Re: Spontaneous supersymmetry breaking

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saju wrote:

> Greetings,
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> Assuming that during the very early instances of the big bang there did exist a supersymmetric 10−D universe, what triggered the symmetry breaking and resulting 6−D compactification and particle creation ?
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> Does a drop in temperature because of the expansion after big bang cause super symmetry to be broken ? Why ? If the answer is known, can it be explained in "interested layman" terms please :) ?

Since supersymmetric particles have not yet been observed, it is not known whether supersymmetry actually exists and has been broken. In that sense, the answer is not known. However, the physical phenomenon of spontaneous symmetry breaking (SSB), that the proponents of supersymmetry are trying to leverage, is well known as well as widely observed and studied.

The simplest example of SSB is a magnet. A magnet has a magnetic moment because the spins of its electrons or nuclei have aligned such that their sum gives a non−zero total magnetization. But if you heat up the same magnet, after a certain temperature (called the Curie temperature, incidentally), it looses its magnetization−−−the electron and nuclear spin alignment is lost. Notice that temperature does play a crucial role here.

So what happened? Recall that heat is motion. The higher the temperature, the more microscopic motion will there be inside a solid. The lower the temperature, the lower the total energy of the solid wants to be.

At high temperature, everything is moving around. For instance, nuclear or electronic spins are twirling and pointing in different directions, ignoring what their neighbors are doing. Because they have no special direction to point in, on average, the sum of individual spins will come out to zero−−−no magnetization.

But at lower temperatures, the spins don't twirl around too much and pay more attention to what their neighbors are doing. At some point, the spins notice that they like to point in the same direction as their neighbors (such configurations have lower energy). And, once the temperature is low enough and the spins are rotating sufficiently slowly, they notice that they'd like nothing better to do than for all of them to point in the same direction (the state with the lowest available energy).

But here's a puzzle. If we start with a heated magnet (such that it's not magnetized) shaped like a sphere and then cool it down, once it acquires a magnetization, which way will it point? After all, there's nother special about any way in which the sphere is oriented.

Here we come back to the name of the phenomenon: spontaneous symmetry breaking. The symmetry breaking corresponds to the fact that once the sphere becomes magnetized, we can identify two special points on its surface: the North and South poles. So, the rotational symmetry of the sphere has been broken. The word spontaneous tells us that the answer to the puzzle above is: very hard to know in advance.

Examining the transition between the non−magnetized and magnetized states, we find that at the transition temperature the non−magnetized state becomes unstable. It is unstable in the same way that a ball sitting at the very apex of a hill. It is in equilibrium. As long as it is not touched it will stay there for every. However, even the tiniest gust of wind or the smallest tremble of the ground will send it rolling. The ball can roll to the left or to the right depending on what force had upset its equilibrium. Physicists say that the ball spontaneously chooses the direction in which to roll. Same for the magnet, the direction of the acquired magnetization could have been influenced by any number of things, from the Earth's magnetic field to the field generated by a nearby computer monitor.

To conclude, here are the ingredients for spontaneous symmetry breaking. There needs to be a symmetry to the individual components of the system. For example, in a magnet, spins are free to point in any direction. At high enough temperatures, the system should be describable as a collection of non−interacting individual components. In this phase, the symmetry is unbroken. For example, this is the high temperature non−magnetized phase of a magnet. Then, at low temperatures, the individual components can no longer be considered non−interacting and they tend to orient themselves in the same way as their neighbors. In a magnet, at low temperature, individual spins like to point in the same direction as their neighbors.

Lets come back to supersymmetry. Every particle is presumed to have a fermion and a boson component. A continuous transformation (much like a rotation) between the components is the symmetry in question. If the interaction between two nearby particles energetically favors both of them to be of the same statistics (bosonic or fermionic), then at low enough temperature one would generically expect a symmetry−broken phase, where each particle is either a fermion or a boson. So, in this scenario, given the cooling of the universe as it expands, it is not unreasonable to expect breaking of supersymmetry.

Hope this helps and was sufficiently in "interested layman terms".

Igor

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