Higgs Boson Mass Can Be Derived From Masses of Z and W Bosons

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For many decades, the Higgs boson was the missing piece of the Standard Model of particle physics — the successful theoretical framework that describes all of the known fundamental particles and their interactions. While the Standard Model predicts the existence of the Higgs boson, it does not predict a specific mass for the particle — this must be determined through experimentation. The masses of the other fundamental particles also must be measured and, to date, there does not appear to be any logical way to derive one mass value from the others. This does not appear to be the case for the Higgs boson, however. Here the author shows that the mass of the Higgs boson can be calculated using the mass values of the Z and W bosons, which represent two of its primary decay channels. The implications of this are potentially far-reaching, particularly as it suggests that the boson discovered at the Large Hadron Collider (LHC) is not a fundamental particle, but instead is derived from Z and W bosons.

The Z and W bosons are carriers of the weak force, in a similar way that photons carry the electromagnetic force. The weak and electromagnetic forces can be combined into a single framework called the electroweak force. Theoretically, the weak and electromagnetic interactions should have the same strength. However, the weak force, as its name implies, is far weaker than electromagnetism. The weak force is thought to lose "symmetry" with the electromagnetic force because its carriers, the Z and W bosons, interact with a complex scalar field — the Higgs field — and in so doing gain mass, while their electromagnetic counterpart, the photon, remains massless when moving through this field. Being heavy particles, the Z and W bosons create a "weaker" force than the photons. The Higgs field is predicted to permeate all of space, and the quantum of this field is the Higgs boson.

The ATLAS and CMS laboratories of the LHC recently combined their mass measurements to determine the most precise mass measurement of the Higgs boson to date:[1]

$$\mathbf{M_H = 125.09 \pm 0.24\ GeV/c^2}$$

Unexpectedly, the 125.09 GeV/c^2 value is approximately one half of the combined mass values for the Z and W bosons, with the Z boson mass being 91.1876 GeV/c^2 and the W bosons being 80.385 GeV/c^2 each:

$$\mathbf{M_H \approx \frac{M_Z}{2} + \frac{[M_{W-} + M_{W+}]}{2} = 125.98\ GeV/c^2}$$

The calculated value over the measured value yields a result of 1.00711, showing good agreement between the two. A prior study reported an apparent relationship between the Higgs boson mass and the mass of the Z boson and the top quark, yielding a calculated value of 125.9 ± 0.4 GeV/c^2.[2] However, the Higgs boson does not appear to decay into top quarks, but it does decay through Z and W boson channels. Additionally, the equation using the Z and W boson masses yields an almost exact match to the value found experimentally if the theoretically determined Z and W boson mass values — at 90 and 80 GeV/c^2, respectively — are used:

$$\mathbf{M_H = \frac{Theoretical\ M_Z}{2} + \frac{[Theoretical\ M_{W-} + Theoretical\ M_{W+}]}{2} = 125\ GeV/c^2}$$

The theoretical values of 90 and 80 GeV/c^2 were determined to be the values necessary for the electromagnetic force to be combined with the weak force to make the electroweak force.[3,4,5] The values of 91.1876 and 80.385 GeV/c^2 were determined through experimentation.

Overall, these results suggest that the mass of LHC's Higgs boson can be separated into distinct constituent parts (in this case, Z and W boson components), unlike the mass values of the elementary matter and force-carrying particles of the Standard Model. This, in turn, suggests that the boson is not fundamental, but may instead be an exotic photon-Z boson-W boson hybrid particle, with only the Z and W bosons contributing to the mass of the composite, as photons are massless. Why exactly half the mass of each of these particles is involved would need to be investigated.

There is also the possibility that the particle is a condition in which quantifiable Z and W boson potential states exist in a sort of equilibrium (along with the photon state potential), decaying into a real and virtual Z boson or W boson pair, or into real photons or fermions. Again, however, this would suggest that the discovered Higgs boson is made of identifiable smaller parts.

In all, there remains the possibility that the particle found at the LHC is a very strong look-alike to the Higgs particle, perhaps producing deviations from the Standard Model that on the surface appear insignificant, but ones that might point to new physics. Further study of these questions is needed.

References

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