Physics 686 **Homework 8** **Due May 4, 2004**

<u>Problem 1.</u> This question refers to the tree-level Higgs sector formulas in the Primer.
(a) When $\tan\beta = 1$, the tree-level prediction for m_{h^0} has a special value. What is it?
(b) Suppose that $m_{A^0} = 500$ GeV. What are the tree-level predictions for $-\sin\alpha/\cos\beta$, $\cos\alpha/\sin\beta$, $\sin(\beta-\alpha)$, $m_{H^\pm}$, m_{H^0}, and m_{h^0}, for each of the possibilities $\tan\beta = 2, 10, 40$?
(c) Repeat part (b), this time with $m_{A^0} = 200$ GeV. Make a table of your findings.
(d) Returning to the case of part (b), suppose $\mu = 1000$ GeV. Reconstruct the values of the Lagrangian parameters $m^2_{H_u}$, $m^2_{H_d}$, and b.
(e) Returning to the general case, expand equation (7.40) to leading non-trivial order in small $m_Z^2/m_{A^0}^2$, so that:

$$\begin{aligned} m^2_{h^0} &= m_Z^2 \cos^2 2\beta + \text{correction} \\ m^2_{H^0} &= m^2_{A^0} + \text{correction}', \end{aligned}$$

and explicitly identify the leading correction in each case. (Note that these are *tree-level* formulas. The one for m_{h^0} is almost worthless, except to see the trend.)
(f) What can you say about the relative mass ordering of A^0, H^0, and $H^\pm$?

<u>Problem 2.</u> Determine a formula for the allowed range for a_t in terms of other parameters, based on an assumed bound $m_{\tilde{t}_1} > m_{\text{bound}}$. Now suppose that $\mu = 1000$ GeV, and $m_t = 175$ GeV, and $\tan\beta = 10$, and the top-squark mass parameters appearing in eq. (7.89) are given by $m^2_{Q_3} = (500 \text{ GeV})^2$ and $m^2_{u_3} = (400 \text{ GeV})^2$. If the top squark masses are at least 100 GeV (don't worry about whether this is the actual bound), what is the allowed range of a_t?

<u>Problem 3.</u> Make sketches like Figure 19, but for the following specific scenarios. [You may resolve any ambiguities in the following however you like; in particular, pick specific numbers for models as you like. Use of computer codes is encouraged. You may find that one of the cases (a)-(e) might require a small amount of fudging.] Comment on as many qualitative features of the mass spectra as you can, especially differences between the various cases, and the qualitative reasons for them.
(a) Dilaton-dominated mSUGRA with $\tan\beta = 40$.
(b) "No-scale" mSUGRA (also known as gaugino mediation) with $\tan\beta = 10$.
(c) GMSB with 1 minimal set of messenger quarks and leptons.
(d) GMSB with 2 copies of the minimal set of messenger quarks and leptons.
(e) GMSB with 3 copies of the minimal set of messenger quarks and leptons.
(f) (Extra credit.) Anomaly mediation (with some fudge factor, like an m_0 added in, to make it work).