Physics 731 Homework 7

Due Friday 13 April, 2007

1 Yukawa interactions

Write out *all* of the Yukawa interactions which arise from the superpotential of the MSSM. Explicitly show generational, SU(2), SU(3), and spinorial indices.

2 Scalar top quark mass

Assume that the Lagrangian coefficient (matrices) Y_u and A_u are diagonal and only have nonzero entries in their (3,3) components. Also assume that $m^2_{\tilde{Q}}$ and $m^2_{\tilde{U}}$ are proportional to the identity matrix. Name the upper SU(2) component of the 3'rd generation $\tilde{Q}$ field $\tilde{t}_L$ and name the 3'rd generation element of the $\tilde{U}$ field $\tilde{t}_R$.

First suppose that $A_u = \mu = 0$. Write all Lagrangian terms giving rise to masses for $\tilde{t}_L$ and $\tilde{t}_R$. Then write all D-term and F-term couplings between $\tilde{t}_L$ or $\tilde{t}_R$ and H_U or H_D. Replace H_U and H_D by their VEV's. Find the masses for the $\tilde{t}_L$ and $\tilde{t}_R$ fields, showing that they do *not* mix with each other.

Now allow μ and A_u to be nonzero. Write out the terms involving these quantities, $\tilde{t}_L$ and $\tilde{t}_R$, and H_U or H_D. Explicitly find the mass matrix

$$\begin{bmatrix} \tilde{t}_L^\dagger & \tilde{t}_R^\dagger \end{bmatrix} \begin{bmatrix} m^2_{LL} & m^2_{LR} \\ m^2_{RL} & m^2_{RR} \end{bmatrix} \begin{bmatrix} \tilde{t}_L \\ \tilde{t}_R \end{bmatrix} \tag{1}$$

and diagonalize it to find its eigenvalues. How do the masses differ from the $\mu = A_u = 0$ case?

3 Extra credit

What is the coefficient of the coupling between the H^+, the anti-top quark, and the bottom quark, in terms of m_t, m_b, v, and $\sin\beta$? If you can, determine the partial width for the decay process $H^+ \to t\bar{b}$ in terms of m_{H^+}, $\tan\beta$, v, m_t, and m_b. (Neglect m_b in the kinematics of the decay.)