Here are my corrections to the 2000-11-23 version.

- **On page 1 :** The appropriate citations for the mSUGRA are [1, 2].
- **Subsection 2.1 rewritten**

  The fact that supersymmetry is not observed at low energies requires the introduction of extra supersymmetry breaking interactions. This is achieved by adding to the Lagrangian density, defined by the given $SU(3)_C \times SU(2)_L \times U(1)_Y$ gauge symmetry and and the superpotential W , extra interaction terms that respect the gauge symmetry but break supersymmetry. This breaking however should be such that no quadratic divergences appear and the technical "solution" to the hierarchy problem is not spoiled. Such terms are generally called "soft" SUSY breaking terms. The most general supersymmetry breaking interaction Lagrangian resulting from spontaneously broken Supergravity in the at flat limit ($M_P \to \infty$) contains just four types of soft terms , i.e gaugino masses, $\Phi^*\Phi$-scalar masses, $\Phi\Phi\Phi$-scalar cubic superpotential interactions and $\Phi\Phi$-scalar quadratic superpotential interactions.

  A dramatic simplification of the structure of the supersymmetry breaking interactions is provided either by Grand Unification assumptions or by Superstrings. For example, SU(5) unification implies at tree level equality relations between the scalar "soft" SUSY breaking masses $m_{\tilde{Q}} = m_{\tilde{U}^c} = m_{\tilde{E}^c}$, and $m_{\tilde{L}} = m_{\tilde{D}^c}$, equality between the "soft" breaking gaugino masses $M_1 = M_2 = M_3$ and for the two of the trilinear "soft" breaking couplings, $A_d = A_e$. Furthermore, SO(10) unification implies equality of all sparticle masses, equality of Higgs masses and equality of the three types of cubic couplings. The simplest possible choice at tree level is to take all sparticle and Higgs masses equal to a common mass parameter M_0, all gaugino masses equal to some parameter $M_{1/2}$ and all cubic couplings flavour blind and equal to A_0. This situation is common in the effective Supergravity theories resulting from Superstrings but there exist more complicated alternatives. Interestingly, the contribution of the family–anomalous $U(1)$ universal D-term to the squark masses may be intra-family non-universal, and may differ from the usual (universal) boundary conditions assumed in the MSSM [3]. Another alternative is that for example Superstrings with massless string modes of different modular weights lead to different sparticle masses at tree level [4]. Thus, it seems that in almost all the "realistic" models motivated by Grand Unified Theories (GUTs) or Superstrings the universality assumption is broken and certainly one should address each model separately in order to study its phenomenology at low energies. Note, however that such non-minimal alternatives like flavour dependent sparticle masses are constrained by limits on Flavour Changing Neutral Currents (FCNC) processes. In what follows, we shall consider the simplest case (which is considered as a rather simplification assumption here) of the three parameters at the GUT scale, namely M_0, $M_{1/2}$ and A_0 and that is what we will call mSUGRA scenario.

As in the numerous [5] existing analyses of radiative symmetry breaking in the MSSM, in the present article we employ the Renormalization Group. The Higgs boson "running" mass-squared matrix, although positive definite at large energy scales of the order of Grand Unification scale M_{GUT} , yields a negative eigenvalue at low energies causing the spontaneous breakdown of the electroweak symmetry. The "running" of mass parameters from large to low scales is equivalent to computing leading logarithmic radiative corrections. Although this scenario depends on the values of few (3 or 4) free parameters, one could interpret it as leading to the prediction of M_Z in terms of M_{GUT} , or the Planck mass, and the top quark Yukawa coupling. Another way to interpret the predictions of this model is to consider MZ determined by the experiment and deriving the absolute value of the μ-parameter as well the value of the bilinear "soft" breaking parameter B at a scale in the vicinity of the EW scale, from the minimization conditions of the effective potential,

$$\mu^2(Q) = \frac{\bar{m}^2_{H_1} - \bar{m}^2_{H_2}\tan^2\beta}{\tan^2\beta - 1} - \frac{1}{2}M_Z^2(Q) \,, \tag{1}$$

$$B(Q) = -\frac{(\bar{m}_1^2 + \bar{m}_2^2)\sin 2\beta}{2\mu(Q)} \,, \tag{2}$$

where $Q = \sqrt{M_0^2 + 4M_{1/2}^2}$ approximately coincides with the largest first and second generation squark masses[1]. In Eqs.(1,2) $\tan\beta$ is the ratio of the two vacuum expectation values of the Higgs fields H_2 and H_1 responsible in giving masses to the up and down quarks, respectively. In Eqs.(1,2), $\tan\beta$ is evaluated at the scale Q, from the scale M_Z, where is considered as an input parameter[2]. By $\bar{m}^2_{H_i}$ in (1,2) we denote the radiative corrected "running " Higgs soft breaking masses and

$$\bar{m}_i^2 = m^2_{H_i} + \mu^2 + \Sigma_{v_i} \quad (i = 1, 2) \,, \tag{3}$$

where $\Sigma_{v_i}, v_i = (v_1, v_2)$ are the one loop corrections based on the 1-loop Coleman-Weinberg effective potential ΔV, $\Sigma_{v_i} = \frac{1}{2v_i}\frac{\partial \Delta V}{\partial v_i}$,

$$\Sigma_{v_i} = \frac{1}{64\pi^2}\sum_a (-)^{2J_a}(2J_a + 1)C_a\Omega_a \frac{M_a^2}{v_i}\frac{\partial M_a^2}{\partial v_i}\left[\ln\frac{M_a^2}{Q^2} - 1\right] \,, \tag{4}$$

[1] We consider this scale as the so called supersymmetry soft masses breaking scale, M_{SUSY}, since the first supersymmetry breaking evidence becomes "experimentally" apparent at the scale Q when we are approaching the EW scale from a very high energy one. In addition, this coincides with the scale where the radiative corrections to the effective potential are rather small compared to any other scale.

[2] See for example the discussion in the Appendix of [6].

where J_a is the spin of the a-particle, C_a are the color degrees of freedom, and $\Omega_a = 1(2)$ for real scalar (complex scalar), $\Omega_a = 1(2)$ for Majorana (Dirac) fermions. Q is the energy scale and M_a's are the field dependent mass matrices. Explicitly forms of Σ's are given in the Appendices of Ref.[7, 8] and in our analysis contain contributions from all the SUSY particles at 1-loop. With M_Z^2 here we denote the tree level " running" Z-boson mass, $M_Z^2(Q) = \frac{1}{2}(g^2 + g_2^2)v^2$ extracted at the scale Q from its physical pole mass $M_Z = 91.188$ GeV. The Radiative Electroweak Symmetry Breaking (REWSB) is fullfiled, if and only if, there is a solution to the Eqs.(1,2)[3].

In summary, in order to solve Eqs.(1,2) we need to "decide" about the $sign(\mu)$, and input also the value of $\tan\beta(M_Z)$. The "running" soft SUSY breaking Higgs masses, m_{H_1} and m_{H_2}, are defined at the Electroweak scale after their evolution from the GUT scale where we assume that they have a common mass, M_0. In addition the radiative corrections, Σ_{v_i} to the minimization conditions are defined by knowing the low energy SUSY spectrum and the masses of the SM particles, which in turn means knowledge of M_0, $M_{1/2}$ and A_0 at the GUT scale. Thus, apart from the SM masses provided by the experimental data [9], five parameters are required to define the mSUGRA scenario:

$$\{ \; M_0 \; , \; M_{1/2} \; , \; A_0 \; , \; \tan\beta \; , \; sign(\mu) \; \} \; . \tag{5}$$

As for the numerical input values on (5), we postpone here the discussion till the pragraph (**??**).

- **Regarding the subsection 2.5.3 and the REWSB**

  REWSB: parameter sets that do not fulfill the REWSB condition *i.e.,* do not satisfy the 1-loop minimization conditions (1,2). Within the mSUGRA scenario, the condition of REWSB leads e.g. to restrictions on $\tan\beta$. For example, it is almost impossible (or a huge fine tunning is required) to find very large values of $\tan\beta > 60$ which are allowed in the mSUGRA scenario. This is because in that region both the RGEs of the Higgs soft breaking masses receive large corrections not only from the top Yukawa coupling but also from the bottom and the tau one. This results in the numerator of Eq.(1) in such a way that the μ^2 is negative and thus excluded from our analysis. One could also has a case where for very heavy spectrum the $m_{H_2}^2$ never gets negative values and thus not triggering REWSB.

- **Regarding the subsection 2.5.3 and the CCB constraints**

[3] Sometimes in the literature, the requirement of the REWSB is described by the inequality $m_1^2(Q) m_2^2(Q) - |\mu(Q)B(Q)|^2 < 0$. This relation is automatically satisfied here from Eqs.(1,2) and from the fact that the physical squared Higgs masses must be positive.

CCB: regions where charge or color breaking minima (CCB) occur, *i.e.,* cases where the squared squark or slepton masses are becoming negative at the scale Q. However, it could be possible for values of the scale Q greater than few TeV, that the lifetime of a color or charge breaking minimum is longer than the present age of the universe and surviving quantum tunneling and thus in practice not dangerous [10, 11, 12, 13]. As we will see below the scale Q in our analysis is taken to be $Q < 2.4$ TeV and thus we consider those bounds. A detailed analysis in the mSUGRA parameter space is rather complicated and certainly beyond the aim of this article.

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