The Higgs boson

1 What is the Higgs?

To make the Standard Model of Particle Physics (which I shall describe hereunder) work, it needs a unique completely new particle which gives other particles mass, the Higgs boson. The existence of the Higgs was predicted by Dr. Peter Higgs and Francois Englert.

The Standard Model of Particle Physics is the best answer we have to the question: “What is everything (including humans) made of when we break it down to its smallest components?” We all know everything can be broken down to molecules, atoms, particles, sub-atomic particles and forces. An atom consists of a nucleus surrounded by electrons. The nucleus consists of protons and neutrons (except hydrogen with one proton and an electron). Protons are positively charge particles and neutrons are neutral. Protons and neutrons can be broken down into quarks and gluons. A Proton consists of two up quarks and one down quark and a neutron of two down quarks and one up quark. For every particle there is an anti particle like the anti proton, anti neutron except the photon which is its own anti particle.

This brings us to the force carrying particles. Gluons carry the strong force holding the quarks together. Only quarks can experience the strong force. Quarks are part of fundamental particles since it cannot be broken down into other particles. Electrons are another example of fundamental particles since it cannot be broken down into other particles. The electromagnetic force is carried by photons (quanta of light) and is experienced by all charged particles. The weak force is carried by the W and Z bosons and is experienced by all particles. Gravity does not fit into the Standard Model and is described by

Einstein's General Theory of Relativity. It is believed that the force of gravity is carried by the graviton but this could not be confirmed.

The reader can skip the following technical description of the Higgs and still understand the significance of the Higgs for the Standard Model. The Higgs is the smallest possible excitation of the Higgs field. The Higgs field, can, unlike the electromagnetic field, not be turned off. Instead it takes on a non-constant value, almost everywhere. (Described by Wiki.) The presence of this field explains why some particles have mass and why the weak force has a much shorter range than the electromagnetic force.

The word boson usually causes a lot of trouble because it is often not understood. Boson is the name for a generic class of particles. In the Standard Model all particles that carry forces are gluons, the W and Z photons plus the graviton, if there is one, are bosons. On the other hand quarks, electrons and neutrinos are called fermions. Bosons have integer spin. The Higgs has zero, the gluon, photon and W and Z particles have one. The graviton has two units of spin while quarks, electrons and neutrinos are fermions with half a unit of spin.

It should be noted that the force carriers are vector bosons. Instead of thinking about the Higgs as a particle we should think of it as a field. Fields described by a single number are called scalar fields and have no direction. Other fields, such as the electric and magnetic fields and the Higgs field have direction and are called vector fields. In addition to the particles described here there are also the tau and muon which are just like electrons, just heavier. Those are all the particles we know of. Below is an image of the Standard Model of Particle Physics.

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