Higgs Boson: The Nobel Winning Particle

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Nobel Prize, the most prestigious honor awarded to physicists in his life time for outstanding contribution to physics. In 2013, Nobel Prize in Physics has been awarded to physicist Peter Higgs along with F. Englert for their contribution of Higgs Boson, the particle which is supposed to give mass to other particles. Higgs boson is also known as the God particle named by Leo Lederman. And it deserves the name. The dilemma of how a particle gets mass was theorized by these scientists in back 60s which has been confirmed experimentally on March, 2013 in Large Hadron Collider, world's most costly laboratory. Since Nobel Prize cannot be given to more than three people at a time, and also not to dead scientist, so these two scientist were awarded with the prize and other scientists were awarded another high honor with J.J. Sakurai Prize in theoretical physics in 2010.

In very simple words, Higgs mechanism explain us how a particle can get mass. There exist a Higgs field throughout the space, the particles interact with the bosons of the field and generate mass. Electromagnetic nature particles cannot interact with Higgs field that is why Photons do not possess rest mass. If you are comfortable with little bit physics, the above said can also re-written as "Higgs Mechanism is a process by which a vector boson get rest mass without explicitly breaking the Gauge invariance as a byproduct of spontaneous symmetry"

In 1964, Peter Higgs along with his colleagues F. Englert, Robert Brout, Gerald Guralink, C.R. Hagen, Tom Kibble published three outstanding papers on broken symmetry of standard model and introduced the concept of Higgs field. These three papers were regarded as the milestone papers during Physical Review letters 50th anniversary. All the six scientist carried out their independent research work which eventually led to similar consequences.

Some of you may wonder, if six scientists were involved in the prediction of the bosons, why then it is known after Peter Higgs. It is termed as Higgs Boson, because the major contribution of predicting the massive scalar boson's existence in the standard model of the universe was carried out by Peter Higgs alone. Others were involved in focusing on vector bosons. After his publication, other scientist had published their assumptions. Another important characteristic of Higgs boson is that it is the first known scalar particle to be discovered in nature.

Why do we need Higgs field? Simplicity and unification of all fundamental forces and particles led to the discovery of standard model. This is the ultimate model of the universe, it describes how a particle interact with its force carrier particle, what are the fundamental forces in nature, their behavior. Although it can describe physics from quarks to big bang, but some how this model is not a complete one. Two major drawback of the model it cannot describe Gravity, and mass of the gauge bosons. Although now-a-days, the neutrino mass modelling leads to a physics beyond standard model, we are not considering it here. In 1960, particle physicist realized that the two fundamental forces of standard model viz. electromagnetic and weak interactions are the same at very high energies and to retain the symmetry of

the standard model mathematically, all the force carrier particles i.e. the gauge bosons must be massless. But, experimentally it has been found that W and Z bosons have very high masses. The standard model must retain its symmetry under gauge transformation mathematically. And this symmetry is maintain if and only if the mediator particles are massless. To overcome this dilemma, Higgs mechanism was introduced. In 1964, six scientists developed a mathematical model which explains that bosons can be massive despite their governing symmetry. To explain the detail mechanism, neither I can write it here, nor you can understand it without having extra-ordinary mathematical skills.

In a simple explanation, the condition of symmetry would be broken if a hypothetical field would exist throughout space, via which the particles would be able to have mass. This field is termed as Higgs field which breaks certain symmetry laws of electroweak interaction causing the mediator particles to be massive. So we have now retain the symmetry of the model as well as we have the gauge bosons theoretically massive.

Higgs along with the other scientists were much confident that this particle would exist to give mass. With lots of hard work of several scientists from different corner of the globe, billions of dollars spent, finally we have got the ultimate result of the higgs boson in LHC.

Mass; the very basic fundamental quantity of physics. Still pretty much diffuclt to understand how it comes. Salute to these physicists, in back 60s, without having much experimental facility, they assumed the mathematically very strong hypothetical particle, and now we have the explanation of mass. A long waited Nobel prize in the history of Physics, over 40 years. And they deserve it. Kudos.

Remember, as Blackholes are not completely black, Vacuum is also not completely empty.

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