

Physics 926: Homework #12

Due on April 30, 2020 at 5pm

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Problem 1

Suppose that instead of introducing an $SU(2)$ doublet of complex fields to do the symmetry breaking that generates the boson masses, we used an $SU(2)$ triplet instead. In that representation, the generators of the group are

$$T^1 = \frac{1}{\sqrt{2}} \begin{pmatrix} 0 & 1 & 0 \\ 1 & 0 & 1 \\ 0 & 1 & 0 \end{pmatrix} \quad T^2 = \frac{1}{\sqrt{2}} \begin{pmatrix} 0 & -i & 0 \\ i & 0 & -i \\ 0 & i & 0 \end{pmatrix} \quad T^3 = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & -1 \end{pmatrix}$$

(a) Take

$$\phi_0 = \begin{pmatrix} 0 \\ 0 \\ v \end{pmatrix}$$

assign the hypercharge such that the field is electrically neutral. Calculate M_W/M_Z in this model.

(b) Now take

$$\phi_0 = \begin{pmatrix} 0 \\ v \\ 0 \end{pmatrix}$$

and show that only the charged weak bosons acquire mass in this case.

Solution

(a) We want the field be electrically neutral, this means that $Q\phi_0 = 0$

$$\begin{aligned} Q &= T_3 + \frac{Y}{2} \\ T_3\phi_0 &= -\phi_0 \\ Y\phi_0 &= 2\phi_0 \end{aligned}$$

A hypercharge of 2 gives us a field which is electrically neutral.