

The Standard Model of Particle Physics

Exercises III

to be handed in by 02 May 2010

1 Higgs decay

10 points

Show that, to lowest order, the decay width of the Standard Model Higgs boson to $b\bar{b}$ pairs is given by

$$\Gamma(H \rightarrow b\bar{b}) = \frac{3m_H}{8\pi} \left(\frac{m_b}{v}\right)^2 \left(1 - \frac{4m_b^2}{m_H^2}\right)^{3/2}.$$

2 Majorana spinor fields

20 points

One way of defining the charge conjugate of a fermion field ψ is (in the Dirac representation):

$$\psi_c = i\gamma_2\psi^*.$$

- (a) Show that ψ_c satisfies the Dirac equation.

The most general expression for the lagrangian density arising from scalar bilinears in the fermion field is

$$\mathcal{L}_m = D \bar{\psi}_L \psi_R + A \bar{\psi}_L^c \psi_L + B \bar{\psi}_R^c \psi_R + cc.$$

- (b) Show that $\psi_L^c \equiv (\psi_L)^c = (\psi^c)_R$.
- (c) Self-conjugate fields are defined by, $\chi \equiv \psi_L + \psi_L^c$ and $\omega = \psi_R + \psi_R^c$. Express \mathcal{L}_m in terms of these new fields.
- (d) Now let $\chi' \equiv \gamma_5\chi$ and $\omega' \equiv \gamma_5\omega$. What is \mathcal{L}_m in terms of the fields χ' and ω' ?
- (e) In the special case $B = 0$, find the mass eigenstates in terms of χ and ω . Compute the corresponding masses.
- (f) The new types of mass term $\bar{\psi}_L^c \psi_L$ and $\bar{\psi}_R^c \psi_R$ are known as Majorana mass terms. Show that these new terms are not invariant under $U(1)_{em}$ transformations. What does this imply for their potential use in particle physics phenomenology?