frame and a defined direction is a direction in a coordinate system. In this paper the difference between a coordinate system and a reference frame is explained. Directions are defined by coordinate systems, but they are detected by reference frames. This has important implications for the detection of the spin direction of entangled particles, for the interpretation of entanglement and finally for the realisation of quantum computers.

Part One: Detection of directions

Although everyone knows what direction is, almost no one knows how to detect it. Basically detection of a direction is a comparison of the direction to a known or a defined direction. Direction is not a physical entity. Direction is given by the shape of an object or the movement of an object in respect to other objects. Direction can be represented by a vector.

In case of the shape of an object the direction is obvious: a needle or a pointer gives the direction.

Movement of an object is change of position in time of that object in respect of other objects. Position is a point in space. Mathematically space is an infinite empty volume. To define a position in that space a coordinate system is needed. The coordinate system can be chosen at will. It fixes the space as it were: every point, every position is fixed in space by the coordinate system.

Physical space differs from mathematical space. It is linked to time into spacetime. Spacetime may be infinite, it certainly is not empty. It is full of energy and forces. Spacetime is a kind of substance. Not a substance in spacetime but a substance of spacetime. It has properties of its own. In our non-relativistic world physical space can be treated as mathematical space. However, in physical space a coordinate system cannot be chosen at will: it always has to be defined in respect of existing objects, observers or detectors.

A reference frame is a coordinate system that is defined in respect of an observer or a detector. As an observer can move at will, and a detector can be placed at will, the coordinate system that is defined in respect of the observer or detector, moves along with the observer or detector. So a position is not fixed in space by a reference frame. A reference frame doesn't fix space: it is a coordinate system that can rotate or change position itself in respect of other objects.

Movement, being change of position in time, has a direction (one direction) at every moment. The direction can be represented by a vector. The vector has a length > 0.

A spinning object rotates around an imaginary axis. Applying the 'right hand rule' the spin direction along this axis is defined. This spin direction can also be represented by a vector.

An object can be observed from all directions. An observer can look in all directions. Yet an observer can look at an object from only one direction. Always. Looked at that object from another direction, it will usually look differently. So two observers looking at the same object will see that object differently. If the object is an arrow, it may point upwards for one observer, while it points downwards for another observer, depending on his position. If the object consists of two opposite arrows from which one observer can only see one arrow and another observer, who is at another position, can only see the other arrow, then things get complicated. The first observer (observer A) cannot know how the second observer (observer B) sees the other arrow, even if A knows that the arrows are exactly opposite. A cannot predict B's outcome and vice versa. Yet the combination of the positions of the observers determine the combinations of outcomes of the observations.

Applying a coordinate system could be a solution. When A knows the position of B, then B's coordinates of B's arrow can be transformed to those of A and then A would know B's outcome for B's arrow. If, however, the coordinates of arrows are unknown, a coordinate system doesn't bring a solution.

Now we can see the problems that arise when opposite spin directions from a pair of entangled particles, moving in opposite directions, is being measured and the outcomes are being compared to each other. It is not possible to predict the combination of outcomes for a certain pair. Yet there must be a condition for the pairs to give a certain combination of outcomes: equal or opposite. For there is a correlation between the relative positions of the detectors and the probability for a certain pair to give a certain combination of outcomes. In every repetition of an experiment in which spin directions of entangled particles are being measured, that correlation shows up. The condition for the pairs appears to depend on the relative positions of the detectors. To find that condition is the problem.

Part Two

I have a problem. The problem is that there is something I can't explain. Yet I can see it clearly in my mind. What I see, is a vector space. In it are pairs of opposite vectors. The shape of the vector space is that of two opposite cones with a common axis and a common tip point. The vector space is part of a sphere from which the centre is the common tip point of the cones and the diameter is the common axis of the cones.

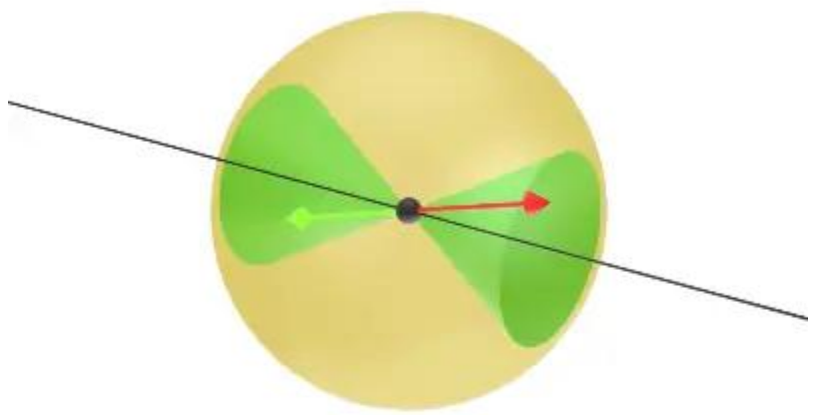


Fig.1 Opposite cone shaped vector spaces in a total spherical vector space.

The opposite vector pairs in the cones belong to pairs of particles. They represent the spin direction of the particles. Opposite vector pairs are not only in the cones: they are all over the sphere. And they also represent opposite spin directions of particle pairs. But the vector pairs in the cones are special. They belong to the particle pairs that show combinations of equal results when their spin is measured. The tip angle of the cones depends on the settings of the detectors that measure the spin direction of the particles. The tip angle of the cones is double the angle between the settings of the detectors. In fact the cones are obtained by rotating one setting around the other keeping the angle constant.

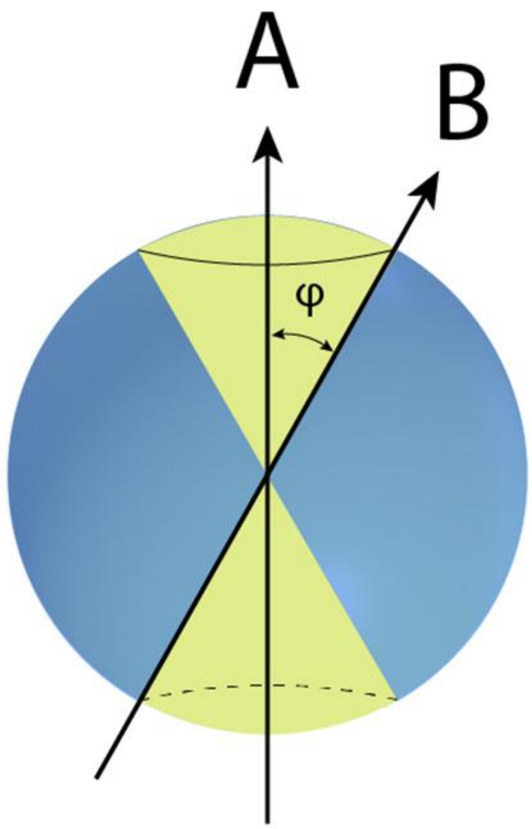


Fig.2 Relative angle between the settings of the detectors A and B.

The opposite spin directions of a particle pair are arbitrarily oriented in space. The opposite vector pairs, representing spin directions, of all the measured particle pairs are uniformly distributed in the sphere. The opposite vector pairs in the cones are special. All pairs in the cones yield combinations of equal spin result. All other pairs in the sphere yield combinations of opposite spin result. The number of pairs in the cones in respect to the total number of pairs in the sphere is equally proportional to the volume of the cones in respect to the total volume of the sphere, or, for that matter, the sum of the basic areas of the cones in respect of the total surface of the sphere.

This is true. It corresponds to the outcomes of experiments in which from a number of particle pairs the spin direction is measured. It has been demonstrated by a computer program producing random opposite vector pairs and counting the number of pairs in the cones. Remarkably the orientation of the cones in the sphere makes no difference. Every set of cones in the sphere gives a correct result as long as it is a fixed set of cones. This doesn't make it easy to deduce why it is the pairs in the cones that gives the correct results. Yet there is a special set of cones, as we shall see.

The particles of measured pairs move in opposite directions along a line of motion. To be able to detect the particles, the detectors have to be on that line of motion, facing the particles. It is this line of motion that defines the main reference direction. It determines a lot. For example the planes of settings of the detectors: the detectors have to be placed perpendicular on the line of motion and their setting can freely be chosen in that planes. It is not the absolute setting of the detectors but the difference between the settings of the detectors (the relative settings) that define the width of the cones, the number of opposite vector pairs in them and therefore the correlation, the correlation between the relative angle of settings and the probability to find a combination of equal spin results for a certain pair of particles.

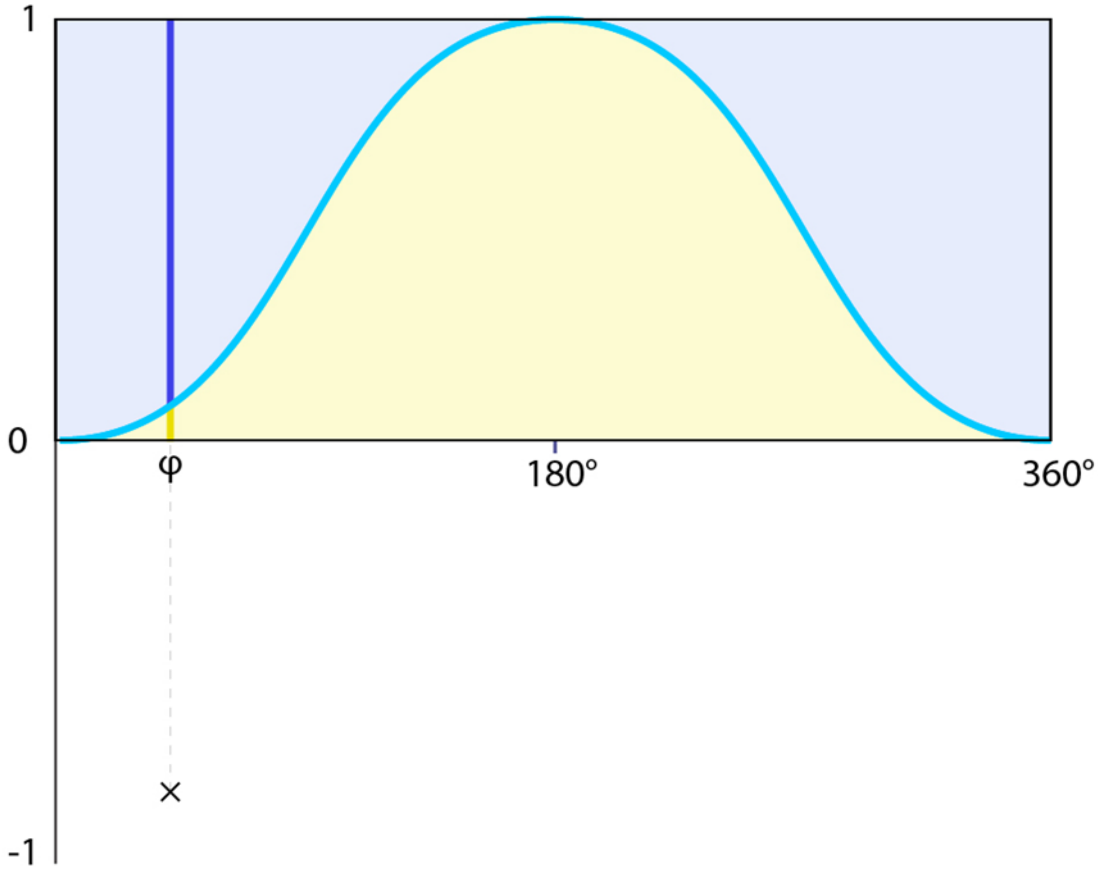
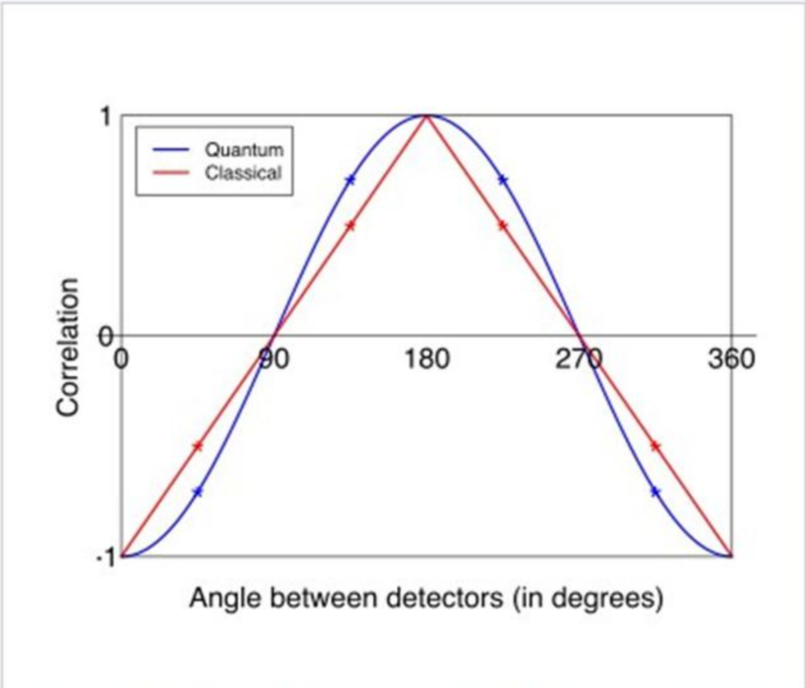


Fig.3 Probability for a certain random vector pair to be in the cone. The angle φ is the relative angle between the settings of the detectors. The tip angle of the cones is 2φ. Blue represents the probability for combinations of opposite spin result and pink the probability for combinations of equal spin results. The cross is the probability for equal spin outcomes minus the probability for opposite spin outcomes at that relative angle of settings (φ).

The probabilities for a pair of particles to show a combination of equal spin or a combination of opposite spin add up to 1. The correlation is defined as the probability for equal spin combination minus the probability for opposite spin combination (fig.4).



The best possible local realist imitation (red) for the quantum correlation of two spins in the singlet state (blue), insisting on perfect anti-correlation at 0°, perfect correlation at 180°. Many other possibilities exist for the classical correlation subject to these side conditions, but all are characterized by sharp peaks (and valleys) at 0°, 180°, and 360°, and none has more extreme values (±0.5) at 45°, 135°, 225°, and 315°. These values are marked by stars in the graph, and are the values measured in a standard Bell-CHSH type experiment: QM allows $\pm 1/\sqrt{2} = \pm 0.7071\ldots$, local realism predicts ±0.5 or less.

Source: Wikipedia

Fig.4 The blue negative cosine is the correlation shown in experiments and given by Quantum Mechanics.

The line of motion of the pairs of particles has nothing to do with the opposite spin directions of a pair: the opposite spin directions are totally random (yet opposite) oriented in space. But because mainly the line of motion determines the position of the detectors, it is the main reference direction. The cones with the line of motion being their common axis therefore are unique. I suspect that those cones are the cones which contain the real opposite vector pairs (the real opposite spin directions) of the particle pairs that yield combinations of equal spin results. This may be understood by realizing that there are three ‘direction systems’ involved in the measurements. One is the movement of the particles and their spin directions. Two is the position and setting of detector A and three is the position and setting of detector B. If one meticulously analyses the movements and rotations of both detectors in respect of the line of motion and of each other in reaching their final position at the moment of a measurement, one will find the correct cones at the exact position with their common axis being the line of motion. (If coordinate transformations are applied, for instance in a computer program in which the coordinates of generated vectors are known, then the direction system of the particles also has to be taken into account.)

The idea of rotations of the detectors in respect of each other and in respect of the line of motion of the particles explaining the correlation may seem strange, but if the position of an observer in respect of an object determines how that object is seen, then the positions of a combination of observers in respect of a combination of objects determine the combination of resulting pictures, or: then the positions of a combination of detectors in respect of a combination of directions determine the combination of outcomes, even if the directions are opposite and in fact one object. It is the rotation of the detectors in respect of each other and in respect of the line of motion of the particles that defines the relative positions of the participants of a measurement. And therefore the cones.

All this is based on the assumptions that the particles of a pair of entangled particles have opposite spin directions and that spin of a particle can be represented by a vector. If one of these assumptions is wrong, then correlation cannot be explained, unless it is some magic property of entanglement. But if these assumptions are correct, then this explanation of the correlation is very straightforward. We only had to discover which pairs yield combinations of equal spin results. They are the pairs that have their opposite spin directions in the cones defined by the relative angle between the settings of the detectors and the relative positions of the participants of a measurement. The problem I have is that this cannot be deduced (not more than I tried to do). Once you know, it is evident. But it had to be discovered first.

Since repeated experiments show the same correlations there must be a condition by which the pairs yielding combinations of equal spin results and the pairs yielding opposite spin results, can be distinguished. This condition appears to be that the pairs whose angle between their spin direction and their line of motion is smaller than the angle between the settings of the detectors (the pairs with their spin directions in the cones), yield combinations of equal spin result. The remaining pairs yield combinations of opposite spin result. And of course the particles don't need to know the setting of the detectors that measure them. It is just the combinations of outcomes that show this correlation.

This account for the correlation means that there is nothing special about entanglement: it is just that certain pairs of particles have opposite properties. They move in opposite directions and they have opposite spin directions. The probabilities for a certain pair of particles to show a combination of equal spin results or a combination of opposite spin results, are correctly given by Quantum Mechanics. These probabilities are defined by the relative angle between the settings of the detectors. They have nothing to do with the quantum states of the particles. These probabilities are represented on the Bloch Sphere. The probabilities of the Bloch Sphere are mistakenly ascribed to quantum states of qubits. Since quantum computers operate on qubits and make use of the probabilities on the Bloch Sphere and these probabilities do not apply to qubits, it is unlikely that quantum computers will be operational.

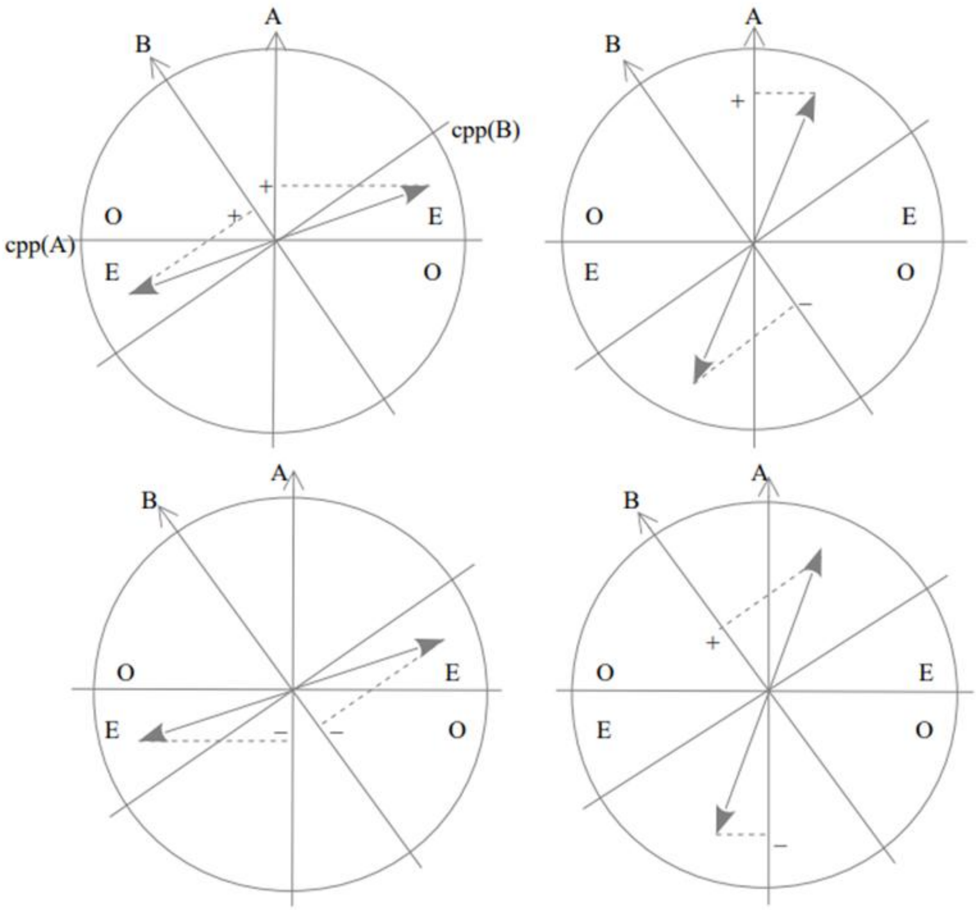
Reference:

Gerard van der Ham;   The Principle of Perspective   https://bell-game-challenge.vercel.app/

Appendix A

From one point of view it is easy to see which pairs yield combinations of equal outcomes and which pairs yield opposite outcomes. When A and B are at the same position, B slightly rotated in respect of A, then the sphere segments (E) between centre perpendicular planes (cpp) of A and B contain the pairs that yield combinations of equal outcomes. Pairs in the remaining spaces (O) yield combinations of opposite outcomes. See the figure in here.

This is the situation that yields Bell's inequalities: the red sawtooth line in fig.4. But in reality the spin directions are not being detected from one viewpoint. So Bell's inequalities are violated by experiments.



Figure

Left: pairs in E yielding combinations of equal outcomes. Right: pairs in O yielding combinations of opposite outcomes.

Appendix B

Time is equivalent to a direction in spacetime. Movement of an object is in one direction. Always. At any time. That is the reason why we experience time to have one direction. It is like a cyclist in calm weather. He always experiences himself to cycle against the wind, in whatever direction he goes. And the faster he goes, the stronger the wind or the more time he experiences and the slower his watch runs.