General Flavour Blind MSSM and CP Violation

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ABSTRACT: We study FCNC and CP violating processes in the MSSM without a new flavour structure (flavour blind MSSM). The low energy parameters are determined by the running of the soft breaking terms from the GUT scale with SUSY phases consistent with the EDM constraints. We find that the CP asymmetry in $b \to s\gamma$ can reach large values potentially measurable at B factories, especially in the low $BR(b \to s\gamma)$ region. We analyze the SUSY contributions to the anomalous magnetic moment of the muon pointing out its impact on the $b \to s\gamma$ CP asymmetry and on the SUSY spectrum.

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In this contribution we study in a systematic way the restrictions on the supersymmetry (SUSY) parameters and complex phases which can be derived from the experimental information on flavour changing neutral currents (FCNC) and on CP violation. We choose the Minimal Supersymmetric Standard Model (MSSM) as our theoretical framework and focus on a class of SUSY models that we call *flavour blind MSSM*. With this term we refer to a model where the soft breaking terms at the grand unification (GUT) scale do not introduce any new flavour structure beyond the usual Yukawa matrices. In this restricted class of models, the number of parameters is largely reduced and it is therefore possible to perform a complete phenomenological analysis. Here we present the main results of our analysis. For details we refer to [1].

We consider two cases, which are specified by the structure of the soft breaking parameters at the GUT scale. The first case is the simplest version of the constrained MSSM, where we take the following independent parameters:

(I) $M_{1/2}$, M_0^2, $|A_0|$, ϕ_{A_0}, ϕ_μ, and $\tan\beta$,

which are the universal gaugino and scalar mass parameter, the absolute value and the phase of the trilinear scalar coupling, the phase of μ, and the ratio of the vacuum expectation values of the Higgs fields. The second case refers to the SUSY $SU(5)$ model, where we take the following set of parameters:

(II) $M_{1/2}$, M_5^2, M_{10}^2, $M_{H_1}^2$, $M_{H_2}^2$, $|A_u|$, $|A_d|$, ϕ_{A_u}, ϕ_{A_d}, ϕ_μ, $\tan\beta$,

where now M_5^2, M_{10}^2, $M_{H_1}^2$ and $M_{H_2}^2$ are the scalar mass parameters of the $\bar{5}$ and 10 sfermions and the two Higgs doublets, and A_u and A_d are the trilinear scalar couplings of the 10 and $\bar{5}$.

With the SUSY parameters defined at the GUT scale we determine the soft SUSY breaking parameters at the weak scale by evolving them down with the renormalization group equations (RGE). In our analysis, we have used two–loop RGEs as given in [2] and one–loop masses as given in [3]. We fix $|\mu|^2$ by demanding radiative breaking of the electroweak $SU(2)_L \times U(1)$ symmetry. At the weak scale we impose the constraints from direct SUSY and Higgs particle searches [4] and from the ρ–parameter, as well as the requirements of colour and electric charge conservation and the lightest SUSY particle (LSP) to be neutral. With these sets of soft SUSY parameters we calculate the electric dipole moment (EDM) of the electron and the branching ratio of $b \to s\gamma$ and compare them with the experimental data, $|d^e| \leq 4.0 \times 10^{-27}$ e cm and $2 \times 10^{-4} \leq BR(b \to s\gamma) \leq 4.5 \times 10^{-4}$[5]. The sets in agreement with the experimental constraints are used to calculate the CP asymmetry of $b \to s\gamma$ and the SUSY contributions to ϵ_K, ΔM_{B_d} and Δ_{M_s}. We also calculate the SUSY contributions to the muon anomalous magnetic moment a_{μ^+} in order to quantify the effect of the recent experimental data on the observables we are interested in. We assume that the SUSY contribution accounts for the difference between the experimental world average for this quantity [6] and the corresponding SM prediction [7], $\delta a_{\mu^+} = +43(16) \times 10^{-10}$.

We first study the restrictions on the phases from the electron EDM constraint. Due to cancellations between different contributions these restrictions are less stringent and are very different from the case that the EDM constraint is required for each contribution separately (see [8] and references therein). In our numerical calculations we scan the scalar and gaugino masses at M_{GUT} in the range 100 GeV $< M_i <$ 1 TeV, the trilinear terms $0 < |A_d|^2 < M_{10}^2 + M_5^2 + M_{H_1}^2$, $0 < |A_u|^2 < 2\,M_{10}^2 + M_{H_2}^2$, taking their phases arbitrary, and $4 < \tan\beta < 50$. We find that the EDM constraint implies correlations between ϕ_μ and ϕ_{A_0} and between ϕ_μ and M_0^2. While it is possible to find any value for ϕ_{A_0}, the values of ϕ_μ are more constrained: $\phi_\mu \lesssim 0.1$ for lower values of M_0^2, whereas values up to $\phi_\mu = 0.4$ are allowed for higher M_0^2.

Next we discuss the main features of the SUSY particle spectrum relevant for CP violating and FCNC observables. In Fig. 1 we show the scatter plot of the lightest chargino versus the lightest stop masses for the SUSY $SU(5)$ model (set (II)). All points fulfill the EDM and $BR(b \to s\gamma)$ constraints, whereas the black dots are the points of the parameter space that also fulfill the δa_{μ^+} constraint. We confirm the presence of an upper bound on the chargino mass of about 700 GeV for very large $\tan\beta$ (of order 50) [9], and lower for smaller values of $\tan\beta$, which is a consequence of the δa_{μ^+} constraint. It can be shown that this bound is essentially due to our assumption of gaugino mass unification. We would like to stress, however, that in any RGE evolved MSSM with gaugino mass unification the a_{μ^+} constraint has important consequences on the complete MSSM spectrum. As can be seen in Fig. 1, there is a strong correlation among the stop and chargino masses due to the dominant gaugino RGE effects. Then, without any further restriction on the SUSY parameter space, this correlation implies the presence of an upper bound on the light stop mass of $m_{\tilde{t}} \leq 1500$ GeV.

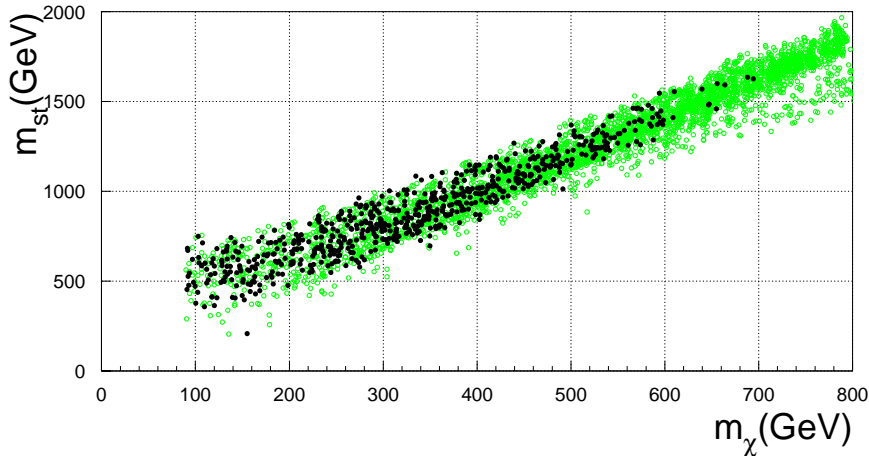An especially interesting observable is the CP asymmetry in the partial width,

$$A_{CP}^{b \to s\gamma} = \frac{BR(\bar{B} \to X_s\gamma) - BR(B \to X_s\gamma)}{BR(\bar{B} \to X_s\gamma) + BR(B \to X_s\gamma)}.$$

The SM prediction for this asymmetry is exceedingly small, therefore, it is sensitive to the new SUSY phases. As ϕ_μ and ϕ_A are associated with chirality changing operators, we can expect large effects in $b \to s\gamma$ [10]. In Fig. 2 we show the correlation among δa_μ and BR($b \to s\gamma$). All points shown fulfill the EDM constraint, whereas the black dots represent the points of the parameter space that also reproduce the measured anomalous magnetic moment. In this plot we can see that the δa_μ constraint cuts out the region of high branching ratios $BR(b \to s\gamma)$. In our flavour blind scenario the main contributions to the $b \to s\gamma$ decay are due to charged Higgs, light stop and light chargino loops. The $BR(b \to s\gamma)$ constraint and the δa_μ constraint favour $Re(\mu) > 0$. Imposing the EDM constraint reduces the CP asymmetry to less than 1% in the region of large branching

ratio $BR(b \to s\gamma)$. However, for small $BR(b \to s\gamma)$ the CP asymmetry can go up to 5%, making it potentially measurable at B factories.

Finally we calculated the SUSY contributions to the CP violating quantities ϵ_K, ΔM_{B_d}, ΔM_{B_s} and studied the modifications of the unitarity triangle. We obtain only small deviations from the SM predictions. This result is different from those obtained in the context of Minimal Flavour Violation MSSM or in the MSSM with non–universal parameters [11, 12]

Figure 1: Chargino–stop mass correlations in the $SU(5)$ inspired MSSM with $b \to s\gamma$ constraint satisfied. The black dots satisfy also the a_{μ^+} constaint.

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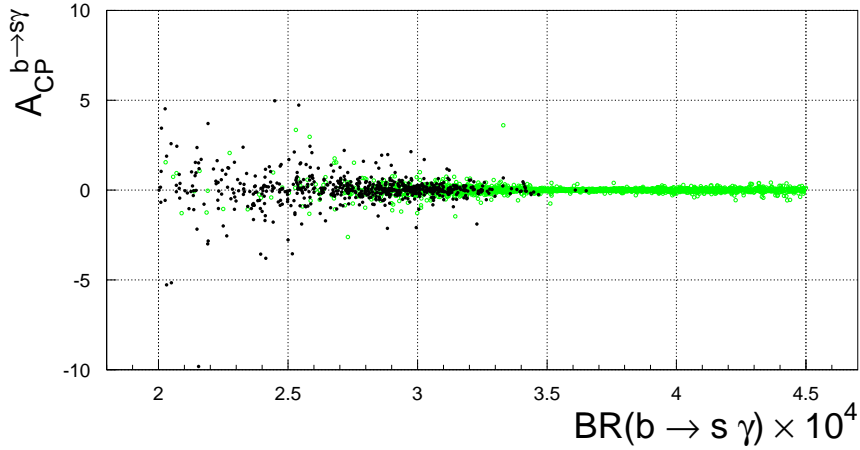
Figure 2: Plot of the CP asymmetry versus the branching ratio of $b \to s\gamma$. We allow only for points whose phases satisfy the EDM's constraints. The black dots satisfy the a_{μ^+} constraint.

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