

MATH431 - Modern Particle Physics
Set Work: Sheet 10;

1. (a)

Show that in the Weinberg–Salam model

$$\frac{M_W}{M_Z} = \cos \theta_W$$

where M_W and M_Z are the masses of the charged weak vector bosons and the neutral electroweak vector boson respectively.

(b)

Suppose that the Higgs scalar field $\phi(x)$ has weak isospin $T = 3$ and hypercharge $Y = -4$. If the neutral component ϕ_0 (with $Q_{\text{e.m.}} = 0$) develops a vacuum expectation value $v/\sqrt{2}$, show that

$$M_W^2 = \frac{g^2}{2} \phi^\dagger (T^+ T^- + T^- T^+) \phi = 4g^2 v^2.$$

Further show that $M_W/M_Z = \cos \theta_W$ just as in the Standard Model.

2.

The decomposition of the fundamental representation of $SU(5)$ under $SU(3) \times SU(2) \times U(1)$ is given by:

$$5 = (3, 1, -\frac{2}{3}) + (1, 2, 1)$$

Derive the charge assignment of the leptoquark vector bosons in the adjoint (24) representation. Draw the Feynman diagram that couple the fermions to the leptoquark vector bosons. Draw the diagram by which the proton decays.