R Parity violating Benchmark Points

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Outline

1. Introduction R Parity Conserving mSUGRA

2. Phenomenology of R Parity Violation

3. 2 Candidates & Outlook

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Intro: mSUGRA

- MSSM most widely studied extension of the SM.

- Unification of the three SM gauge couplings at
  $M_X = \mathcal{O}(10^{16} \text{ GeV}) \rightarrow$ embedding in unified model.

simplest such model: mSUGRA

- SUSY breaking occurs in hidden sector and communicated
  to visible sector via gravity.

- especially, large number of MSSM parameters reduced to

  $$M_0 \,, M_{1/2} \,, A_0 \,, \tan\beta \,, \text{sgn}\mu$$

  at scale of unification.

- RPC $\rightarrow$ LSP stable $\rightarrow$ neutralino–LSP

Snowmass Points and Slopes

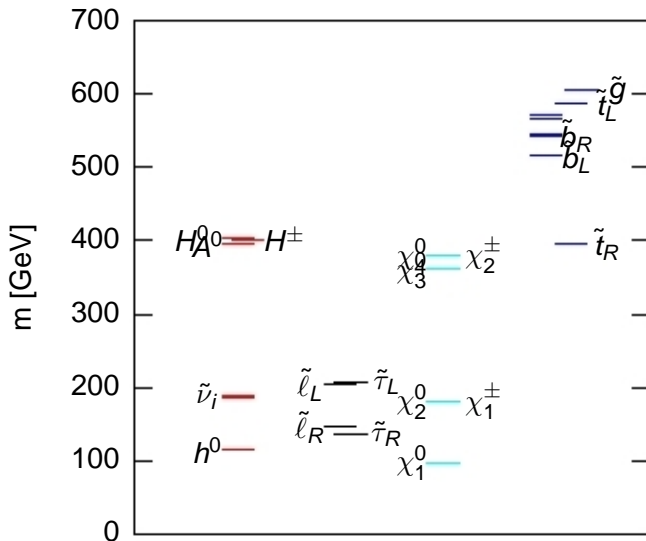- MSSM is widely studied: SPS–benchmark scenarios for comparism.

  [*Snowmass Points and Slopes*, $hep-ph/0202233$]

- SPS consists of 10 characteristic points and 7 slopes.

- most well known (SUGRA point): SPS1a:

  $$M_0 = 100, \, M_{1/2} = 250, \, A_0 = -100, \, \tan\beta = 10, \, \mu > 0.$$

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SPS1a spectrum

What happens with R Parity Violation?

- new couplings in superpotential:

$$
\mathbf{W}_{\not{R}_P} = \epsilon_{ab}\left[\frac{1}{2}\lambda_{ijk}L_i^a L_j^b \bar{E}_k + \lambda'_{ijk}L_i^a Q_j^{bx}\bar{D}_{kx}\right]
$$
$$
+ \frac{1}{2}\epsilon_{xyz}\lambda''_{ijk}\bar{U}_i^x\bar{D}_j^y\bar{D}_k^z - \epsilon_{ab}\kappa^i L_i^a H_2^b.
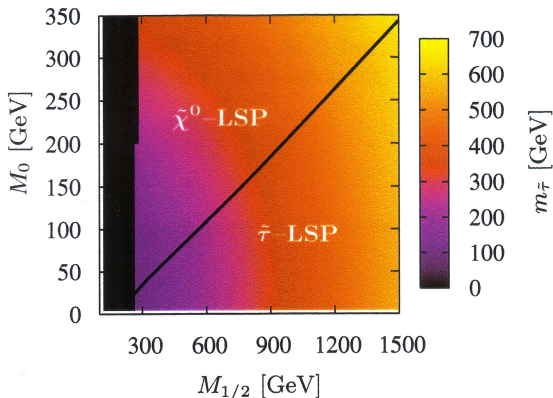$$

- RGEs change.

- what happens to the spectrum?

- restriction to no-scale mSUGRA ($A_0 = M_0 = 0$) with quark-mixing in down sector.

Changes in Spectrum

- the allowed RPV-couplings λ and λ' are $\mathcal{O}(10^{-2\cdots-6})$
  too small to change the spectrum.
  - neutrino mass bounds and tachyons:
    [*Allanach*, *Dedes*, *Dreiner* : *Phys Rev D* 69, 115002 (2004)]

  - low energy pheno:
    [*Allanach*, *Dedes*, *Dreiner* : *hep − ph*/9906209]

- only larger RPV couplings still allowed are λ''_{2jk} s (UDD).

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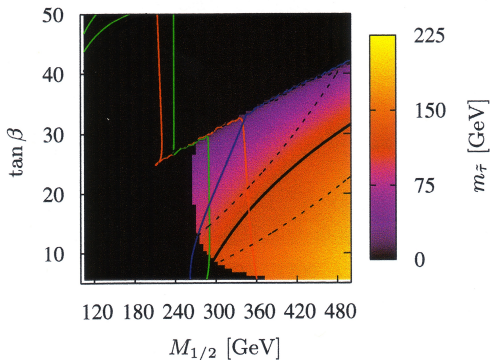
Change in Philosophy I

- possibility of a $\tilde{\tau}$–LSP $\rightarrow$ changes phenomenology

Change in Philosophy II

- possibility: neutralino not even NLSP or NNLSP, but NNNLSP.

black contour: $m_h = m_{\tilde{\tau}_1}$. red contour: $m_{\tilde{\chi}_1^0} = m_{\tilde{e}_1}$. green: $m_h = m_{\tilde{\chi}_1^0}$. blue: $m_{\tilde{\chi}_2^0} = m_{\tilde{\tau}_2}$.
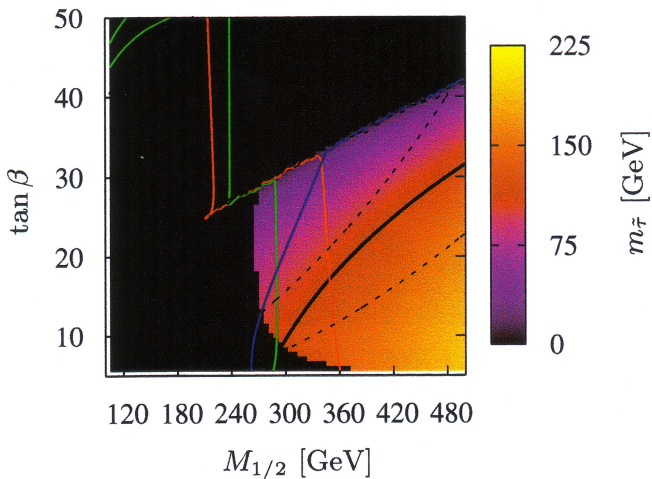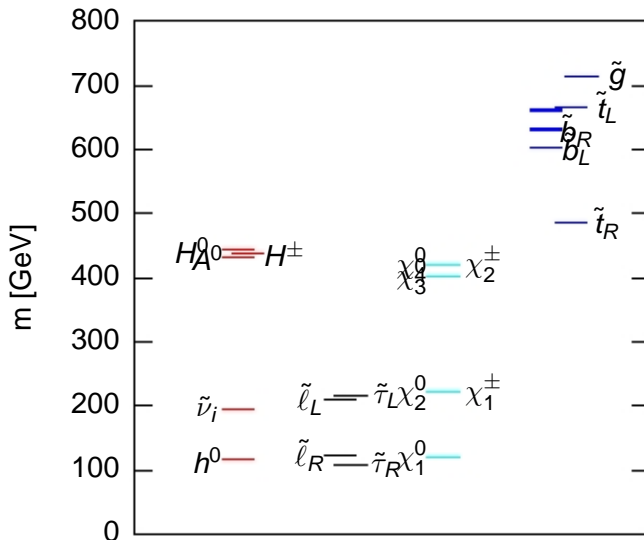
Benchmark Evaluation

- constraints to take into account:

  - $(g-2)_\mu$.

  - $b \to s\gamma$ with new calculation of leading log contribution.

  - $\mathcal{B}(B_s \to \mu^+\mu^-)$ with new calculation of the RPV contribution.

- changes in sparticle mass hierarchy.

Two first candidates: no scale model, down mixing, $M_{1/2} = 300, \tan\beta = 13$ and $M_{1/2} = 400, \tan\beta = 20$.
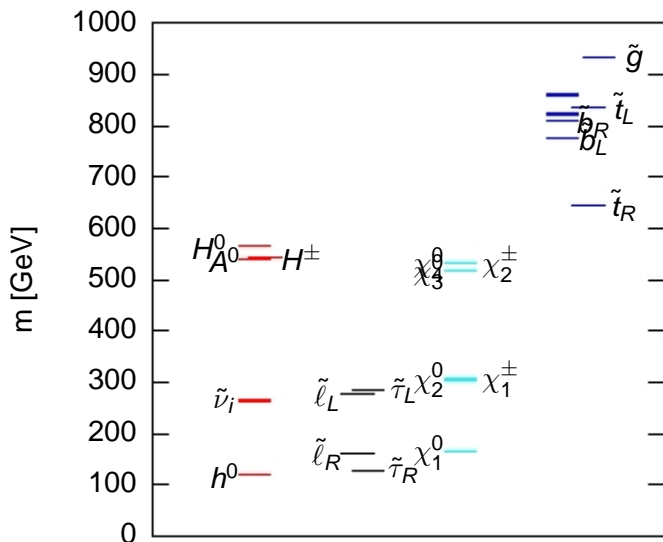
Spectra of Candidates

Spectrum with $\tilde{\chi}^0$ – NLSP

Spectrum with $\tilde{\chi}^0$ – NNNLSP

Summary & Outlook

- mSUGRA benchmarks with RPV.

  - different roles of the lightest neutralino: LSP, NLSP, NNLSP, NNNLSP.

- overview: phenomena taken into account.

- work in progress:
  - analyze *non* no-scale models.
  - analyze models with neutralino LSPs: possibility of detached vertex.
  - philosophy of violated coupling at M_{GUT}.
  - 2-body or 4-body decay of the LSP.
  - possible effects of $\chi^{\pm} - \ell^{\pm}$ and $\tilde{\chi}^0 - \nu$ mixing.

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