Entanglement

Elementary particles can undergo *interactions*, i.e. they can influence each other by exerting a force and sometimes they even modify one another, i.e. they disappear and other particles come into being.

A collection of elementary particles undergoing mutual interactions or originating from the same event is called a *quantum system*. For example an atom, in which all electrons, as well as the atomic nucleaus, are continuously interacting with one another, is a quantum system. An elementary particle can be a member of just one quantum system at a time. This means its very last interaction determines which quantum system it belongs to.

Elementary particles (e.g. electrons) behave as if they are spinning around their own axis, a property which is simply called *spin*. Since we can measure it in just one direction at a time, there are only two relevant possibilities, which we call *spin up* and *spin down* (according to the corkscrew rule). Calling one of them positive and the other negative their total may on average be expected to be nought.

Several conservation laws like the law of *conservation of energy* apply to quantum systems. One other such law is the *conservation of spin*. A conservation law says the total value of the relevant property does not change, e.g. energy or so does not just come into being, nor can it disappear.

Now suppose two electrons collide and then move away from each other. This collision ***is*** an interaction isn't it? So from then on, these electrons form a new quantum system and both have "unsubscribed" from the respective quantum system they may have been part of before this collision. The new quantum system that evolved from this electron collision of course obeys all laws that apply to quantum systems, such as the aforementioned conservation laws.

This means these two electrons, being a quantum system, must now
together obey these laws, even if they are at a great mutual distance.
THAT is entanglement.

Entanglement lasts until either one of the entangled particles undergoes another interaction, which makes the interacting particle a member of a new quantum system toegether with this interacting particle (whatever it may be) and the other one has then become a free particle. The entanglement of the electrons that collided is then broken.

Suppose the total spin of the entangled electrons equals nought. Then it must remain nought as long as these electrons are entangled, even if they become separated by a very large distance. It means we know the distant electron's spin by measuring only the one that is nearby.

A measurement can only be done by letting some other particle, for example a photon (a light particle, the smallest possible fragment of a ray of light), interact with the measured electron, thus breaking the entanglement.

One of the mysterious fundamentals of quantum mechanics is that these electrons themselves do not "know" their own spin until measured! Properties become only relevant when an interaction occurs with another particle. As soon as that takes place the measured electron knows and reveals its own spin and then its distant entangled partner instantly knows it as well. Einstein called it spukhafte Fernwirkung, spooky action at a distance, and he considered it impossible because the information of this interaction would exceed the speed of light. It has however been confirmed by experiments.

The measur*ed* electron has now formed a new quantum system with the measur*ing* particle. The latter will however very soon interact with the actual detector of the measuring device, which is yet another interaction, breaking this secondary entanglement.

Now both electrons are free until they undergo some other interaction with some other particle at some time, somewhere in the universe.