Tree Level Gauge Mediation

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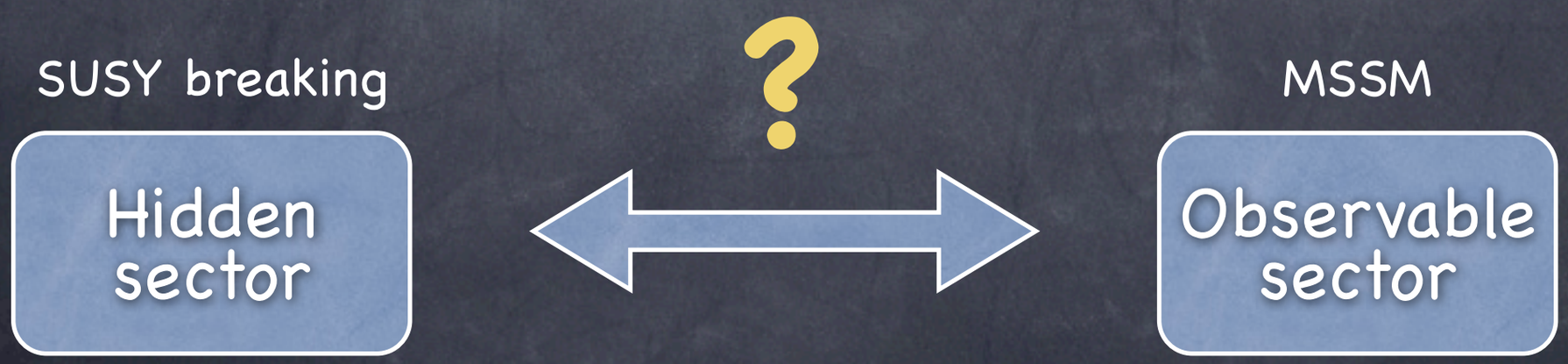
arXiv:0912.5482 (JHEP)
arXiv:0909.3058 (JHEP)

MSSM and SUSY Breaking

- The MSSM, despite its name, is not supersymmetric: $\mathcal{L}^{\rm MSSM} = \mathcal{L}^{\rm MSSM}_{\rm susy} + \mathcal{L}^{\rm MSSM}_{\rm soft}$

$$
\begin{aligned}
\mathcal{L}^{\rm MSSM}_{\rm soft} \;=\; & -\frac{1}{2}\left(M_3\widetilde{g}\widetilde{g} + M_2\widetilde{W}\widetilde{W} + M_1\widetilde{B}\widetilde{B} + \text{c.c.}\right) \\
& -\left(\widetilde{\bar{u}}\,\mathbf{a_u}\,\widetilde{Q}H_u - \widetilde{\bar{d}}\,\mathbf{a_d}\,\widetilde{Q}H_d - \widetilde{\bar{e}}\,\mathbf{a_e}\,\widetilde{L}H_d + \text{c.c.}\right) \\
& -\widetilde{Q}^\dagger\,\mathbf{m^2_Q}\,\widetilde{Q} - \widetilde{L}^\dagger\,\mathbf{m^2_L}\,\widetilde{L} - \widetilde{\bar{u}}\,\mathbf{m^2_u}\,\widetilde{\bar{u}}^\dagger - \widetilde{\bar{d}}\,\mathbf{m^2_d}\,\widetilde{\bar{d}}^\dagger - \widetilde{\bar{e}}\,\mathbf{m^2_e}\,\widetilde{\bar{e}}^\dagger \\
& -m^2_{H_u}H^*_u H_u - m^2_{H_d}H^*_d H_d - (bH_uH_d + \text{c.c})
\end{aligned}
$$

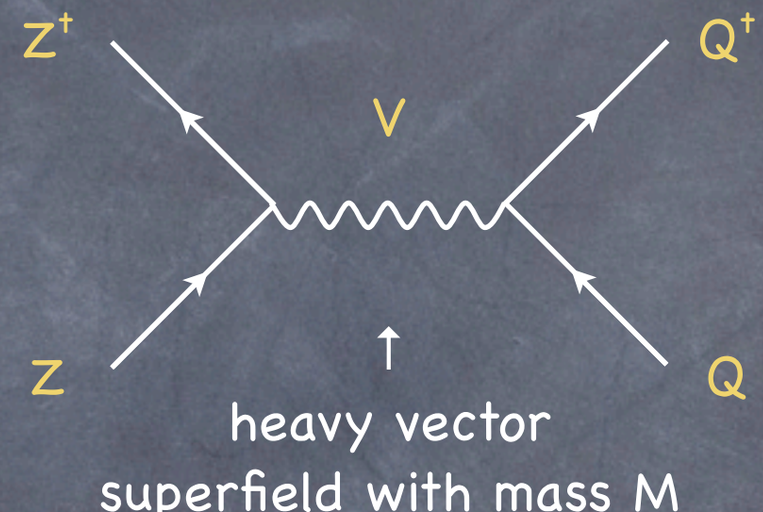
- Around 100 new physical parameters, which can gives rise to FCNC and CP violation
- The soft sector keeps into account the unknown dynamics of the SUSY breaking and its mediation to the SM superfields



Tree Level Gauge Mediation

- In Tree Level Gauge Mediation the supersymmetry breaking is communicated to the scalars of the MSSM trough TREE level gauge interactions:

Z chiral superfield
$\langle Z \rangle = F\theta^2$
$F \gg (M_Z)^2$
SM singlet



heavy vector
superfield with mass M

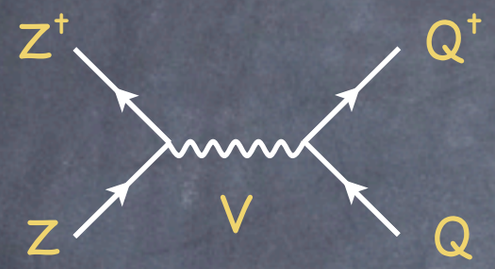
$$\int d^4\theta \, \frac{Z^\dagger Z \, Q^\dagger Q}{M^2}$$

$$\rightarrow m^2 \tilde{Q}^\dagger \tilde{Q}, \quad m^2 = \frac{F^2}{M^2}$$

- Two arguments seem to prevent this possibility: supertrace formula and gaugino masses
- To satisfy the constraints imposed by the supertrace formula we need two ingredients: an extra U(1) gauge interactions and heavy d.o.f. which receive negative supersymmetry breaking contributions
- Gaugino Masses arise at 1-loop trough the usual loop gauge mediation, the expected hierarchy between sfermion and gaugino masses can be reduced trough model dependent factors

[Arkani-Hamed Dimopoulos
Giudice Romanino]

A concrete example

- G = SO(10) "minimal" GUT (V heavy SM singlet means rank ≥ 5)
- V associated to the SU(5)-invariant generator "X"
- 

gives $\tilde{m}_Q^2 \propto X_Q X_Z$

- The (usual) embedding of a MSSM family in a single 16 does not work (whatever the sign of X_Z)
- The three MSSM families are embedded in $16_i + 10_i$, i=1,2,3 (needs $X_Z > 0$)

SO(10)		SU(5)		
16_i	=	5_i +	$\boxed{10_i}$ +	1_i
X		−3	1	5

SO(10)		SU(5)	
10_i	=	$\boxed{5_i}$ +	5_i
X		2	−2

- Prediction: $\tilde{m}_q^2 = \tilde{m}_{u^c}^2 = \tilde{m}_{e^c}^2 = \tilde{m}_{10}^2 = \frac{1}{10}\, m^2, \quad \tilde{m}_l^2 = \tilde{m}_{d^c}^2 = \tilde{m}_{\bar{5}}^2 = \frac{1}{5}\, m^2, \quad m = \frac{F}{M}$

An example of spectrum

Higgs:	m_{h^0}	114
	m_{H^0}	1543
	m_A	1543
	$m_{H^\pm}$	1545
Gluinos:	$M_{\tilde{g}}$	448
Neutralinos:	$m_{\chi_1^0}$	62
	$m_{\chi_2^0}$	124
	$m_{\chi_3^0}$	1414
	$m_{\chi_4^0}$	1415
Charginos:	$m_{\chi_1^\pm}$	124
	$m_{\chi_2^\pm}$	1416
Squarks:	$m_{\tilde{u}_L}$	1092
	$m_{\tilde{u}_R}$	1027
	$m_{\tilde{d}_L}$	1095
	$m_{\tilde{d}_R}$	1494
	$m_{\tilde{t}_1}$	1007
	$m_{\tilde{t}_2}$	1038
	$m_{\tilde{b}_1}$	1069
	$m_{\tilde{b}_2}$	1435
Sleptons:	$m_{\tilde{e}_L}$	1420
	$m_{\tilde{e}_R}$	1091
	$m_{\tilde{\tau}_1}$	992
	$m_{\tilde{\tau}_2}$	1387
	$m_{\tilde{\nu}_e}$	1418
	$m_{\tilde{\nu}_\tau}$	1382

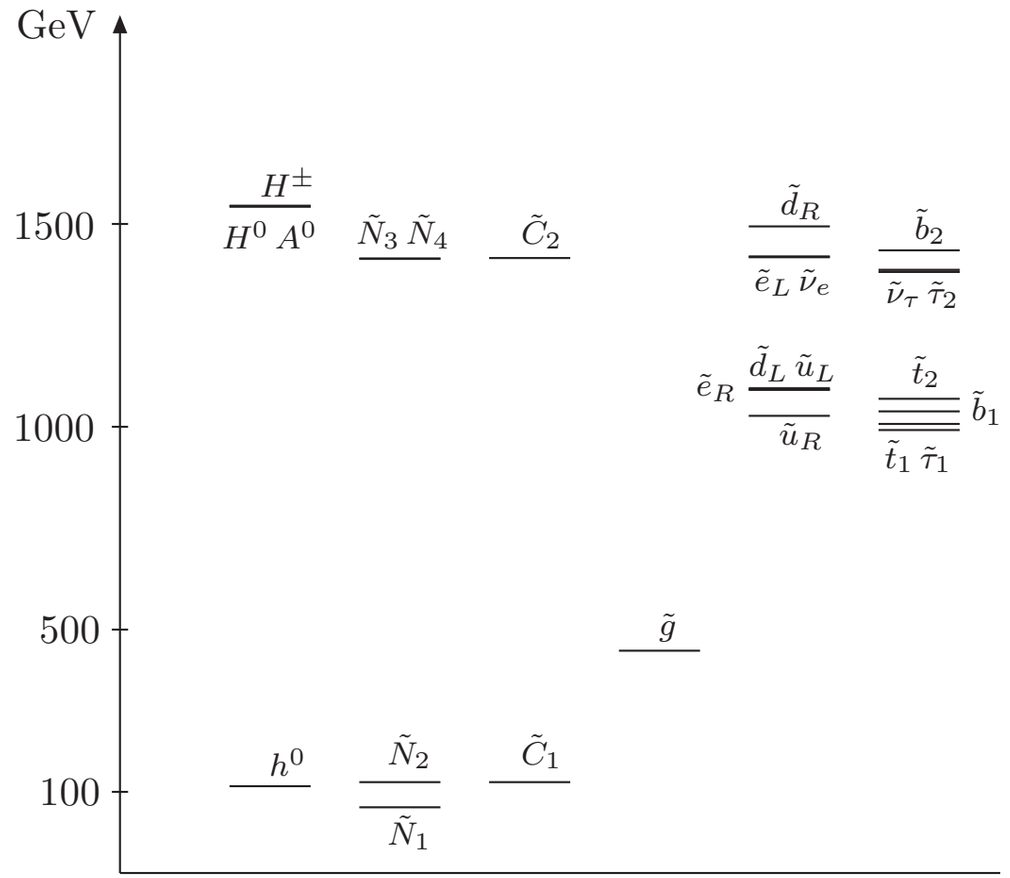


Figure 2: An example of spectrum, corresponding to $m = 3.2\,\mathrm{TeV}$, $M_{1/2} = 150\,\mathrm{GeV}$, $\theta_d = \pi/6$, $\tan\beta = 30$ and $\mathrm{sign}(\mu) = +$, $A = 0$, $\eta = 1$. All the masses are in GeV, the first two families have an approximately equal mass.

Conclusions

- Tree level gauge mediation is one simple way to communicate supersymmetry breaking: through the tree level renormalizable exchange of a heavy gauge messenger

- This possibility is viable, despite the well known arguments associated to the supertrace formula

- It offers new model building avenues (including μ-problem)

- It solves the susy flavour problem

- It leads to a description of supersymmetry breaking in terms of few parameters, with peculiar relations among sfermion masses that can be tested at the LHC