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News

The search for Higgs



Tantalising evidence for the existence of a fundamental particle, which has been predicted but never observed, won for the world's largest particle collider a brief stay of execution, but was not enough to save it.

CERN's Large Electron Positron (LEP) collider in Switzerland was due to be decommissioned in October, to make way for the construction of its replacement, the Large Hadron Collider, which will take five years to build. However, at the beginning of September, scientists at LEP announced that they had observed several unusual events which could have been the signature of the elusive Higgs boson.

The scientists asked for more time to confirm their results, and the LEP continued running until 2 November. At that point, however, with conclusive evidence still lacking, CERN decided to close the LEP and go ahead with dismantling it and building the LHC. Although it is likely that the LHC will be able to detect the Higgs particle conclusively, the fact that it will not be operational for five years means that the Fermilab collider in the US, just outside Chicago, is likely to get there first. Earlier last year it was Fermilab who announced that they had direct evidence of the existence of the last of the 12 postulated building blocks of matter, the tau neutrino.

The source of mass

The most elegant working theory of the interaction of elementary particles requires the masses of all the particles to be zero. However the particles are observed to have masses, and moreover these masses are different. To solve this apparent conflict, thirty years ago Peter Higgs proposed a mathematical solution in which the particles move through a field, the Higgs field, which in many ways closely resembles empty space. As the zero-mass particles move through the field they interact with it and experience a drag, which we observe as mass.

Where does the Higgs particle come into this? Well, all particles exhibit wave-particle duality particles sometimes behave like waves and sometimes like self-contained objects, depending on how you look at them, so the Higgs particle could be taken as a snapshot of the Higgs field (the "surface" that the "waves" travel across) in a tiny instant of time.

It's hardly surprising that finding an object which closely resembles empty space has proved to be difficult. However, a team conducting research at CERN claimed to have seen traces of Higgs in the subatomic debris left over after particle collisions in recent experiments.

The search for Higgs

The discovery of the Higgs particle would vindicate this theory of the Higgs mechanism by which particles acquire mass, and would therefore be a crucial moment in the history of particle physics. Cosmologists would also be particularly interested if the Higgs is proved to exist, as the existence of particles of this type is fundamental to the theory of inflation, which models the growth of the early Universe.

The Standard Model

The Higgs particle is part of the so-called Standard Model, a mathematical description of what we believe the ultimate components of matter and force look like. The Standard Model was given a huge boost last July, when scientists at Fermilab announced they had seen the tau neutrino – completing the 12 building blocks of matter that were predicted to exist.

How are such predictions made? Fundamental to the modern understanding of particles is that they obey certain symmetries. *Group theory* is a powerful mathematical technique for studying symmetry. Thus, although group theory was invented as a purely mathematical idea with no known physical applications, it has turned out to be very important to particle physics. Experimental results led theorists to hypothesise a collection of particles that compose matter with a particular symmetry group, but this included particles that had never yet been observed. The tau neutrino was the last of them to be experimentally confirmed.



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