One way to guarantee the absence of significant FCNC's mediated by virtual supersymmetric particle exchange is to posit that the diagonal soft-supersymmetry-breaking scalar mass matrices are proportional to the unit matrix (in flavor space) at some energy scale (normally taken to be the Planck scale) [28]. Renormalization group evolution is used to determine the low-energy values for the scalar mass parameters listed above. This assumption substantially reduces the MSSM parameter freedom. For example, supersymmetric grand unified models with universal scalar masses at the Planck scale typically give [29] $M_{\widetilde{L}} \approx M_{\widetilde{E}} < M_{\widetilde{Q}} \approx M_{\widetilde{U}} \approx M_{\widetilde{D}}$ with the squark masses somewhere between a factor of 1–3 larger than the slepton masses (neglecting generational distinctions). More specifically, the first two generations are thought to be nearly degenerate in mass, while $M_{\widetilde{Q}_3}$ and $M_{\widetilde{U}_3}$ are typically reduced by a factor of 1–3 from the other soft-supersymmetry-breaking masses because of renormalization effects due to the heavy top quark mass. As a result, four flavors of squarks (with two squark eigenstates per flavor) and $\widetilde{b}_R$ will be nearly mass-degenerate and somewhat heavier than six flavors of nearly mass-degenerate sleptons (with two per flavor for the charged sleptons and one per flavor for the sneutrinos). On the other hand, the $\widetilde{b}_L$ mass and the diagonal $\widetilde{t}_L$ and $\widetilde{t}_R$ masses are reduced compared to the common squark mass of the first two generations. In addition, third generation squark masses and τ slepton masses are sensitive to the strength of the respective $\widetilde{f}_L$–$\widetilde{f}_R$ mixing as discussed below Eq. (5).

Two additional theoretical frameworks are often introduced to reduce further the MSSM parameter freedom [1,2,30]. The first is that of grand unified theories (GUTs) and the desert hypothesis (*i.e* no new physics between the TeV-scale and the GUT-scale). In the absence of low-energy supersymmetry, the simplest models of this type fail because the three SU(3)×SU(2)×U(1) gauge couplings fail to unify at a common scale [31,32]. Remarkably, in the case of the MSSM (with a supersymmetry-breaking scale of order 1 TeV or below), the three gauge couplings do unify at a common energy scale of order 10^{16} GeV (with only very mild assumptions about the GUT-scale theory) [31,33]. Unification constraints on the Higgs-fermion Yukawa couplings may also exist but are more GUT-model dependent [34]. The second theoretical framework is that of minimal supergravity theory, which can impose nontrivial constraints on the soft-supersymmetry breaking parameters. Referring to the parameter list given above Eq. (1), the Planck-scale values of the soft-supersymmetry-breaking parameters in the simplest supergravity models take the following form: (i) a universal gaugino mass $m_{1/2}$ [assuming grand unification; Eq. (4) is a consequence of this assumption]; (ii) a universal diagonal scalar mass parameter m_0 [whose consequences were described in the preceding paragraph]; (iii) a universal A-parameter, A_0; and (iv) three scalar Higgs mass parameters—two common diagonal squared-masses given by $|\mu_0|^2 + m_0^2$ and an off-diagonal squared-mass given by $B_0\mu_0$ (which defines the Planck-scale supersymmetry-breaking parameter B_0), where μ_0 is the Planck-scale value of the μ-parameter. As before, renormalization group evolution is used to compute the low-energy values of the supersymmetry-breaking parameters and determines the supersymmetric particle spectrum. Moreover, in this approach, electroweak symmetry breaking is induced radiatively if one of the Higgs diagonal squared-masses is forced negative by the evolution. This occurs in models with a large Higgs-top quark Yukawa coupling (*i.e.* large m_t). As a result, the two Higgs vacuum expectation values (or equivalently, m_Z and $\tan\beta$) can be expressed as a function of the Planck-scale supergravity parameters. The simplest procedure [29] is to remove μ_0 and B_0 in favor of m_Z and $\tan\beta$ (the sign of μ_0 is not fixed in this process). In this case, the MSSM spectrum and its interactions are determined by m_0, A_0, $m_{1/2}$, $\tan\beta$, and the sign of μ_0 (in addition to the parameters of the Standard Model). Combining both grand unification and the minimal supergravity approach yield the most constrained version of the MSSM.

Nonminimal versions of low-energy supersymmetry can also be constructed. These models add additional matter and/or gauge super-multiplets to the MSSM (at the TeV scale or below). Experimental and theoretical constraints place some restrictions on these approaches, although no comprehensive treatment has yet appeared in the literature.

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