On The Origin of Mass of Fundamental Particles

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Abstract

This paper aims to give basic theoretical approach in order to interpret the origin of masses in elementary particles. This solution of mass problem is very crucial and forms a fundamental base in theoretical particle physics. For particle and nuclear physicists this solutions is a holy grail in particle physics. Particles of group fermions and bosons are evolved without mass this means these were massless [1] at the beginning, but soon they acquire mass by an interaction which is called as mechanism known Brout-Englert-Higgs mechanism.

Keywords: Gauge Bosons, Higgs Field, Electroweak Symmetry.

Note: - Gauge Boson: spin 1, Scalar Boson: 0 spin

Please Read the paper "The Origins of The Brout-Englert-Higgs mechanism" CERN archive for better understanding of this paper.

The BEH Mechanism

The Gauge invariant theory (simply theory of gauge bosons and its interactions especially the force carriers) for weak force was somehow unsuccessful due to the violation of the symmetry requirement which predicted that both electromagnetism's gauge boson (photon) and weak forces gauge boson (W,Z bosons) should be massless, however experiments showed that photons are indeed massless but weak force's bosons have mass. This experimental outcome simply states something unknown may be something weird but interesting things are giving them mass. This means electroweak symmetry of mass is broken. The solution of this problem that what is responsible for this electroweak symmetry breaking was theorized by Robert Brout, Francois Englert and Peter Ware Higgs in 1964 when they published a paper in Physical Review Letters, the road to the solution of this particular problem can be explained by the introduction of an unusual kind of field that exist in the entire universe the field now called Higgs field, it is really wired but far interesting as its theoretical indications are concerned. The Higgs field is a scaler field with four components, two neutral and two electrically charged components which have a non zero constant value in vacuum. An essential feature of the field is that it takes less energy for the field to have a non zero value or simply vacuum expectation value (VEV). Few seconds after the big bang the universe began to cool down then this Higgs field of Mexican hat shaped potential spontaneously grows. Below a certain extremely high energy level the existence of this field spontaneously breaks electroweak gauge symmetry which in terms generates the Higgs mechanism and triggers the origin or acquisition of masses to those particles interacting with this field.

This so called mechanism which we instantly call as effect occurs in its (field's) vacuum states the field breaks the weak isospin symmetry of electroweak interaction, simply the field breaks the electroweak symmetry, when this happens the three of the four components (two charged and one neutral) of the Higgs field are absorbed by gauge boson to acquire mass. The remaining electrically neutral component of the field either excites as a Higgs Boson or interacts separately to other particles known as fermions via Yukawa interaction simply causing these fermions to acquire mass as well. The Higgs boson is a quantum excitation of one of the four components (neutral component) of the associated field.

This field is however scalar means it does not transforms under Lorentz transformation and has imaginary mass (mathematically) and therefore a tachyonic (faster than speed of light imaginary, but here as imaginary mass) field. This imaginary mass creates instability; any condition in which one or more field excitation (scalar boson or Higgs Boson) is tachyonic must spontaneously decay and the resulting condition has no physical tachyonic. This process is known as tachyonic condensation and explains the Higgs mechanism itself arises in nature and therefore the reason for electroweak symmetry or gauge symmetry breaking. Higgs boson is a quantum excitation of the neutral component of Higgs field such that Higgs boson has no charge, no spin and is also its own antiparticle and this boson is highly unstable due to the field of imaginary mass but it then decays into other bosons and fermions due to tachyonic condensation.

Francois Englert and Peter Ware Higgs: Nobel Prize in physics 2013

Electroweak gauge symmetry

Symmetry of electroweak interaction

Electroweak symmetry

Gauge symmetry