

The sparticle spectrum in gaugino-gauge mediation

Roberto Auzzi

Hebrew University of Jerusalem, Racah Institute of Physics

May, 2011

Based on arXiv:1009.1714, 1011.1664 with Amit Giveon

Supersymmetry is a valuable candidate for physics beyond the Standard Model.

It addresses the hierarchy problem
It provides gauge coupling unification at the GUT scale

However, it should be broken at low energy.
This is ruled out at the tree level (supertrace formula)

Present paradigm: SUSY is broken in a hidden sector and then this is communicated to SM.

$$W_{MSSM} = \bar{u}y_uQH_u - \bar{d}y_dQH_d - \bar{e}y_eLH_d + \mu H_uH_d$$

Need for soft SUSY breakings terms:

$$\begin{aligned} & -\frac{1}{2} \left(M_1 \tilde{B}\tilde{B} + M_2 \tilde{W}\tilde{W} + M_3 \tilde{g}\tilde{g} + \text{c.c.} \right) \\ & - \left(\tilde{u}A_u \tilde{Q}H_u - \tilde{d}A_d \tilde{Q}H_d - \tilde{e}A_e \tilde{L}H_d + \text{c.c.} \right) \\ & - \tilde{Q}^\dagger m_Q^2 \tilde{Q} - \tilde{L}^\dagger m_L^2 \tilde{L} - \tilde{u}m_{\tilde{u}}^2 \tilde{u}^\dagger - \tilde{d}m_{\tilde{d}}^2 \tilde{d}^\dagger - \tilde{e}m_{\tilde{e}}^2 \tilde{e}^\dagger \\ & - m_{H_u}^2 H_u^* H_u - m_{H_d}^2 H_d^* H_d - (B\mu H_u H_d + \text{c.c.}) \end{aligned}$$

The SUSY breakdown is transmitted to known particles by interactions of the SM $SU(3) \times SU(2) \times U(1)$ gauge boson and their superpartners. It is assumed that some chiral superfields in the hidden sector (the "messengers") have non-vanishing SM gauge quantum numbers (there should not be too many messenger in order to avoid the Landau-pole problem)

This kind of coupling is flavor blind, and so solves automatically the flavor problem

An extra mechanism is needed to generate $(\mu, B \mu)$, and it is not so straightforward to generate both μ and B of the same order, and also of the same order of $m_{H_{u,d}}^2$ (μ problem)

Minimal Gauge Mediation

In the minimal scenario we can think of just one messenger pair T, \tilde{T} (for example in the $5 + \bar{5}$ of $SU(5)_{\text{GUT}}$), which couples to the SUSY breaking spurion S with the superpotential:

$$ST\tilde{T}.$$

The field S breaks SUSY via an F-term:

$$S = M + \theta^2 F.$$

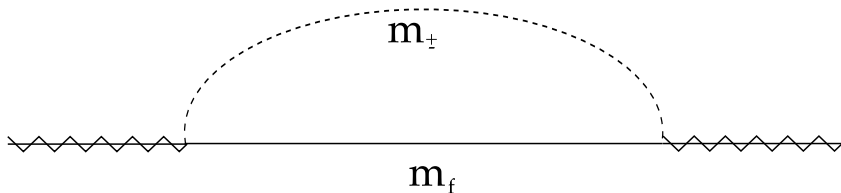
The bosonic components of the messenger superfield get a mass

$$m_{\pm} = \sqrt{M^2 \pm F},$$

while the fermionic component has mass

$$m_f = M.$$

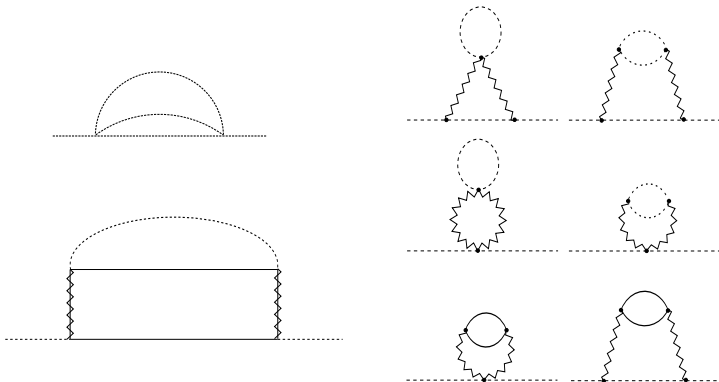
They are generated at one loop :



$$g^2 \int \frac{d^4 k}{(2\pi)^4} \left(\frac{1}{k^2 - M^2 - F} - \frac{1}{k^2 - M^2 + F} \right) \frac{\not{k} + M}{k^2 - M^2} \approx \frac{\alpha}{4\pi} \frac{F}{M},$$

Sfermion masses² in MGM

They are generated at two-loops :



Result of the calculation in MGM

n_r : Dynkin index messengers. $C_r^{\tilde{f}}$: quadratic Casimir of MSSM sfermion

$$m_{\tilde{g}_r} = \frac{\alpha_r}{4\pi} \frac{F}{M} n_r q(x), \quad x = F/M^2,$$

$$q(x) = \frac{1}{x^2} ((1+x) \log(1+x) + (1-x) \log(1-x)).$$

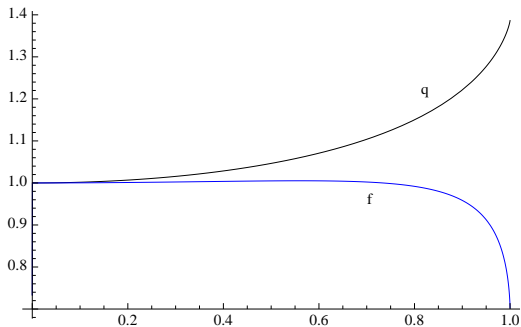
$$m_{\tilde{f}}^2 = 2 \left(\frac{F}{M} \right)^2 \sum_r \left(\frac{\alpha_r}{4\pi} \right)^2 C_r^{\tilde{f}} n_r f(x),$$

$$f(x) = (1+x) \left(\log(1+x) - 2\text{Li}_2 \left(\frac{x}{1+x} \right) + \frac{1}{2} \text{Li}_2 \left(\frac{2x}{1+x} \right) \right) + (x \rightarrow -x)$$

S. Dimopoulos, G. F. Giudice and A. Pomarol, hep-ph/9607225.

S. P. Martin, hep-ph/9608224.

Plot for MGM



The functions $q(x)$ and $f(x)$ which give the gaugino masses and the sfermion masses² in MGM. $x = F/M^2$.

A more general messenger sector

Several messengers (T_i, \tilde{T}_j) , and a more general superpotential:

$$W = (S\lambda_{ij} + m_{ij})T_i\tilde{T}_j,$$

where we take a basis in which m_{ij} is diagonal and λ_{ij} is real and symmetric (we can do this if messenger parity and CP invariance is assumed). In the $F \ll m_i^2$ limit:

$$m_{\tilde{g}}^2 \propto \frac{g^2}{8\pi^2} F \frac{\partial}{\partial S} \log \det(\lambda S + m) = \frac{g^2}{8\pi^2} F \sum_i \frac{\lambda_{ii}}{m_i},$$

$$m_{\tilde{f}}^2 \propto \frac{g^4 Y^2 F^2}{64\pi^4} \sum_i \left(\frac{\lambda_{ii}^2}{m_i^2} + \sum_{j \neq i} \frac{\lambda_{ij}^2}{m_i^2 - m_j^2} \log \frac{m_i^2}{m_j^2} \right).$$

C. Cheung, A. L. Fitzpatrick, D. Shih, 0710.3585 ; T. T. Dumitrescu, Z. Komargodski, N. Seiberg, D. Shih, 1003.2661

Very heavy sfermions in Direct Gauge Mediation

In models of Direct Gauge Mediation, the messengers are a part of the SUSY breaking sector

The SUSY breaking sector can be described by an O’Raifeartaigh model; then there always exist tree-level flat directions emanating from any local SUSY breaking vacuum, which is stabilized by the Coleman-Weinberg one loop potential

If the pseudo-moduli space is locally stable everywhere, then the gaugino masses are zero at the leading order in SUSY breaking:

$$m_{\tilde{g}} \propto F \frac{\partial}{\partial S} \log \det(\lambda S + m) = 0$$

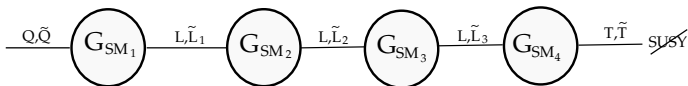
Need for an **”Uplifted Vacuum”** if one wants to consider Direct Gauge Mediation and avoid an hierarchy between gaugino and sfermions masses (with consequent fine tuning due to very heavy sfermions)

Z. Komargodski, D. Shih, 0902.0030

It is then interesting to study mechanisms that suppress sfermion masses compared to gaugino masses in gauge mediation, such as

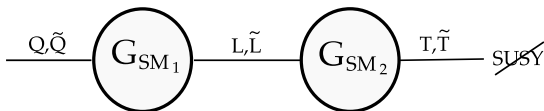
Gaugino Mediation

GM was introduced in the context of extra dimensions
Deconstruction suggests how to implement gaugino mediation in a
4-dimensional theory:



H. C. Cheng, D. E. Kaplan, M. Schmaltz and W. Skiba, hep-ph/0106098;
C. Csaki, J. Erlich, C. Grojean and G. D. Kribs, hep-ph/0106044.

Minimal gaugino-Gauge Mediation



We will consider the shortest non-trivial quiver (1 link field (L, \tilde{L}))
The messengers T, \tilde{T} are coupled to the SUSY breaking spurion as
in MGM

$$W = ST\tilde{T} + K(L\tilde{L} - v^2)$$

The gaugino masses are the same as in MGM
The link field gets a VEV v ; in the limit $v \gg M$ (where M is the messenger mass), MGM sfermion masses are recovered
The gaugino mediation limit correspond to the $v \ll M$ limit, where sfermion masses are suppressed

Higgsing by the link field

The following combination of the two gauge groups gets a mass:

$$2v^2(g_1^2 + g_2^2) \left(\frac{g_1 A_\mu^1 - g_2 A_\mu^2}{\sqrt{g_1^2 + g_2^2}} \right)^2$$

The corresponding gaugino mixes with the link fermion to form a Dirac fermion:

$$v\sqrt{2}(g_1\lambda_1 - g_2\lambda_2)(\psi_L - \psi_{\tilde{L}})$$

The gauge boson and the gaugino :

$$\frac{g_2 A_\mu^1 + g_1 A_\mu^2}{\sqrt{g_1^2 + g_2^2}}, \quad \lambda_A = i \frac{g_2 \lambda_1 + g_1 \lambda_2}{\sqrt{g_1^2 + g_2^2}},$$

stay massless.

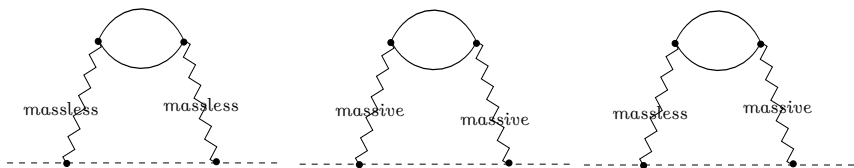
Sfermion masses² in MgGM: scalar contribution



$$\begin{aligned}
 & -2 \int \frac{d^4 p}{(2\pi)^4} \frac{d^4 k}{(2\pi)^4} \frac{1}{(k-p)^2 - m_+^2} \frac{1}{p^2 - m_-^2} \frac{1}{k^2} \left(\frac{4g_1^2 g_2^2 v^2}{k^2 - m_v^2} \right)^2 \\
 & = \int \frac{d^4 p}{(2\pi)^4} \frac{d^4 k}{(2\pi)^4} (\text{MGM integrand}) f,
 \end{aligned}$$

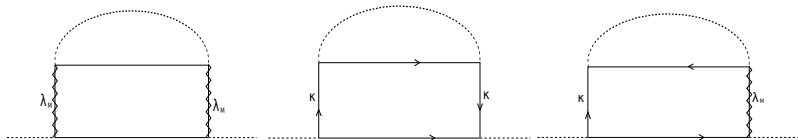
$$\text{where } f(k^2, m_v^2) \equiv \left(\frac{m_v^2}{k^2 - m_v^2} \right)^2, \quad m_v = 2v \sqrt{g_1^2 + g_2^2}$$

Sfermion masses² in MgGM: vector contribution



$$\int \frac{d^4 p}{(2\pi)^4} \frac{d^4 k}{(2\pi)^4} (\text{MGM integrand}) \left(1 + \frac{(k^2)^2}{(k^2 - m_V^2)^2} - \frac{2k^2}{(k^2 - m_V^2)} \right) .$$
$$= \int \frac{d^4 p}{(2\pi)^4} \frac{d^4 k}{(2\pi)^4} (\text{MGM integrand}) f ,$$

Sfermion masses² in MgGM: the total



Similarly it happens for the gaugino contribution; then the 2-loop sfermion masses are given by

$$\int \frac{d^4 p}{(2\pi)^4} \frac{d^4 k}{(2\pi)^4} (\text{MGM integrand}) f ,$$

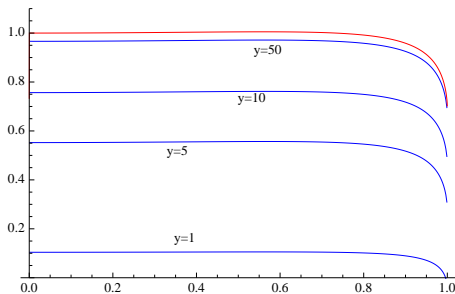
The same results were obtained by M. McGarrie, 1009.0012, using the deconstruction formalism

Sfermion masses² suppression factor

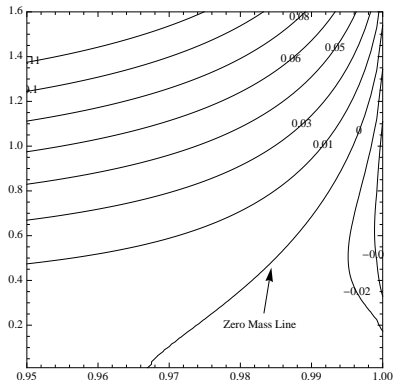
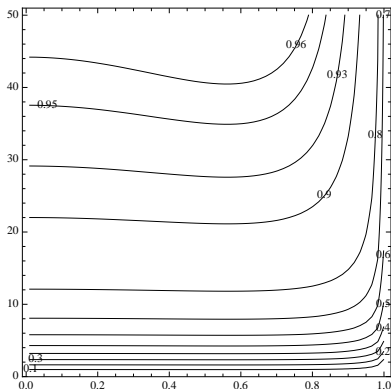
$$x = \frac{F}{M^2}, \quad y = \frac{m_\nu}{M}, \quad m_\nu = 2v\sqrt{g_1^2 + g_2^2}, \quad \frac{1}{g_e^2} = \frac{1}{g_1^2} + \frac{1}{g_2^2}.$$

$$m_{\tilde{f}}^2 = 4 \left(\frac{F}{M} \right)^2 \left(\frac{\alpha_e}{4\pi} \right)^2 s(x, y),$$

An explicit analytical formula was found for $s(x, y)$ in arXiv:1009.1714;
some plots as a function of x for some fixed values of y :



Sfermion masses² suppression factor, contour plot



Sfermion masses² function s in the (x, y) plane,
 $(x = \frac{F}{M^2}, y = \frac{m_\nu}{M})$.

Sfermion masses² suppression factor, analytical expression

$$s(x, y) = \frac{1}{2x^2} \left(s_0 + \frac{s_1 + s_2}{y^2} + s_3 + s_4 + s_5 \right) + (x \rightarrow -x),$$

$$s_0 = 2(1+x) \left(\log(1+x) - 2\text{Li}_2\left(\frac{x}{1+x}\right) + \frac{1}{2}\text{Li}_2\left(\frac{2x}{1+x}\right) \right),$$

$$s_1 = -4x^2 - 2x(1+x)\log^2(1+x) - x^2\text{Li}_2(x^2),$$

$$s_2 = 8(1+x)^2 h\left(\frac{y^2}{1+x}, 1\right) - 4x(1+x) h\left(\frac{y^2}{1+x}, \frac{1}{1+x}\right)$$

$$- 4xh(y^2, 1+x) - 8h(y^2, 1),$$

$$s_3 = -2h\left(\frac{1}{y^2}, \frac{1}{y^2}\right) - 2x h\left(\frac{1+x}{y^2}, \frac{1}{y^2}\right) + 2(1+x)h\left(\frac{1+x}{y^2}, \frac{1+x}{y^2}\right),$$

$$s_4 = (1+x) \left(2h\left(\frac{y^2}{1+x}, \frac{1}{1+x}\right) - h\left(\frac{y^2}{1+x}, 1\right) - h\left(\frac{y^2}{1+x}, \frac{1-x}{1+x}\right) \right),$$

$$s_5 = 2h(y^2, 1+x) - 2h(y^2, 1).$$

$$h(a, b) = \int_0^1 dx \left(1 + \text{Li}_2(1 - \mu^2) - \frac{\mu^2}{1 - \mu^2} \log \mu^2 \right), \quad \mu^2 = \frac{ax + b(1-x)}{x(1-x)}.$$

From the Soft Masses to the physical MSSM spectrum

Now one has to solve the MSSM RG equations up to the electroweak scale, and then diagonalize the mass matrices for each class of MSSM particle; there exists several programs that can do this, for example SOFTSUSY

We choose ν in such a way that $y_0 = 1$, in order to keep the massive vectors decoupled from the RG MSSM equations; also for very low ν we cannot neglect the 3-loops contributions, which are more difficult to compute

This is a hybrid regime (where $\nu \approx M$) between MGM and gaugino mediation

MSSM spectrum examples, 1 pair of messengers

$N_{\text{mess}} = 1$ $\tan \beta = 20$ $\alpha_{g_2}^{-1} = 10$	$M = 2.4 \times 10^5$ $\Lambda = 0.99M$ $v = 9.6 \times 10^4$	$M = 10^8$ $\Lambda = 2.1 \times 10^5$ $v = 3.9 \times 10^7$	$M = 10^{15}$ $\Lambda = 1.5 \times 10^5$ $v = 3.7 \times 10^{14}$
(y_1, y_2, y_3) $(s(1), s(2), s(3))$	(1, 1.10, 1.66) (0.02, 0.03, 0.09)	(1, 1.10, 1.39) (0.10, 0.12, 0.16)	(1, 1.03, 1.05) (0.10, 0.11, 0.11)
(M_1, M_2, M_3) (m_Q, m_u, m_d) (m_L, m_e) $(\mu, B\mu)$	(497, 862, 1808) (665, 652, 651) (140, 59) (534, 736^2)	(372, 589, 999) (707, 668, 663) (257, 131) (661, 598^2)	(430, 472, 497) (332, 289, 275) (205, 152) (610, -176^2)
$m_{\tilde{g}}$	2131	1475	1089
$m_{\tilde{\chi}_0}$	(425, 526, 528, 845)	(281, 520, 637, 666)	(198, 375, 606, 618)
$m_{\tilde{\chi}_{\pm}}$	(516, 845)	(520, 665)	(375, 618)
$(m_{\tilde{u}_L}, m_{\tilde{d}_L})$ $(m_{\tilde{u}_R}, m_{\tilde{d}_R})$ $(m_{\tilde{\tau}_1}, m_{\tilde{\tau}_2})$ $(m_{\tilde{b}_1}, m_{\tilde{b}_2})$	(1405, 1407) (1380, 1380) (1280, 1383) (1354, 1377)	(1298, 1300) (1258, 1256) (1102, 1251) (1218, 1249)	(1027, 1030) (981, 975) (781, 978) (929, 965)
$(m_{\tilde{e}_R}, m_{\tilde{e}_L}, m_{\tilde{\nu}_e})$ $(m_{\tilde{\tau}_1}, m_{\tilde{\tau}_2}, m_{\tilde{\nu}_\tau})$	(129, 302, 292) (106, 309, 291)	(174, 363, 354) (150, 368, 352)	(223, 368, 359) (197, 371, 355)
m_{h_0} $(m_{H_0}, m_{A_0}, m_{H_{\pm}})$	116 (566, 566, 572)	116 (689, 689, 694)	116 (660, 660, 666)
$(\mu, B\mu)$	(519, 641^2)	(631, 735^2)	(600, 687^2)

MSSM spectrum examples, 5 pairs of messengers

$N_{\text{mess}} = 5$ $\tan \beta = 20$ $\alpha_{g_2}^{-1} = 10$	$M = 7.0 \times 10^4$ $\Lambda = 0.99M$ $v = 2.8 \times 10^4$	$M = 10^8$ $\Lambda = 5 \times 10^4$ $v = 3.9 \times 10^7$	$M = 10^{15}$ $\Lambda = 3.4 \times 10^4$ $v = 3.6 \times 10^{14}$
(y_1, y_2, y_3) $(s(1), s(2), s(3))$	(1, 1.10, 1.73) (0.02, 0.03, 0.10)	(1, 1.10, 1.39) (0.10, 0.12, 0.16)	(1, 1.03, 1.05) (0.10, 0.11, 0.11)
(M_1, M_2, M_3) (m_Q, m_u, m_d) (m_L, m_e) $(\mu, B\mu)$	(706, 1240, 2709) (462, 454, 453) (90, 38) (496, 812^2)	(443, 700, 1185) (374, 353, 351) (137, 70) (647, 576^2)	(487, 534, 562) (168, 146, 139) (104, 77) (655, -204^2)
$m_{\tilde{g}}$	3005	1705	1212
$m_{\tilde{\chi}_0}$	(481, 495, 645, 1212)	(334, 578, 626, 696)	(225, 424, 650, 664)
$m_{\tilde{\chi}_{\pm}}$	(490, 1212)	(578, 695)	(424, 664)
$(m_{\tilde{u}_L}, m_{\tilde{d}_L})$ $(m_{\tilde{u}_R}, m_{\tilde{d}_R})$ $(m_{\tilde{t}_1}, m_{\tilde{t}_2})$ $(m_{\tilde{b}_1}, m_{\tilde{b}_2})$	(1577, 1579) (1548, 1548) (1459, 1558) (1530, 1546)	(1325, 1327) (1294, 1293) (1145, 1291) (1253, 1285)	(1102, 1105) (1060, 1057) (855, 1052) (1004, 1045)
$(m_{\tilde{e}_R}, m_{\tilde{e}_L}, m_{\tilde{\nu}_e})$ $(m_{\tilde{\tau}_1}, m_{\tilde{\tau}_2}, m_{\tilde{\nu}_\tau})$	(144, 345, 335) (129, 348, 334)	(149, 333, 323) (122, 339, 321)	(200, 360, 351) (171, 364, 347)
m_{h_0} $(m_{H_0}, m_{A_0}, m_{H_{\pm}})$	116 (560, 560, 566)	116 (663, 663, 668)	116 (693, 693, 698)
$(\mu, B\mu)$	(485, 652^2)	(618, 717^2)	(645, 723^2)

The lightest SUSY particle in Gauge Mediation is the gravitino,

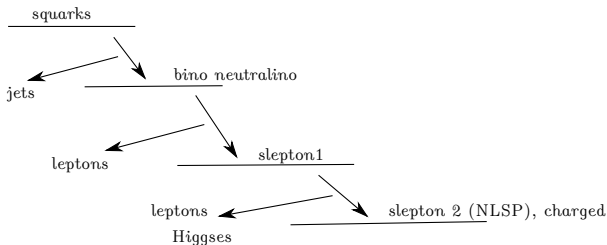
$$m_{3/2} = \frac{F}{k\sqrt{3}M_P} \quad \text{where} \quad k = F/F_0 < 1.$$

Assuming R-parity conservation we expect that all SUSY particle will promptly decay into cascades leading to the NLSP; the nature of the NLSP then determines the nature of the signatures in collider experiments

In MGM the NLSP can be a bino or a stau (for 1 messenger it is usually a bino).

In the hybrid regime that we studied the NLSP is a stau in most of the parameter space already for one messenger

In the low-scale mediation regime, both the right handed as well as the left-handed sleptons are lighter than the bino; this leads to cascade scenarios with copious leptons production. These signatures can be tested at the LHC already in the near future.



A. De Simone, J. Fan, M. Schmaltz and W. Skiba, 0808.2052,0903.5305.

Since the the right-handed slepton masses originate from a flavor universal boundary condition, the right handed selecton and smuon are always nearly degenerate; the lightest stau $\tilde{\tau}_1$ is always the lightest right-handed slepton, because of RG running and left-right mixing.

For sufficiently small $\tan \beta$ (for example, $\tan \beta = 8$), the model has Slepton co-NLSP: the first two generations of sleptons dominantly decay to a lepton and a gravitino instead than to $\tilde{\tau}_1$

$$\delta m_{\tilde{l}_R} = m_{\tilde{e}_R} - m_{\tilde{\tau}_R} \lesssim 5 - 10 \text{ GeV} ,$$

Multilepton final states, Tevatron has an advantage over early LHC: J. T. Ruderman and D. Shih, 1009.1665.

A messenger sector from a dynamical model

"Direct gaugino mediation", D. Green, A. Katz, Z. Komargodski,
arXiv:1008.2215

The messenger sector is as follows :

$$W = (S\lambda_{ij} + m_{ij}) T_i \tilde{T}_j, \quad m_{ij} = \begin{pmatrix} M & m \\ m & 0 \end{pmatrix}, \quad \lambda_{ij} = \begin{pmatrix} 1 & 0 \\ 0 & 0 \end{pmatrix}.$$

The gaugino masses are vanishing at the leading order in F/M (so in principle the sfermions are very heavy compared to gauginos)

What is the effect of the sfermion mass suppression ?

We can again insert the same momentum dependent factor in the sfermion masses integral (M. Sudano, 1009.2086).

MSSM spectrum example

$$x = F/M^2 = 0.8, \quad y_i = m_{\nu_i}/M \approx 0.5, \quad m = M$$

$N_{\text{mess}} = 1$	$M = m = 9 \times 10^5$
$\tan \beta = 20$	$\Lambda = 7.210^5$
$\alpha_{\bar{g}}^{-1} = 5$	$\nu = 1.8 \times 10^5$
$(s(1), s(2), s(3))$	(0.03, 0.03, 0.04)
(M_1, M_2, M_3)	(92, 162, 347)
(m_Q, m_u, m_d)	(1411, 1353, 1348)
(m_L, m_e)	(434, 201)
$(\mu, B\mu)$	(586, 705^2)
$m_{\bar{g}}$	520
$m_{\tilde{\chi}_0}$	(80, 159, 579, 585)
$m_{\tilde{\chi}_{\pm}}$	(159, 586)
$(m_{\tilde{u}_L}, m_{\tilde{d}_L})$	(1438, 1440)
$(m_{\tilde{u}_R}, m_{\tilde{d}_R})$	(1379, 1374)
$(m_{\tilde{t}_1}, m_{\tilde{t}_2})$	(1253, 1377)
$(m_{\tilde{b}_1}, m_{\tilde{b}_2})$	(1354, 1377)
$(m_{\tilde{e}_R}, m_{\tilde{e}_L}, m_{\tilde{\nu}_e})$	(215, 437, 429)
$(m_{\tilde{\tau}_1}, m_{\tilde{\tau}_2}, m_{\tilde{\nu}_\tau})$	(202, 438, 428)
m_{h_0}	115
$(m_{H_0}, m_{A_0}, m_{H_{\pm}})$	(679, 679, 684)
$m_{\text{messengers}}/M$	(0.31, 0.62, 0.75, 1.45, 1.62, 1.80)

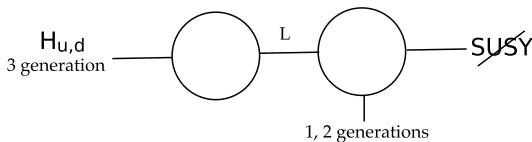
(work in progress with Tomer Shacham)

More general quiver structure

Gaugino/gauge mediation can be studied on more general quiver structures (in the case of linear quiver, see McGarrie, 1009.0012)

”Effective supersymmetry”: the third generation sfermions are light ($\mathcal{O}(\text{TeV})$), while the first and second are considerably heavier.

This can be realized if we make the standard model generations charged under different nodes of the quiver (such as in N. Craig, D. Green, A. Katz, 1103.3708):



[work in progress with Sven Bjarke Gudnason]

MSSM spectrum example

$N_{\text{mess}} = 1$ $\tan \beta = 20$	$M = 2.4 \times 10^5$ $\Lambda = 0.99M$	$M = 10^8$ $\Lambda = 2.1 \times 10^5$	$M = 10^{15}$ $\Lambda = 1.5 \times 10^5$
α_2^{-1} (y_1, y_2, y_3) $(r(1), r(2), r(3))$ $(s(1), s(2), s(3))$	7 (1., 1.06, 1.3) (34.96, 11.76, 2.76) (0.02, 0.03, 0.05)	6 (1., 1.05, 1.16) (39.81, 16.15, 5.79) (0.1, 0.11, 0.13)	5 (1., 1.01, 1.02) (22.38, 18.6, 16.8) (0.1, 0.11, 0.11)
(M_1, M_2, M_3) $(m_Q, m_u, m_d)_{1,2}$ $(m_Q, m_u, m_d)_3$ $(m_L, m_e)_{1,2}$ $(m_L, m_e)_3$ $(\mu, B\mu)$	(494, 854, 1785) (4482, 3919, 3673) (500, 485, 484) (2909, 2369) (131, 59) (482, 659 ²)	(369, 583, 986) (4838, 4230, 3966) (625, 584, 579) (3138, 2551) (247, 130) (595, 461 ²)	(425, 467, 492) (4132, 3607, 3374) (323, 281, 267) (2703, 2205) (201, 150) (530, -456 ²)
$m_{\tilde{g}}$	2280	1574	1157
$m_{\tilde{\chi}_0}$	(419, 476, 487, 861)	(284, 508, 572, 625)	(200, 373, 517, 539)
$m_{\tilde{\chi}_{\pm}}$	(466, 861)	(507, 624)	(373, 539)
$(m_{\tilde{u}_L}, m_{\tilde{d}_L})$ $(m_{\tilde{u}_R}, m_{\tilde{d}_R})$ $(m_{\tilde{t}_1}, m_{\tilde{t}_2})$ $(m_{\tilde{b}_1}, m_{\tilde{b}_2})$	(4640, 4641) (4086, 3848) (1130, 1235) (1200, 1224)	(4946, 4947) (4337, 4074) (899, 1048) (1005, 1043)	(4211, 4212) (3684, 3452) (499, 716) (634, 692)
$(m_{\tilde{e}_R}, m_{\tilde{e}_L}, m_{\tilde{\nu}_e})$ $(m_{\tilde{\tau}_1}, m_{\tilde{\tau}_2}, m_{\tilde{\nu}_\tau})$	(2373, 2922, 2920) (102, 274, 253)	(2553, 3147, 3145) (116, 300, 278)	(2206, 2709, 2708) (99, 241, 207)
m_{h_0} $(m_{H_0}, m_{A_0}, m_{H_{\pm}})$ $(\mu, B\mu)$	116 (505, 505, 511) (467, 572 ²)	116 (599, 599, 605) (565, 638 ²)	117 (519, 519, 526) (512, 536 ²)

Already in the hybrid regime, minimal gaugino-gauge mediation leads to an effective sfermion mass suppression compared to Minimal Gauge Mediation. Leptogenic SUSY in the low-scale mediation regime.

Gauginos and sfermion masses can be comparable even if gaugino masses vanish at leading order in SUSY breaking

Effective supersymmetry can be realized in models where different generation are coupled to different nodes of the quiver. There are important constraints from FCNC that should be inspected carefully.