A model of dynamical SUSY breaking with R symmetry and Dirac gauginos

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Motivation for R symmetry

- Dirac masses:
  - MSSM: top/stop loop in Higgs mass log-divergent hence: Naturalness→low scale stops
  - **BUT** Dirac gluino mass cuts off the divergence, it <u>allows heavier superpartners (1 TeV)</u>

- Heavy gluino (5 TeV) production is kinematically suppressed

- Naturally squarks lighter than gluinos

- R symmetry:
  - Takes care of FCNC and CP-violation, relevant interactions are absent (Kribs et al., hep-ph: **0712.2039**)

Collider phenomenology

Kribs,Martin, hep-ph:**1203.4821**

- T-channel gluino exchange is forbidden (same handedness) or suppressed by M_3^2 (mixed)
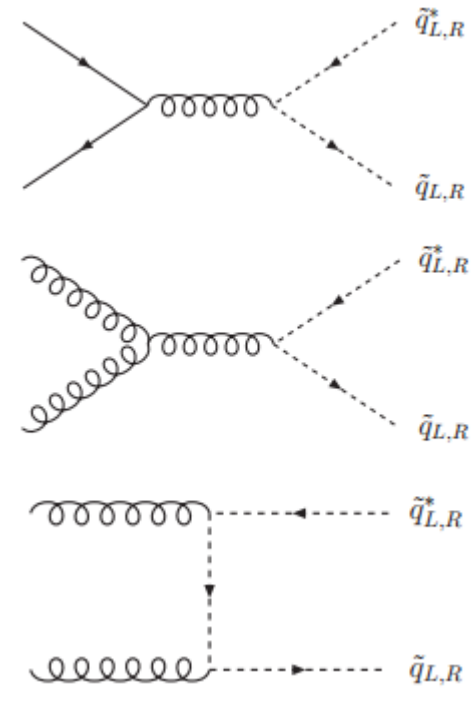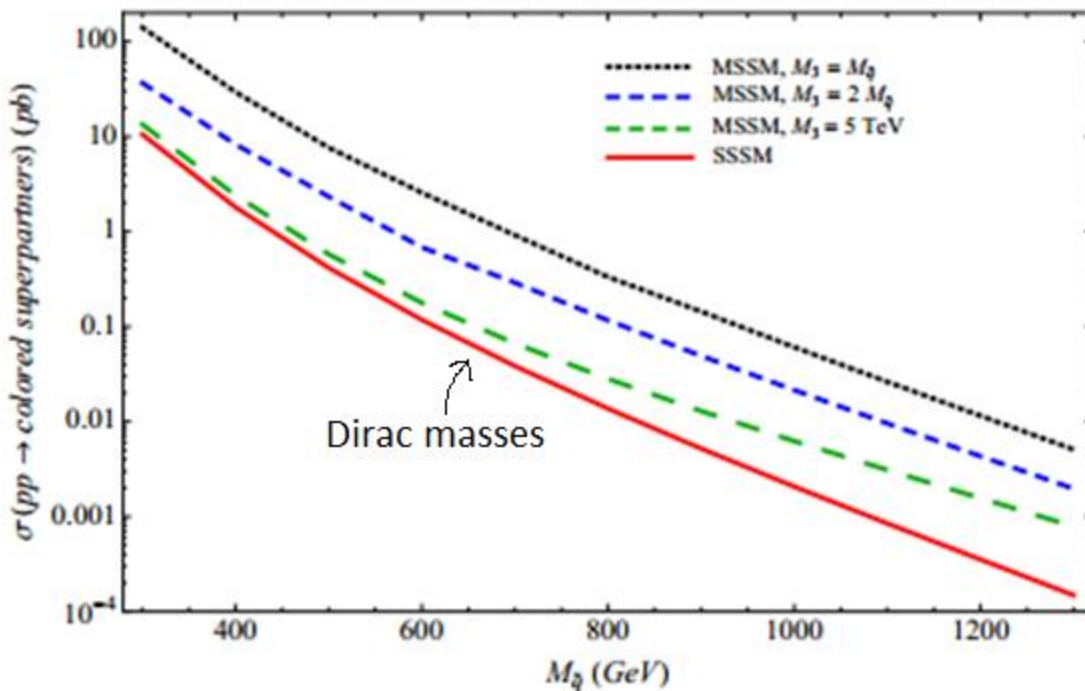
Only relevant **squark production** channels

Dirac masses

Supersoft mediation

- $\int d^2\theta \; \dfrac{W'_\alpha W_j^\alpha M_j}{\Lambda}$

  W': U(1)' gauge. Wj: SM gauge field; Mj: adjoint chiral superfield: gaugino partners

- Need the D' term from a U(1)' gauge field

- Contains Dirac mass term: $\dfrac{D'}{\Lambda} \lambda_j \widetilde{m_j}$

- Generates **FINITE** sfermion masses, gauge loops

- Can generate this operator from messengers

$$\int d^2\theta \; m\bar{\phi}\phi + \bar{\phi}M\phi$$

Seiberg duality and modifying ISS

- The s-confining low energy dual of SUSY QCD with 6 flavors
- Flavor group SU(6) broken by gauging SU(5) subgroup and identifying with the SM

- Theory of Baryons and Mesons

$$B = \begin{pmatrix} \phi_j \\ \psi \end{pmatrix} \qquad\qquad \widetilde{M} = \begin{pmatrix} M_i^j & N^j \\ \overline{N_i} & X \end{pmatrix}$$

- Seiberg$\rightarrow W = \bar{B}\widetilde{M}B = \boldsymbol{\overline{\phi}M\phi} + \psi N\bar{\phi} + \bar{\psi}\bar{N}\phi + \psi\bar{\psi}X$
- **M adjoint is partnered to SM gauginos, automatic trilinear term**

Additional Superpotential

From Seiberg   Meson

- $(\psi\overline{\psi}X) - \mu^2 X +$
  $$+hS(\psi + T) + h'\overline{S}(\overline{\psi} + \overline{T}) + \alpha ZT\overline{T}$$

Baryon   Baryon

- Singlets $S, \overline{S}, T, \overline{T}, Z$
- Can Gauge U(1)$_B$ Baryon number
- Consistent with U(1)$_R$ R-symmetry

	M	$\mathrm{Tr}M$	N	$\overline{N}$	X	ψ	$\overline{\psi}$	ϕ	$\overline{\phi}$	S	$\overline{S}$	T	$\overline{T}$	Z	W	N'	$\overline{N'}$
$SU(5)$	Adj	1	□	□	1	1	1	□	□	1	1	1	1	1	1	□	□
$U(1)$	0	0	0	0	0	+1	−1	+1	−1	−1	+1	+1	−1	0	0	0	0
$U(1)_\mathrm{R}$	0	0	1	1	2	0	0	1	1	2	2	0	0	2	2	1	1

- The additional terms force asymmetric VEV's
  →D term

Minimum and VEV's

- $\psi, \overline{\psi}(\textit{within baryons}) \,\&\, T, \overline{T}$ get VEV's

- TrM is given VEV by hand with additional singlet. This also provides φ masses

- Couplings h and h' are irrelevant in the "Electric theory", some tuning required. Can be chosen equal and then Charge Conjugation is broken spontaneously→ D term

- There is NO flat direction

- M adjoint remains massless

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Mediation (loops)

- **Dirac gaugino** mass:
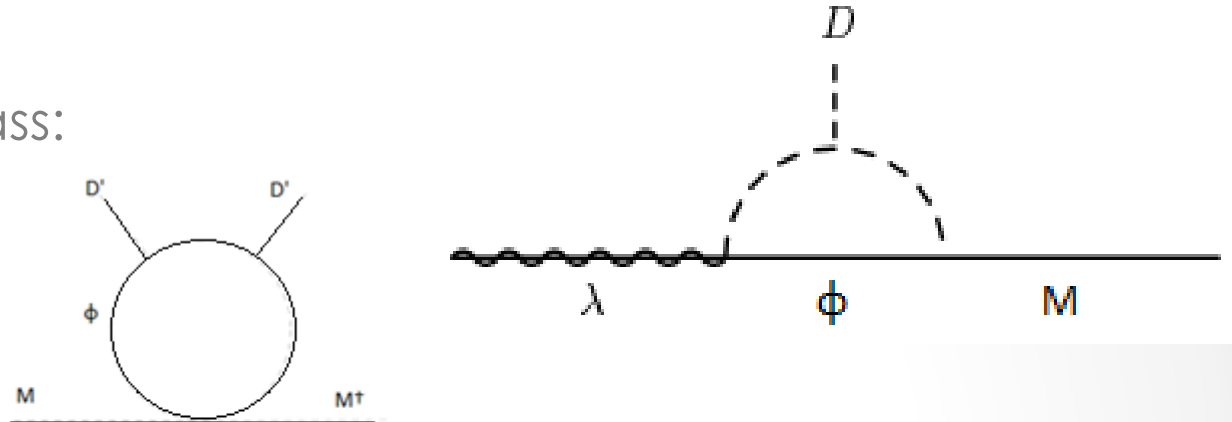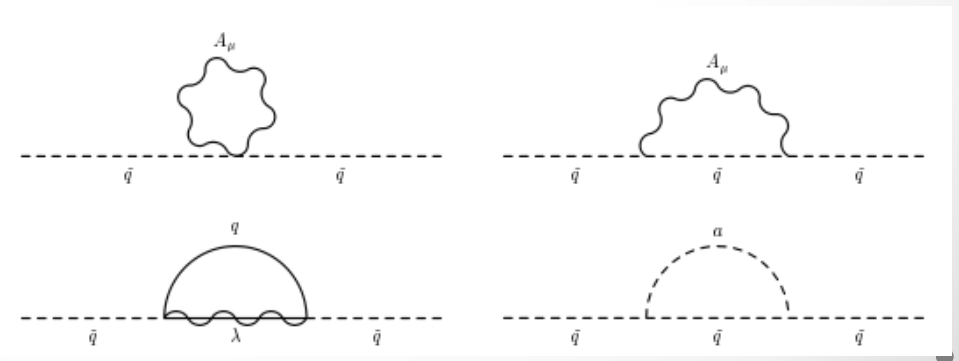
- **Scalar M** masses:
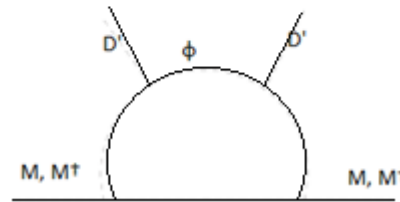
- **Sfermion soft** masses, $m^2 = \dfrac{C_i(r)\alpha_i m_i^2}{\pi}\log(\dfrac{\delta^2}{m_i^2})$

  δ is the mass of scalar M

Scales

- **Require tuned coincidence coupling** of $S\,\psi\ \approx S\,T$

- Spectrum much dependent on parameters
- *Example:*
- $\mu^2 = \Lambda\,m_{Electric} \sim (5000\;TeV)^2$

- $h \cong h' = \left(\frac{\Lambda}{M_{UV}}\right)^3 \Lambda \sim 10{,}000\;TeV$

- $\Lambda\;as\;high\;as\;10^{15}\,GeV$

- Gluino ~ 5 TeV
- Scalar M adjoint ~ 50 TeV
- Squarks ~ 800 Gev − 1 TeV

Conclusions

- It was possible to construct a model of SUSY breaking that produces both D and F terms

- An R symmetry is unbroken which allows evading collider bounds and flavor bounds

- Dirac gaugino masses are naturally heavier and partners can be automatically obtained from mesons in a confining SQCD theory

- Interesting phenomenologies are now within reach of model-builders

- The Higgs sector is work for the future

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Higgs

- R symmetry forbids having both **μ** and **Bμ** together

- In original Fox, Nelson, Weiner quartic is suppressed but **NOT** here, due to large mass for scalar Adj M

- Possible to introduce fields with R-charge 2:
  - $W = \mu_u H_u R_u + \mu_d H_d R_d$

- Not clear how to generate this within our mediation →Need direct coupling

- Can use standard mechanisms for generating Bμ