Journal Heading Year; Vol. (No.): page range
DOI: 10.5923/j.xxx.xxxxxxxx.xx

The Higgs-like Bosons Couplings to Quarks

Mario Everaldo de Souza[1]

[1]Departmento de Física, Universidade Federal de Sergipe, São Cristovão, 49100-000, Brazil

Abstract The allowed and suppressed Higgs-like bosons couplings to quarks are identified. The ratios of the strengths of allowed couplings are calculated. The latter is extremely important for experimentalists in the determination of the nature of the recently found Higgs boson and in the search for the charged Higgs-like bosons.

Keywords Higgs boson, Higgs-like bosons, Higgs couplings.

1. Introduction

It is very important to know the Higgs couplings to quarks to determine the nature of the recently found Higgs-like boson. Taking into account the Higgs-like quantum numbers shown in reference [1], this work identifies all couplings of the Higgs-like bosons to quarks.

2. Calculation of all Higgs-like bosons couplings to quarks

In order to make easier the understanding of the assignment of the Higgs-like bosons couplings to quarks I reproduce below Table 8 and Table 4 (without the 2nd column) from reference [1] which are now called Table 1 and Table 2, respectively.

Table 1. The quantum numbers of the Higgs-like bosons

	H^0	H^+, H^-
Σ_3	$\pm 1(s,b)$	$\pm 2(u)$
	$0(d)$	$\pm 1(c,t)$

*Corresponding author:
mariodesouza.ufs@gmail.com
Published online at http://journal.sapub.org/xxx

Table 2. Projections of the quantum number Σ.

Primons	Σ_3
p_1	$+1$
p_j	-1
$(j = 2,3,4)$	0

The values of Σ_3 for primons and quarks are discussed in detail in reference [1]. For example, the u quark has $\Sigma_3 = 0$ and its primons p_1 and p_2 have $\Sigma_3 = +1$ and $\Sigma_3 = -1$, respectively.

According to Table 1 the neutral Higgs-like boson H^0 is a triplet in which each member belongs to one of three possible values of Σ_3 which are $-1, 0, +1$. Because of this feature let us use a subscript for assigning the different values of Σ_3, and thus, there are H_0^0 for the Higgs-like with $\Sigma_3 = 0$, H_{-1}^0 for the Higgs-like with $\Sigma_3 = -1$, and H_{+1}^0 for the Higgs-like with $\Sigma_3 = +1$. For simplifying matters further, let us call both H_{+1}^0 and H_{-1}^0 by H_1^0. This way we can say that as a proton and a neutron exchange a pion by means of a strong interaction, primons p_2 and p_4 exchange a H_1^0 and form quark s, yielding its mass, that is,

$$p_2 \xleftrightarrow{H_1^0} p_4 .$$

According to the above reasoning, there are the

charged bosons H_{+1}^{+}, H_{-1}^{+}, H_{+2}^{+}, H_{-2}^{+} and also H_{+1}^{-}, H_{-1}^{-}, H_{+2}^{-}, H_{-2}^{-}. We can simplify the notation and designate both H_{+1}^{+} and H_{-1}^{+} by H_{1}^{+} and H_{+2}^{+} and H_{-2}^{+} by H_{2}^{+}. And for each Σ_3 we can drop the plus and minus signs and consider, for example, that the interaction of p_1 and p_2 by means of H_2 produce the u quark , that is,

$$p_1 \xleftrightarrow{H_2} p_2 .$$

This symbolizes

$$p_1 + H_{-2}^{-} = p_2$$

and

$$p_2 + H_{+2}^{+} = p_1$$

which in terms of the electric charges are, respectively,

$$\frac{5}{6} + (-1) = -\frac{1}{6}$$

and

$$-\frac{1}{6} + (+1) = +\frac{5}{6}$$

and in terms of the Σ_3 charge are, respectively,

$$+1 + (-2) = -1$$

and

$$-1 + (+2) = +1 .$$

2.1 Interactions with equal quarks

Let us begin with the $q_j q_j$ interactions. For example, the u quark is the combination $p_1 p_2$, and thus between two u quarks there are two interactions involving H_2. Between two $d(p_2 p_3)$ quarks there are two interactions by means of H_0^0. Doing the same for the other quarks we obtain Table 3.

Table 3. Interactions involving equal quarks.

$q_j q_j$	Interacting bosons
uu	$2H_2$
dd	$2H_0^0$
ss	$2H_1^0$
cc	$2H_1$
bb	$2H_1^0$
tt	$2H_1$

2.2 Interactions between two different quarks

Since there are too many interactions between two different quarks, we classify them keeping one quark fixed, avoiding repetitions. For example, between quarks $u(p_1 p_2)$ and $d(p_2 p_3)$ there are interactions mediated by the bosons H_0^0, H_1 and H_2. Doing the same for the other quarks we obtain Tables 4, 5, 6, 7 and 8.

Table 4. Interactions involving the u quark.

$q_j q_k$	Interacting bosons
ud	H_0^0, H_1, H_2
us	H_1^0, H_1, H_2
uc	H_0^0, H_1, H_2
ub	$H_0^0, H_1^0, 2H_1$
ut	H_1^0, H_1, H_2

Table 5. Interactions involving the d quark, excluding ud

$q_j q_k$	Interacting bosons
ds	$H_0^0, 2H_1^0$
dc	H_0^0, H_1, H_2
db	$H_0^0, 2H_1^0$
dt	$2H_1^0, H_1, H_2$

Table 6. Interactions involving the s quark, excluding us and ds.

$q_j q_k$	Interacting bosons
sc	H_0^0, H_1^0, H_1, H_2
sb	$H_0^0, 2H_1^0$
st	H_1^0, H_1, H_2

Table 7. Interactions involving the c quark, excluding uc, dc and sc.

$q_j q_k$	Interacting bosons
cb	$H_1^0, 2H_1$
ct	$H_1^0, 2H_1$

Table 8. Interaction involving the b quark, excluding ub, db, sb and bt.

$q_j q_k$	Interacting bosons
bt	$H_1^0, 2H_1$

2.3 Most Intense Interactions with H^0

As we see from the above tables, the most intense interactions involving H^0 are those of the b quark with the d quark and the s quark, and the interaction of the d quark with the s quark because they are mediated by one H_0^0 and two H_1^0. This is an important result from the experimental point of view because we can compare one of these three interactions with an interaction mediated by only one H^0. For example, comparing the interaction $s \leftrightarrow b$ with the interaction $c \leftrightarrow b$, we obtain a factor of 3 for the relative strength,

$$\frac{s \leftrightarrow b}{c \leftrightarrow b} = 3.$$

And we should also have the ratios

$$\frac{s \leftrightarrow b}{d \leftrightarrow b} = \frac{s \leftrightarrow b}{d \leftrightarrow s} = \frac{d \leftrightarrow b}{d \leftrightarrow s} = 1.$$

2.4 Medium Intensity Interactions with H^0

We obtain from the above tables, that there are interactions involving two H^0's which are the interactions $d \leftrightarrow d$, $s \leftrightarrow s$, $b \leftrightarrow b$, $u \leftrightarrow b$, $s \leftrightarrow c$ and $d \leftrightarrow t$. We can compare them with those of section 2.3 and obtain the important relation (just one of the several ratios)

$$\frac{s \leftrightarrow b}{b \leftrightarrow b} = \frac{3}{2} = 1.5.$$

And we should also have the ratios (just some of the ratios)

$$\frac{d \leftrightarrow d}{s \leftrightarrow s} = \frac{d \leftrightarrow d}{b \leftrightarrow b} = \frac{b \leftrightarrow b}{s \leftrightarrow s} = 1$$

$$\frac{u \leftrightarrow b}{s \leftrightarrow c} = \frac{u \leftrightarrow b}{d \leftrightarrow t} = \frac{s \leftrightarrow c}{d \leftrightarrow t} = 1$$

2.5 Less Intense Interactions with H^0

From the above tables we obtain that there are interactions involving just one H^0 which are the interactions $u \leftrightarrow d$, $u \leftrightarrow s$, $u \leftrightarrow c$, $d \leftrightarrow c$, $s \leftrightarrow t$, $c \leftrightarrow b$, $b \leftrightarrow t$, $c \leftrightarrow t$ and $u \leftrightarrow t$. We can compare them with those of section 2.3 and 2.4 and obtain the important relation (just some of several ratios)

$$\frac{c \leftrightarrow b}{s \leftrightarrow b} = \frac{d \leftrightarrow c}{d \leftrightarrow b} = \frac{d \leftrightarrow c}{d \leftrightarrow s} = \frac{b \leftrightarrow t}{d \leftrightarrow b} = \frac{1}{3}.$$

And we should also have the ratios (just some of the ratios)

$$\frac{u \leftrightarrow d}{u \leftrightarrow c} = \frac{u \leftrightarrow s}{u \leftrightarrow c} = \frac{u \leftrightarrow c}{d \leftrightarrow c} = \frac{d \leftrightarrow c}{c \leftrightarrow b} = \frac{b \leftrightarrow t}{c \leftrightarrow t} = 1$$

2.6 Interactions without H^0

We also obtain from the above tables that there are exactly three suppressed interactions involving H^0 which are the interactions $u \leftrightarrow u$, $c \leftrightarrow c$ and $t \leftrightarrow t$. This is an important prediction that can be experimentally tested.

2.7 Interactions with the Charged Bosons

With respect to the charged bosons we notice that there is no interaction involving three bosons, that is, the most intense interactions involve two charged bosons. There are 15 of these interactions that are listed on Table 9. It is important to observe that there are interactions that do not involve the charged bosons. These are the six interactions $s \leftrightarrow b$, $d \leftrightarrow b$, $d \leftrightarrow s$, $d \leftrightarrow d$, $s \leftrightarrow s$ and $b \leftrightarrow b$.

Table 9. Interactions involving 2 charged bosons.

$q_j q_k$	Interacting bosons H_1, H_2
ud	H_1, H_2
us	H_1, H_2
uc	H_1, H_2
ub	$2H_1$
ut	H_1, H_2
uu	$2H_2$
cc	$2H_1$
tt	$2H_1$
dc	H_1, H_2
dt	H_1, H_2
sc	H_1, H_2
st	H_1, H_2
cb	$2H_1$
ct	$2H_1$
bt	$2H_1$

3. Conclusion

All couplings of the Higgs-like bosons to quarks are identified. With them we are able to indicate the relative strengths of the interactions among quarks as well as the suppressed interactions. A very important result is that the search for the charged Higgs-like bosons should not involve the interactions $s \leftrightarrow b$, $d \leftrightarrow b$, $d \leftrightarrow s$, $d \leftrightarrow d$, $s \leftrightarrow s$ and $b \leftrightarrow b$ because they are suppressed for the charged Higgs-like bosons.

REFERENCES

[1] M. E. de Souza, "Higgs-like Bosons and Quark compositeness", accepted for publication in Frontiers in Science.