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A global fit to the anomalous magnetic moment, $b \to X_s\gamma$ and Higgs limits in the constrained MSSM[1]

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Abstract

New data on the anomalous magnetic moment of the muon together with the $b \to X_s\gamma$ decay rate and Higgs limits are considered within the supergravity inspired constrained minimal supersymmetric model. We perform a global statistical χ^2 analysis of these data and show that the allowed region of parameter space is bounded from below by the Higgs limit, which depends on the trilinear coupling and from above by the anomalous magnetic moment a_μ.

1 Introduction

Recently a new measurement of the anomalous magnetic moment of the muon became available, which suggests a possible 2.6 standard deviation from the Standard Model (SM) expectation[1]: $\Delta a_\mu = a_\mu^{exp} - a_\mu^{th} = (43 \pm 16) \cdot 10^{-10}$. The most popular explanation is given in the framework of SUSY theories[2]. To explain the desired difference Δa_μ it requires the Higgs mixing parameter to be positive [3] and the sparticles contributing to the chargino-sneutrino ($\tilde{\chi}^{\pm} - \tilde{\nu}_\mu$) and neutralino-smuon ($\tilde{\chi}^0 - \tilde{\mu}$) loop diagrams to be relatively light[4]. The positive sign of μ_0 is also preferred by the branching ratio of the b-quark decaying radiatively into an s-quark - $b \to X_s\gamma$ -[5, 2]. The error on the $b \to X_s\gamma$ measurements is still so large (at least 15%), that it does not give a significant constraint on the sparticle masses. However, it prefers the trilinear coupling at the GUT scale A_0 to be positive for light sparticles. In this case of $A_0 > 0$ the lower limit on the Higgs mass of 114 GeV[6] becomes the most effective lower limit on the sparticle masses. Without the $b \to X_s\gamma$ constraint, which implies arbitrary values of A_0, the lower limit on the sparticle masses is determined by $b \to X_s\gamma$. Lack of space forces us to refer the reader to Ref.[2] for details.

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2 Results

To find out the allowed regions in the parameter space of the CMSSM, we fitted both the $b \to X_s\gamma$ and a_μ data simultaneously[2]. The fit includes the following constraints: i) the unification of the gauge couplings, ii) radiative elctroweak symmetry breaking, iii) the masses of the third generation particles, iv) $b \to X_s\gamma$ and Δa_μ, v) experimental limits on the SUSY masses, vi) the lightest superparticle (LSP) has to be neutral to be a viable candidate for dark matter. We assume common GUT scale mass parameters, i.e. m_0 for the spin 0 sparticles and $m_{1/2}$ for the spin 1/2 gauginos. In addition the usual CMSSM parameters at the GUT scale (Higgs mixing parameter μ_0, $\tan\beta$ and trilinear coupling A_0) are varied. Since a_μ and $b \to X_s\gamma$ both have loop corrections with charginos their SUSY contributions are correlated, as shown in Fig. 1 (top): the large positive SUSY contributions to a_μ for light sparticles correspond to negative contributions for $b \to X_s\gamma$. The bottom of Fig. 1 shows the combined χ^2 contributions in the m_0, $m_{1/2}$ plane, both in 3D and 2D. For the preferred positive values of A_0 the Higgs bound of 114 GeV from LEP[6] becomes an effective lower limit on $m_{1/2}$ of about 300 GeV, as shown on the right hand bottom side of Fig. 1. If A_0 is fixed at 0, the lower limit on $m_{1/2}$ is given by $b \to X_s\gamma$ [2]. These fits were made for $\tan\beta = 35$. Lower values decrease the allowed area, for larger values the LSP limit becomes more severe[2].

The 95% upper limit on $m_{1/2}$ is determined by the lower limit on a_μ^{SUSY} and therefore depends on $\tan\beta$. For $\tan\beta$ =35(50) one finds $m_{1/2} \leq 610(720)$ GeV, which implies that the lightest chargino is below 530(620) GeV and the lightest neutralino is below 270(310) GeV. It should be noted that this upper limit strongly depends on the vacuum polarization contributions to the fine structure constant. Recent evaluations reduce Δa_μ from a 2.6 σ effect to less than 2 σ[7], which increases the upper limits given above by about 25%.

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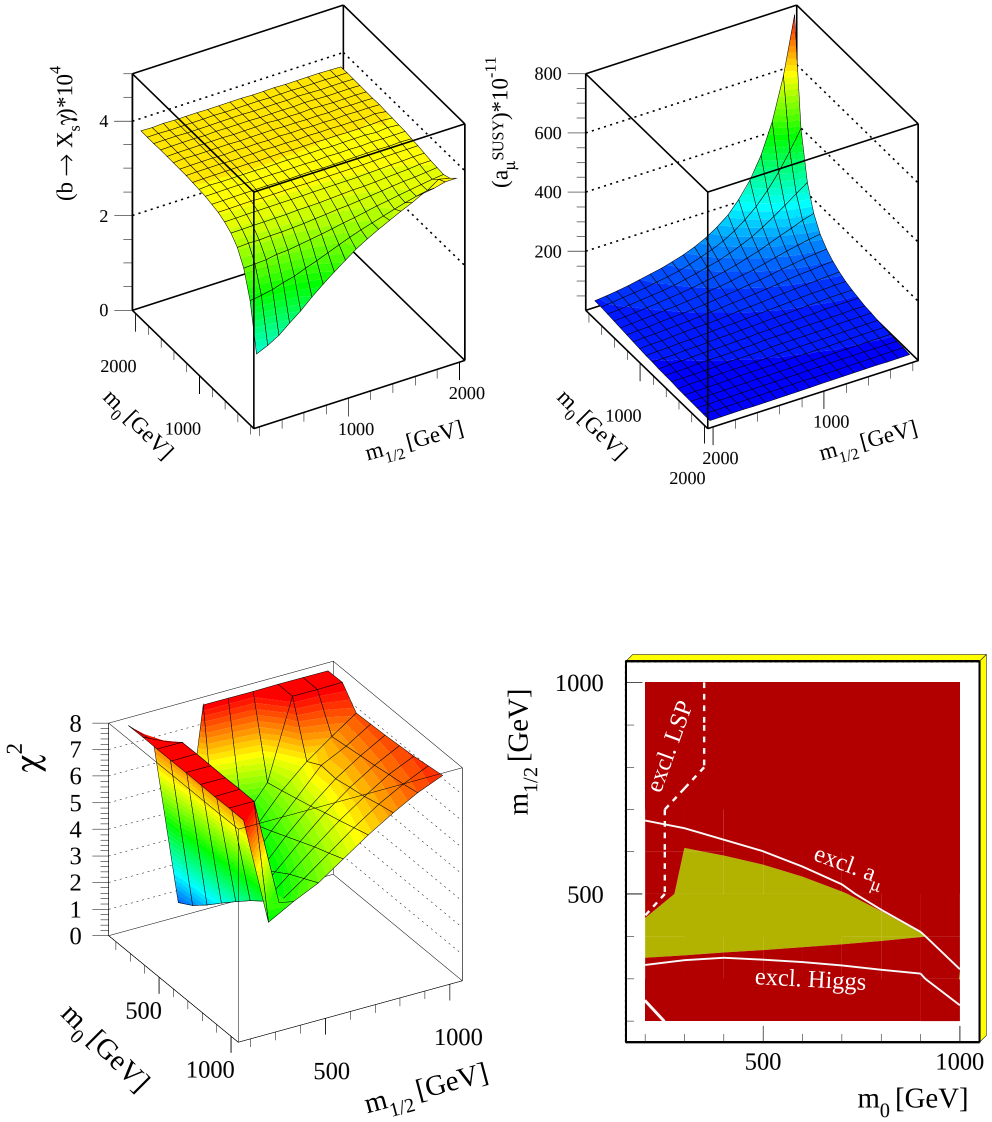

Figure 1: Top: The values of $b \to X_s\gamma$ and a_μ^{SUSY} in the $m_0, m_{1/2}$ plane for positive μ and $\tan\beta = 35$ to be compared with experimental data $b \to X_s\gamma = (2.96 \pm 0.46) \cdot 10^{-4}$ and $a_\mu^{SUSY} = (43 \pm 16) \cdot 10^{-10}$.
Bottom: The χ^2 contribution (left) and its projection (right) in the $m_0, m_{1/2}$ plane for $\tan\beta = 35$ and A_0 left free. The light shaded area is the region, where the combined χ^2 is below 4. The regions outside this shaded region are excluded at 95% C.L.. The white lines correspond to the "two-sigma" contours, i.e. $\chi^2 = 4$ for that particular contribution. The little white line at the left hand corner results from the $b \to X_s\gamma$ limit.