The Fourth Direction

Gerard van der Ham

Abstract

This paper is about the importance in physics of an extra direction axis, on top of the three direction axes of space. Such a direction can occur in different shapes: time, scale, object, surface or spin axis. All directions need a point of reference (the origin in a coordinate system). From that point a perspective has to be chosen: a direction to look in. From this obliged choice the Principle of Perspective is born, which is explained in this paper.

Did you ever realize that someone else cannot see your face as it is for you? I intentionally do not say: ‘as you see it yourself’ because you can’t see your own face. You can see your face in the mirror but the mirror image is not like your face. It comes close but it looks in the opposite direction. Rotating the mirror is no option because then the image of your face disappears. Taking a picture of the mirror image and then turn it in the right direction also is no option because then your right eye suddenly is on the left side. A picture of your face also is not like your face is for you: your right eye is left in the picture. A picture of your face is how your face is for someone else, but that was not the question. You could have made a wax sculpture of your face but even that is not like your face is for you for the same reason. And if you turn the sculpture in the right direction you would only see the back of it. You could even make a mould of your face and look at the inner side of the mould. Like the mirror image this comes close too but now the convex parts of your face are concave in the mould and vice versa. It just seems not possible for someone else to see your face as it is for you.

An object can be observed from all directions. An observer can look at an object from only one direction. This has nothing to do with time: it is true in any case. The point is: when an observer looks at an object, he/she can impossibly know how the object looks like from another direction. Of course he can look at the object from another direction but then he cannot see how the object looks like from the original direction. He also can take pictures of the object from different directions and compare them. But what does the comparison of the pictures mean? What do the pictures tell about the object? Nothing, unless the directions from which the pictures have been made, are given. This is an important note.

But, the above assertion that someone else cannot see your face as it is for you, is not true. If a picture is taken from your mirror image and that picture is turned in the same direction as your face, then indeed your right eye moves to the left. Only that is for you but you cannot see this because you look at the back of the picture. For the person opposite of you, your right eye is still at the right side of the picture. So with that picture he sees the mirror image of your face in the correct direction and that is how your face is for you. It only is not how your face is for him but that has nothing to do with the assertion that he cannot see how your face is for you.

But the above conclusion still stands that the comparison of pictures of an object do not tell anything about the object unless the direction from which the pictures have been made, is given. I call this The Principle of Perspective. Perspective is the direction in which an object is observed, measured or detected.

In 3-dimensional space there are three orthogonal directions: left-right (the x-axis in a coordinate system), front-back (y-axis) and down-up (z-axis). A fourth direction can show itself in different shapes. For example: past-future in case of time. Or small-big in case of scale. And inside-outside in case of an object, a physical body surrounded by a real or imaginary surface. A surface can be convex or concave, depending on the point of view. This makes surface another shape of the fourth direction. All these different shapes of the fourth direction play an important role in physics. Each of these shapes needs a point of reference and a perspective: a direction from which they are observed. For instance: a surface can be concave from the inside and convex from the outside. Yet it is the same surface. A coordinate on the x-axis can be either positive or negative depending on your position in respect of the x-axis. Yet it is the same axis.

Space is defined by a coordinate system. So a coordinate system makes space absolute, so to speak. But a coordinate system always is relative. Usually the positive x-axis is chosen to be to the right side of an observer, the positive y-axis to the front and the positive z-axis upward. When two observers look in the same direction they agree about the coordinate system. Now when the second observer moves over to a position opposite of the first observer, thereby turning so that they look at each other, then either the coordinate system stays as it was defined in respect of the first observer, or it moves along with the second observer whereby the first observer keeps its own original coordinate system. When it stays in respect of the first observer, then it is defined differently for the second observer because for him the positive x-axis is now to the left. When it moves along with the second observer then there are two different coordinate systems that are defined in the same way to each observer. These different but equally defined coordinate systems are reference frames. A reference frame is a coordinate system that moves along with the observer.

To describe an object an observer needs a coordinate system. The coordinate system is defined in respect of the observer and the object is described in respect of the coordinate system. This is no problem because the coordinate system is identical to the reference frame of the observer. Now when a second observer describes the same object from another direction he can only do that from his own reference frame because he can only look at the object from his direction, from his viewpoint, from his perspective. But the coordinate system of his reference frame is different from that of the first observer: either the system has moved along with the second observer or it has been defined differently for the second observer. So when two observers describe one and the same object from different directions, then the descriptions are in respect of different coordinate systems. The descriptions are not equivalent. They cannot be compared. Of course the descriptions can be put side by side and compared to each other but that comparison doesn't tell anything about the object unless the observation direction, the point of reference, the perspective, is given. This is the Principle of Perspective.

When 'object' is replaced by 'pair of entangled particles' and 'observer' by 'detector' and 'description' by 'measurement outcome', then this is exactly what goes on in Bell experiments. In Bell experiments the Principle of Perspective applies. It has to be taken into account to understand the correlations that occur in those experiments, the correlations between the combinations of outcomes of spin detections and the combinations of the settings of the detectors.

To explain this we consider spin. When spin of a particle is measured it shows 'up' spin or 'down' spin. Spin is a notorious difficult phenomenon to describe as is shown by the forces that occur in a gyroscope [1]. Some even assert that spin is a quantum mechanical phenomenon that one better not tries to understand. But that makes no sense. Spin is a rotational movement of an object around an imaginary central axis. When an observer looks along that axis he can see the object spinning right way around or left way around, depending on his direction of looking along the axis. To define the direction of spinning the 'right hand rule' is agreed. Applying that rule, spin can be represented by a vector: put the fingers of your right hand in the spinning direction of the particle and your thumb gives the direction of the vector.

The spin axis is another shape of the fourth direction. It has a point of reference: the particle, and a perspective: a direction from which it is observed. The spinning direction of the particle around that axis depends on the direction from which the particle is observed. Spin of the particle, defined by the right hand rule, on the contrary, is a vector. It only has one direction from whatever perspective it is observed.

The spin axis of a particle has a random direction in space. The particle moves along a trajectory, a line of motion. This line of motion has a certain direction in space. The direction of the spin axis and the direction of the line of motion are totally unrelated: they can be totally different directions. Like an observer, a particle also has a reference frame. We can take the point where the particle starts to move as point of reference and the direction of its movement as perspective. This is the reference frame of the particle (defined by its line of motion). Spin of the particle can be described in respect of this reference frame. Then the position and direction of a detector that measures the spin of the particle, have to be described in respect of that reference frame of the particle too, according to the Principle of Perspective. Otherwise the spin detections have no meaning.

Particles of an entangled pair have opposite properties. Those particles are produced together at the same time and the same place. They travel in opposite directions and they have opposite spin, meaning that they rotate in opposite directions around parallel axes. This means that the vectors representing their spin, point in opposite directions. Since particles of an entangled pair travel in opposite directions, two detectors are needed to measure their spin. These detectors 'look' in opposite directions. Each detector measures at a random setting. Each detector measures one particle of a pair. The outcomes of the measurements of a pair of particles can be compared but, as we have seen, the compared outcomes don't tell anything about the spin of the particles unless we know how they are detected, meaning that we know the settings of the detectors when they measured the particles. Since spin of entangled particles is opposite we know that the combination of outcomes is opposite spin when the detectors detect at the same setting and the combination of outcomes is equal spin when the detectors detect at opposite settings. In case of randomly different settings we can only tell the combination of outcomes (equal or opposite) if we know how the combination of spin outcomes depend on the combination of settings of the detectors. Fortunately the settings of the detectors are vectors too. The movements of the detectors in respect of the line of motion (the trajectory) of the particles and in respect of each other, in order to be able to detect the particles, define a vector space. So that vector space is defined by the fact that the detectors are perpendicular on the line of motion of the particles, by the fact that they detect in opposite directions and by the angle between their settings. The spin directions of pairs (vectors) that belong to that vector space yield combinations of equal spin and the spin directions of pairs that do not belong to that vector space yield combinations of opposite spin. It turns out that if the angle between the spin direction of a pair and the line of motion is smaller than the angle between the settings of the detectors, then that pair will show a combination of equal spin outcomes.

Perspective is the direction in which an observer looks or a detector measures. When an object is detected from opposite directions, then the outcomes are not equivalent because the object is detected in respect of different reference frames. The outcomes of the detections can be compared but they don't tell anything about the object (spin direction/vector) unless the directions of the detections (the perspectives) are given. To make the comparison of the outcomes of the detections equivalent and meaningful, the outcomes must be described as if they are obtained from detections from one perspective. To accomplish this, the movements of the detectors in respect of each other and in respect of the object has to be taken into account. This is the full meaning of the Principle of Perspective. How this can be done, is extensively described in [2]. At that site the movements of the detectors are made visible, as well as the vector spaces that are produced by those movements and computer programs show that for randomly produced opposite vector pairs in the concerning vector spaces the correct correlations show up.

Many readers of that site strongly believe that non-locality is introduced in the programs. It is not. The only data that is used for calculations is data that is available at the moment of comparison of the outcomes plus the knowledge of which pairs show combinations of equal outcomes and which pairs show combinations of opposite outcomes. That knowledge comes from the Principle of Perspective. That knowledge is needed to calculate the correct outcomes. To calculate outcomes a coordinate system is needed. As explained in this paper that knowledge about the pairs cannot come from the coordinate system because there are two different coordinate systems, so the Principle of Perspective is needed. And this knowledge causes the appearance of non-locality but it is really not there. Coordinate systems play no role in experiments. In experiments particles are measured and detectors show outcomes. That is all. And the outcomes that show up in experiments are exactly the same as the outcomes calculated by the computer programs in terms of correlations.

Reference:

[1] Vincent Icke; The Force of Symmetry (book).

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