The Mass of the Higgs Boson Should be Zero*

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If the Higgs boson does mediate a vacuum coupling which gives all particles mass, then it should not itself be massive.

* An earlier version was posted as a blog at the *Science 2.0* web site (`http://www.science20.com/experimental_logician/blog/there_shouldnt_be_massive_higgs_boson`). The present rewrite is based in part on insightful contributions by other discussants.

Introduction

Consistent with the Standard Model of particle physics, there is postulated a ***Higgs field*** which determines the masses of those particles which are massive. Fields in modern quantum theory are mediated by virtual particle exchange. For example, the electromagnetic field is mediated by exchange of transversely polarized photons.

What are the properties of the Higgs field?

Most obviously, because the Higgs field determines rest mass, its effects must be Lorentz invariant. Therefore, it must be a differential field in which position is undefined.

A similar "field" is that of the vacuum permittivity ε_0, which is the same everywhere and which, with the vacuum permeability μ_0, determines the speed of light c, which latter, of course, is the same in all inertial frames. I am not claiming here that vacuum permittivity or permeability depends upon virtual exchange of some particle; I am merely pointing out that the vacuum displays differential properties in which position is undefined. These properties imply that c is the same in all inertial frames. If the vacuum did define position, space would allow for an absolute coordinate grid of some kind, something well known to be false. Therefore, it seems reasonable to allow for a Higgs property of the vacuum, the ***Higgs field,*** which couples individually to each massive particle to give it its proper rest mass.

The Problem

The problem is lack of parsimony: If we don't need a "permittivity particle" to describe electrical properties of the vacuum, why should we need a "mass particle" to describe the mass-giving properties of the vacuum?

The "mass particle" in question is the ***Higgs scalar boson*** -- a scalar to represent the differential nature of the Higgs field, and a boson to account for its assumed zero (or maybe unit) spin. By analogy, the electromagnetic forces are mediated by exchange of photon bosons, the weak force by exchange of W or Z bosons, the strong force by gluon bosons.

All these bosons have positional properties (position wavefunctions) and interact with other particles which, in turn, also have positional properties. But, the Higgs boson must have differential properties, only, as will be discussed below.

The Higgs boson is calculated from Standard Model consistency not to be massless, but rather to have a mass probably between 100 and 200 GeV/c^2, as much as twice the mass of the weak force bosons. According to this model, the Higgs boson may possibly have a mass as great as 1000 GeV/c^2, but not more than this.

Inconsistencies

One of the goals of ongoing work at the Large Hadron Collider at CERN is to observe the Higgs boson. But, if it defines only a nonpositional field, why should energy concentrated at a certain position, the collision point, make any difference?

There is, further, an apparent logical consistency problem with the idea of a massive Higgs boson: If it couples to other particles to give them mass, how can it be massive itself? If it were massive, it seems that this would imply existence of yet another particle which gives mass to the Higgs boson. Claiming that the particle responsible for giving mass to other particles has mass seems a little like claiming that photons, which mediate the electromagnetic force, should have electromagnetic fields. This raises a doubt by analogy, but it proves nothing.

Ignoring this apparent logical inconsistency, there is a different, more directly physical inconsistency in assuming a massive Higgs boson: If the Higgs boson is massive, and if it mediates rest mass (couplings) by vacuum virtual exchanges, the exchange rate must be subject to Lorentz time dilation. Because other forces grow with boson exchange rate, time dilation would suggest that the Higgs-determined rest mass of any particle should decrease with increasing relativistic velocity (boost). Each different particle type would have a different coupling to the Higgs, but the mass resulting would decrease with increasing velocity -- in the limit, the rest mass, and therefore the momentum, of a particle would go to zero in any inertial frame as its velocity in that frame approached c. This seems inconsistent with data from collider experiments -- for example those at SLAC, which depend simply on well-known mass values of electrons and positrons.

In collider experiments, the momentum of the particles collided always seems perfectly consistent with the Lorentz boost value of γmv, in which m is the original rest mass, unchanged because of the boost.

Thus, it appears that there may exist a Higgs vacuum field, but there may not exist a Higgs boson. And if there is a Higgs boson, it should be massless.

Conclusion

Clearly, one way out of this dilemma would be to assume that the massive Higgs boson existed, but that it merely was named for Higgs and was not involved in the value of rest mass measured for other particles. This suggests, too, that such a particle would not show all the expected properties of the Higgs boson of the Standard Model.

How can the preceding objections be answered? Probably, by allowing that the current Standard Model is not entirely correct. The Standard Model apparently is wrong about the mass of neutrinos, so why should it be accepted uncritically in regard to the mass of the Higgs boson? Should we put the Standard Model, a useful analogy for most of particle physics, ahead of relativity?

My conclusion is just that if something fitting the description of the Higgs field exists, it must be defined by virtual exchange of massless particles.