The decay $b \to s\gamma$ and the charged Higgs boson mass without R-Parity

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Abstract: The experimental measurement of $B(b \to s\gamma)$ imposes important constraints on the charged Higgs boson mass in the MSSM. We show that by adding bilinear R–Parity violation (BRpV) in the tau sector, these bounds are relaxed. The bound on $m_{H^\pm}$ in the MSSM–BRpV model is $\gtrsim 200 - 250$ GeV for the the heavy squark limit. For lighter squarks, light charged Higgs bosons can be reconciled with $B(b \to s\gamma)$ only if there is also a light chargino. In the BRpV model if we impose $m_{\chi_1^\pm} > 90$ GeV $m_{H^\pm} \gtrsim 75$ GeV, around 30 GeV down from the MSSM. In this case the charged Higgs bosons would be observable at LEP II. The relaxation of the bounds is due mainly to the fact that charged Higgs bosons mix with staus and they contribute importantly to $B(b \to s\gamma)$.

Keywords: Charged Higgs bounds. BRpV. FCNC. SUSY .

1. Introduction

In this talk, I will try to show you how the existing limits on the mass of the charged Higgs obtained from the measurement of the $B(b \to s\gamma)$ decay by the CLEO group relax in a supersymmetric model with bilinear violation of R-Parity, in the so called ϵ-model, a BRpV model where only the tau neutrino becomes massive at the tree level (see Ref.[1] for a complete exposition).

All previous work on $b \to s\gamma$ in supersymmetry has assumed the conservation of R–Parity. In the model assumed here new particles contribute in the loops to $B(b \to s\gamma)$. Charginos mix with the tau lepton (this mixing is not in conflict with the well measured tau couplings to gauge bosons [2]), therefore, the tau lepton contribute to the decay rate together with up-type squarks in the loops. Nevertheless, this contribution can be neglected [1]. In a similar way, the charged Higgs boson mixes with the two staus [3] forming a set of four charged scalars, one of them being the charged Goldstone boson. In this way, the staus contribute to the decay rate together with up-type quarks in the loops (see Table 1).

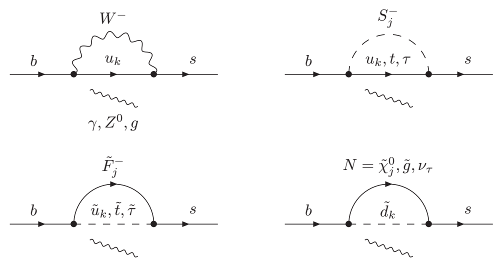

Table 1: $b \to s\gamma$ penguin diagrams in BRpV. S fields are mixtures or charged Higgs and staus. F fields are mixtures or charginos and the tau lepton.

2. FCNC processes and BRpV.

Gauge invariance,renormalizability and particle content of the SM imply the absence of FCNC in the lepton sector. FCNC transitions in the quark sector are absent at the tree level (see Ref.[4, 5, 6] and references therein for a complete review of FCNC processes). At one loop they are suppressed by light quark masses relative to m_W and by small mixing between the third and the first generations. The predicted SM suppression

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of FCNC process is in beautiful agreement with the presently available experimental data.

Being rare processes mediated by loop diagrams, radiative decays of B mesons are potentially sensitive probes of new physics beyond the SM. In the context of SUSY models we confront ourselves with a generic flavor problem. The low scale of new physics together with the absence of any constraint on the structure of SUSY breaking can produce easily huge, disastrous rates for the FCNC and LFV transitions.

In the Minimal and Not-so-Minimal Supersymmetric extensions of the Standard Model (SSM) there are, broadly speaking, two kinds of new contributions to the FCNC transitions:

- Flavor mixing in the sfermion, squark and slepton, mass matrices. FCNC processes as $b \to s\gamma$ and others may depend on the structure of these matrices and its experimental observation could provide some insight on the SUSY breaking mechanism.

- Charged Higgs boson and chargino exchanges.

The dangerous contributions coming from s-fermion mass matrices can be suppresses supposing sfermions of the two first generations: generic but very heavy or, alternatively degenerate in mass. But, from the second point, there will always remain a minimal flavor violation coming from the KM angles present in vertices as charged Higgs-top and chargino-squark loop contributions. FCNC processes, in this case, could provide some insight on the structure of the, possibly enlarged, charged boson and fermion sectors.

Charged Higgs-top and chargino-squark vertices are two kind of vertices modified by the introduction of Bilinear R-parity violation, so it seems relevant to study the $b \to s\gamma$ decay in the framework of a BRpV model and natural to consider a minimal flavor violation hypothesis as it will be done on this work: we will suppose that all squarks other than the scalar partners of the top quark have the same mass $\tilde{m}$ and that contributions from sfermion mass matrices can be neglected completely. In practice, that means that we will neglect contributions coming from gluino and neutralino loops.

3. The CLEO Experimental Results.

In 1995, the CLEO collaboration reported the first measurement of the inclusive branching ratio for the radiative decays $B \to X_s\gamma$. This measurement has established for the first time the existence of one–loop penguin diagrams. The latest presented result is [7]:

$$B(B \to X_s\gamma) = (3.15 \pm 0.35 \pm 0.32 \pm 0.26) \times 10^{-4}.$$

Form here, one obtains an upper limit $BR < 4.5$ at the 95% CL (note that the bound is one sided).

In addition, the ALEPH collaboration has reported [7] a measurement for the corresponding branching ratio for b hadrons produced at the Z resonance, yielding $B(H_b \to X_s\gamma) = (3.11 \pm 0.80 \pm 0.72) \times 10^{-4}$. Theoretically the two numbers are expected to differ by at most a few per cent, the weighted average gives: $B(B \to X_s\gamma) = (3.14 \pm 0.48) \times 10^{-4}$.

In order to reject photon background only the high energy part of the photon produced in the b decay is accessible experimentally. This value quoted above is obtained by extrapolation to the low energy part of the photon spectrum and is model dependent [8]. This fact introduces a significant theoretical uncertainty ($\approx 7\%$ in the last CLEO measurement).

QCD corrections are very important and can be a substantial fraction of the decay rate. Recently, several groups have completed the Next–to–Leading order QCD corrections to $B(b \to s\gamma)$. Two–loop corrections to matrix elements were calculated in [9]. The two–loop boundary conditions were obtained in [10]. Bremsstrahlung corrections were obtained in [11]. Finally, three–loop anomalous dimensions in the effective theory used for resumation of large logarithms were found in [12, 13]). In this work we include all these QCD corrections. The present theoretical incertitude is slightly less than the experimental errors: $<\approx 10\%$. During the years 1996-1997 the next-to-leading order analysis was extended to the cases of two-Higgs doublet models and MSSM [14].

In the SM, loops including the W gauge boson and the unphysical charged Goldstone boson $G^{\pm}$ contribute to the decay rate. The up-to-date SM theoretical value is ($E_\gamma > 0.1 E_\gamma^{max}$):

$$Br(B \to X_s\gamma) = (3.29 \pm 0.33) \times 10^{-4} N_{LO},$$

Where $N_{LO} = Br(B \to X_c e\overline{\nu})/0.108 \simeq 1$. This prediction is in agreement with the CLEO measurement at the 2σ level. It expected some improvements in the experimental error coming from the possibility of a better rejection of background and the measurement of the emitted photon spectrum. However, possible new physics contributions would not affect the shape of this photon spectrum. They would enter the theoretical predictions for the $BR(B \to X_s\gamma)$ through the values of the Wilson coefficients at the scale M_W.

4. The ϵ-BRpV model

The study of models which include BRpV terms, and not trilinear (TRpV), is motivated by spontaneous R–Parity breaking [15, 16]. The superpotential we consider here contains the following bilinear terms which violates R–Parity and tau–lepton number explicitly.

$$W_{Bi} = \varepsilon_{ab}\left[-\mu \widehat{H}_1^a \widehat{H}_2^b + \epsilon_3 \widehat{L}_3^a \widehat{H}_2^b\right], \qquad (4.1)$$

where both parameters μ and ϵ_3 have units of mass.

The electroweak symmetry is broken when the two Higgs doublets $H_{1,1}$ and the third component of the left slepton doublet acquire nonzero Vev's by the presence of the extra term (respectively $v_{1,2}$ and v_3). We define the angles β and θ in spherical coordinates $v_1 = v\cos\beta\sin\theta$, $v_2 = v\sin\beta\sin\theta$, $v_3 = v\cos\theta$ where $v = 246$ GeV and the MSSM relation $\tan\beta = v_2/v_1$ is preserved [17, 18]. The v_3 is related to the mass parameter ϵ_3 through a minimization condition. This non–zero sneutrino vev is present even in a basis where the ϵ_3 term disappears from the superpotential. This basis is defined by the rotation $\mu'\widehat{H}_1' = \mu\widehat{H}_1 - \epsilon_3\widehat{L}_3$ and $\mu'\widehat{L}_3' = \epsilon_3\widehat{H}_1 + \mu\widehat{L}_3$, with $\mu'^2 = \mu^2 + \epsilon_3^2$. The sneutrino vev in this basis (v_3') is non–zero due to mixing terms that appear in the soft sector between $\widetilde{L}_3$ and H_1 scalars. It is also possible to choose a basis where the sneutrino vev is zero. In this basis a non–zero ϵ_3 term is present in the superpotential [19]. All three basis are equivalent.

The BRpV model has the attractive feature of generating masses radiatively for the two first generations, thus naturally small in this framework. The origin of the tau neutrino mass is linked to supersymmetry [20] through the mixing of neutral higgsinos and gauginos with the neutrino. In a see–saw type of mechanism, with the neutralino masses ($\sim$ M) playing the role of a high scale and v_3' as the low scale, the tau–neutrino mass is approximately given by the expression (for m_{ν_τ} small and M not so small):

$$m_{\nu_\tau} \simeq -(g^2 + g'^2)\, v_3'^2/4M.$$

In addition, the combination v_3' is radiatively induced in soft universal models and then naturally small. The dependence of the tau–neutrino mass on v_3' can be appreciated in Fig . 1 where results of a random scan are shown (see below). We easily find solutions with neutrino masses from the collider limit of 20 MeV down to eV. The experimental bound on the tau neutrino mass, given by $m_{\nu_\tau} < 18$ MeV [21], implies an upper bound for v_3' of about 5–10 GeV.

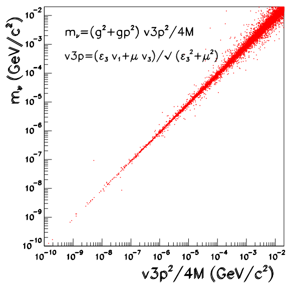

Figure 1: Correlation of m_τ with v_3' for the points belonging to the MSSM-BRpV parameter space scan (see text).

5. $H^{\pm}$ mass and $b \to s\gamma$ decay

Direct search limits on charged Higgs bosons are provided by LEP. However, by far the most restrictive process in constraining the charged Higgs sector in 2HDM is the radiative b-quark decay, These constraints are specially important in 2HDM type II models because the charged Higgs contribution always adds to the SM contribution [22]. Constraints on $m_{H^\pm}$ are not important in 2HDM type I because charged Higgs contributions can have either sign.

In supersymmetric models, loops containing charginos/squarks, neutralinos/squarks, and gluino/squarks have to be included [23]. In the limit of very heavy super-partners, the stringent bounds on $m_{H^\pm}$ are valid in the MSSM, a 2HDM-II model [22]. Nevertheless, even in this case the bound is relaxed at large $\tan\beta$ due to two-loop effects [24]. It was shown also that by decreasing the squarks and chargino masses this bound disappears because the chargino contribution can be large and can have the opposite sign to the charged Higgs contribution, canceling it [25, 26]. Further studies have been made in the MSSM and in its Supergravity version [27, 28]. As a result, for example, most of the parameter space in MSSM-SUGRA is ruled out for $\mu < 0$ especially for large $\tan\beta$ ([23, 25] see also Ref.[1] and references therein).

Relative to the calculation of $B(b \to s\gamma)$, the main difference of MSSM-BRpV with respect to the MSSM is that in BRpV the charged Higgs boson mixes with the staus and the tau lepton mixes with the charginos. This way, new contributions have to be added and the old contributions are modified by mixing angles.

In the MSSM–BRpV, the charged Higgs sector mixes with the stau sector forming a set of four charged scalars. The four charged scalars in the original basis are $\mathbf{\Phi}^\pm = (H_1^\pm, H_2^\pm, \tilde\tau_L^\pm, \tilde\tau_R^\pm)$ and the corresponding mass matrix is diagonalized after the rotation $\mathbf{S}^\pm = \mathbf{R}_{S^\pm}\mathbf{\Phi}^\pm$ where $\mathbf{S}_i^\pm$, $i = 1, 2, 3, 4$ are the mass eigenstates (one of them the unphysical Goldstone boson). One of the massive charged scalars has similar properties to the charged Higgs of the MSSM. In BRpV we call the "charged Higgs boson" to the charged scalar whose couplings to quarks are larger, *i.e.*, maximum $(\mathbf{R}_{S^\pm}^{i1})^2 + (\mathbf{R}_{S^\pm}^{i2})^2$. Nevertheless, for comparison we have also study the case in which the "charged Higgs boson" corresponds to the charged scalar with largest components to the rotated Higgs fields $H_1'^\pm$ and $H_2'^\pm$, *i.e.*, maximum $(\mathbf{R'}_{S^\pm}^{i1})^2 + (\mathbf{R'}_{S^\pm}^{i2})^2$.

In BRpV, the tau lepton mixes with the charginos forming a set of three charged fermions $F_i^\pm$, $i = 1, 2, 3$. In the original basis where $\psi^{+T} = (-i\lambda^+, \widetilde H_2^1, \tau_R^+)$ and $\psi^{-T} = (-i\lambda^-, \widetilde H_1^2, \tau_L^-)$, the charged fermion mass 3x3 matrix $\boldsymbol{M}_C$ is of the form:

$$\boldsymbol{M}_C = \begin{bmatrix} M & \frac{1}{\sqrt2}gv_2 & 0 \\ \frac{1}{\sqrt2}gv_1 & \mu & -\frac{1}{\sqrt2}h_\tau v_3 \\ \frac{1}{\sqrt2}gv_3 & -\epsilon_3 & \frac{1}{\sqrt2}h_\tau v_1 \end{bmatrix} \tag{5.1}$$

where τ Yukawa coupling h_τ is a complicated function of SUSY parameters and is fixed by the condition $m_\tau = 1.77$ GeV. In the not-so-small M limit we recover a simple expression for h_τ ($v_1' \equiv (\mu v_1 - \epsilon_3 v_3)\mu'$):

$$h_\tau \simeq \sqrt2 m_\tau / v_1'.$$

In the $b \to s\gamma$ amplitude appears the Wilson coefficients $C_{7,8}$ at the $\sim M_w$ scale (see Ref.[1] for concrete expressions):

$$C_{7,8}(M_w) \sim A_{\gamma,g} = A^W_{\gamma,g} + A^{F^\pm}_{\gamma,g} + A^{S^\pm}_{\gamma,g} + A^{\chi^0,\tilde g}_{\gamma,g}$$

where A^W is the SM contribution and $A^{F,S}$ the contributions of the F, S fields defined previously. The running down the $\sim m_b$ scale has been performed using the corrections developed in Refs.[12, 5]. According to our hypothesis of minimal flavor violation, we neglect in our calculations neutralino and gluino ($A^{\chi^0,\tilde g}_{\gamma,g}$) contributions. In any case the contribution of neutralinos is small [23] as it is small that one of the gluino whose different squark contributions tend to cancel with each other [29]. In addition, if gaugino masses are universal at the GUT scale, gluinos must be rather heavy considering the bound on the chargino mass from LEP2 [30], which makes the contribution smaller. We can ignore safely the light gluino window [31] because it is inconsistent with the experimental bound on the mass of the lightest Higgs boson in the MSSM [32]. In the decay amplitude [1], it appears the matrix $R_{\tilde t}$ the rotation matrix which diagonalizes the stop quark mass matrix [33] necessary to take into account the left–right mixing in the stop mass matrix. We neglect this mixing for the other up–type squarks.

6. Results. The parameter space scan

In order to study the effect of BRpV on $B(b \to s\gamma)$ we consider the so-called unconstrained MSSM–BRpV where all soft parameters are independent at the weak scale, *i.e.*, not embedded into supergravity. We study the predictions of this model varying randomly the soft parameters at the weak scale [1]. The scan over parameter space contains over 5×10^4 points in the ranges:

$$\begin{aligned} &\mid \mu, B \mid &< 500 \text{ GeV}\,, \\ 0.5 < \;&\tan\beta &< 30\,, \\ 10 < \;&M_{L_3}, M_{R_3} &< 1000 \text{ GeV}\,, \\ 100 < \;&M_Q = M_U &< 1500 \text{ GeV}\,, \\ 50 < \;&M = 2M' &< 1000 \text{ GeV}\,, \\ &\mid A_t, A_\tau \mid &< 500 \text{ GeV} \end{aligned} \tag{6.1}$$

for the MSSM parameters, and

$$\begin{aligned} \mid \epsilon_3 \mid &< 200 \text{ GeV}\,, \\ \mid v_3' \mid &< 10 \text{ GeV} \end{aligned} \tag{6.2}$$

for the BRpV parameters.

In addition, in order to study more in detail the neutrino low mass region we have performed a dedicated scanning for masses $m_\nu < 100$ eV.

In Eq. (6.1), B is the bilinear soft mass parameter associated with the μ term in the superpotential, M_{L_3} and M_{R_3} are the soft mass parameters in the stau sector, M_Q and M_U are the soft mass parameters in the stop sector. The parameters A_t and A_τ are the trilinear soft masses in the stop and stau sector respectively. Note that B_2, the bilinear soft mass parameter associated with the ϵ_3 term in the superpotential, is fixed by the minimization equations of the scalar potential.

6.1 Discussion

In order to have an idea of the effects of BRpV on the constraints from the measurement of $B(b \to s\gamma)$ it is instructive to take the limit of very massive squarks. In this limit the chargino amplitude can be neglected relative to the charged scalar amplitude and a lower limit on the MSSM charged Higgs mass is inferred.

In Fig. 2 we plot the branching ratio $B(b \to s\gamma)$ as a function of the charged Higgs mass $m_{H^\pm}$ in the MSSM with large squark masses (in practice, masses at least equal to several TeV are necessary to suppress the chargino amplitude). The horizontal dashed line corresponds to the latest CLEO upper limit. In Fig. 3 we plot the $B(b \to s\gamma)$ as a function of $m_{H^\pm}$ in the MSSM–BRpV model in the same heavy squark limit. The difference is exclusively due to the mixing of the charged Higgs boson with the staus. The clear bound we had before dissapears. The reason for this relaxation is simple. We have now new contributions in the charged boson sector and while the charged Higgs couplings to quarks diminish due to Higgs–Stau mixing, the contribution from the staus does not always compensate it, because staus may be heavier than the charged Higgs boson.

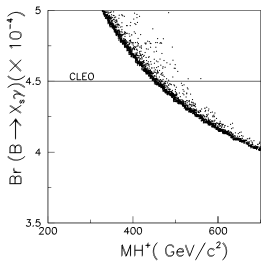

Figure 2: Branching ratio $B(b \to s\gamma)$ as a function of the charged Higgs boson mass $m_{H^\pm}$ in the limit of very heavy squark masses within the MSSM.

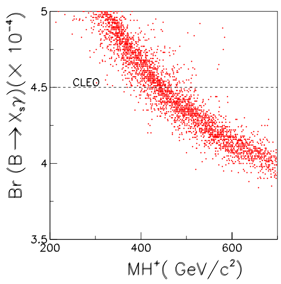

Figure 3: Branching ratio $B(b \to s\gamma)$ as a function of the charged Higgs boson mass $m_{H^\pm}$ in the limit of very heavy squark masses in MSSM–BRpV. The charged Higgs boson is defined as the massive charged scalar field with largest couplings to quarks.

A summary of the results can be appreciated in Fig. 4. In the limit of very heavy squarks, the strong constraints imposed on the charged Higgs mass of the MSSM are relaxed in the MSSM–BRpV. Above and to the right of the solid line in the figure are the solutions of the MSSM consistent with the CLEO measurement of $B(b \to s\gamma)$. Without considering theoretical uncertainties, the limit on the charged Higgs mass is $m_{H^\pm} > 440$ GeV. This bound is relaxed by about 70 to 100 GeV in BRpV as can be seen from the dotted and dashed lines. If a 10% theoretical uncertainty is considered, the MSSM bound reduces to $m_{H^\pm} > 320$ GeV, but the BRpV bound decreased as well such that the reduction of the bound is maintained.

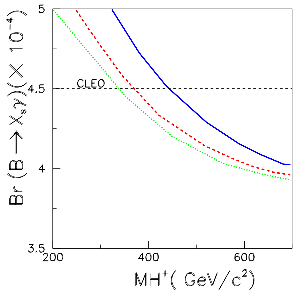

Figure 4: Lower limit on the branching ratio $B(b \to s\gamma)$ as a function of the charged Higgs boson mass $m_{H^\pm}$. We consider the limit of very heavy squark masses within the MSSM (solid) and the MSSM–BRpV (dashes and dots).

Another interesting region of parameter space to explore is the region of light charged Higgs boson and light chargino. It is known that in order to have a light charged Higgs boson, its large contribution to $B(b \to s\gamma)$ must be canceled by the contribution from light charginos and stops.

In Fig. 5 we give the lower bounds on $m_{H^\pm}$ as a function of the lightest chargino mass $m_{\chi_1^\pm}$. All the points satisfy the CLEO bound mentioned before. The solid vertical line is defined by $m_{\chi_1^\pm} = 90$ GeV, which is approximately the experimental lower limit found by LEP2, at least for the heavy sneutrino case. The solid curve corresponds to the MSSM limit and the dotted curve corresponds to the MSSM–BRpV limit. From the figure, we observe that in order to have $m_{\chi_1^\pm} > 90$ GeV, the CLEO measurement of $B(b \to s\gamma)$ implies that $m_{H^\pm} \gtrsim 110$ GeV in the MSSM. However, in the MSSM-BRpV, in order to have $m_{\chi_1^\pm} > 90$ GeV compatible with $B(b \to s\gamma)$ we need $m_{H^\pm} \gtrsim 85$ GeV, therefore, relaxing the MSSM bound by about 25 GeV.

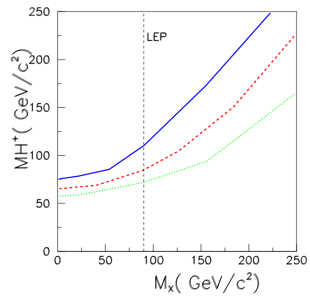

Figure 5: Lower limit of the charged Higgs boson mass as a function of the lightest chargino mass for $B(b \to s\gamma)$ compatible with CLEO measurement in the MSSM (solid) and in MSSM–BRpV (dashes and dots as explained in the text). The vertical dashed line corresponds to $m_{\chi 1} = 90$ GeV.

In the same way, in Fig. 6 we plot the same lower bounds on $m_{H^\pm}$ but this time as a function of the lightest stop mass $m_{\tilde{t}_1}$. We observe from this figure that in order to cancel large contributions to $B(b \to s\gamma)$ due to a light charged Higgs boson, it is more important to have a light chargino rather than a light stop.

An important point to see is what happens for low neutrino masses. We have checked explicitly that our results remain if we impose progressively stronger cuts on the neutrino mass. As example, in Fig.(7) we show what happens when the neutrino mass is down 100 eV in both, the heavy squark and the light chargino limits. We see that there is no significant differences with respect to the plots we have shown before. It is difficult to say anything definitive much below the 100 eV region because radiative corrections could play an important role at very low neutrino masses.

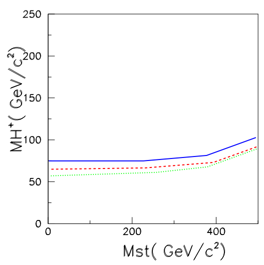

Figure 6: Lower limit of the charged Higgs boson mass as a function of the lightest stop mass for $B(b \to s\gamma)$ compatible with CLEO measurement in the MSSM (solid) and in the MSSM–BRpV (dashes and dots as explained in the text).

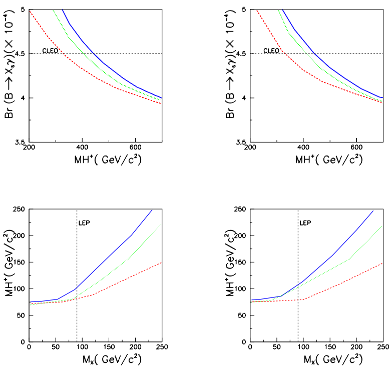

Figure 7: Top and Bottom Left figures: Respectively figures 4 and 6 for the case $m_\nu < 100$ eV. Top and Bottom Right figures: Respectively figures 4 and 6 for the case $m_\nu < 100$ eV and "faked" universality: $\Delta B/\sqrt{\Delta M} < 0.05\sqrt{(1+\tan^2\beta)}$, (see Eqs.(15,16) in Ref.[34]).

It is important to take into account the theoretical uncertainties on the calculation of $B(b \to s\gamma)$. We note that in implementing the QCD corrections we simply take the B scale $Q_b = 5$ GeV (see Ref. [5] for a discussion on the uncertainties of the QCD corrections to the branching ratio). If we assume a 10% error, then the bound on the charged Higgs boson mass in the heavy stop limit within the MSSM reduces to $m_{H^\pm} \gtrsim 320$ GeV. For the same reason, the corresponding bounds on the MSSM–BRpV reduce to $m_{H^\pm} \gtrsim 200-250$ GeV, which corresponds to a decrease in 70–120 GeV, *i.e.*, comparable to the values quoted above. No changes are observed in the case of light charged Higgs limits.

7. Conclusions

In summary, we have proved that the bounds on the charged Higgs mass of the MSSM coming from the experimental measurement of the branching ratio $B(b \to s\gamma)$ are relaxed if we add a single bilinear R–Parity violating term to the superpotential.

In the MSSM–BRpV model the staus mix with the charged Higgs bosons and these contribute importantly to $B(b \to s\gamma)$ in loops with up–type quarks. In an unconstrained version of the model where the values of all the unknown parameters are free at the weak scale we have showed that the bounds on the charged Higgs boson mass from $B(b \to s\gamma)$ are relaxed by ~ 100 GeV in the heavy squark limit (squark masses of a few TeV) where the chargino contribution is negligible.

Even though in the MSSM–BRpV model the tau lepton mixes with charginos, implying that the tau-lepton also contributes to $B(b \to s\gamma)$ in loops with up–type squarks, we have shown that this contribution is negligible.

In order to have a light charged Higgs boson in SUSY, its large contribution to $B(b \to s\gamma)$ can only be compensated by a large contribution from a light chargino and squark. In order to satisfy the experimental bound on $B(b \to s\gamma)$ with $m_{\chi_1^\pm} > 90$ GeV in the MSSM it is necessary to have $m_{H^\pm} \gtrsim 110$ GeV. In the MSSM–BRpV model this bound is $m_{H^\pm} \gtrsim 75-85$ GeV, i.e. 25–35 GeV weaker than in the MSSM. It is important to note that, in contrast to the MSSM, charged Higgs boson masses as small as these can be achieved in MSSM–BRpV already at tree level, as discussed in Ref. [35]. In this case, charged Higgs lighter that the W–gauge boson are possible and observable at LEP2. Nevertheless, R–Parity violating decay modes will compete with the traditional decay modes of the charged Higgs in the MSSM.

The reason to the relaxation of the MSSM bounds can be understood as follows: while the charged Higgs couplings to quarks diminish with the presence of Higgs–Stau mixing, the contribution from the staus not always compensate this decrease because the stau mass is, in general, different from the charged Higgs boson mass, and could be larger.

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