

Aspects of Non-minimal SUSY phenomenology.

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Fellow Day '17

Hamburg, 12.12.17

Personal

- > Last Fellow day: 31.10.16
- > Arrival in Hamburg: 01.11.16
- > So, just starting 😊



Diplom and PhD at TU Dresden
with Dominik Stöckinger
Floated down the Elbe to DESY

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What about SUSY?

MSSM is appealing from theory side:

- > Hierarchy problem
- > Gauge coupl. unific.
- > REWSB
- > DM candidate



MSSM didn't light up LHC experiments

ATLAS Preliminary

 $\sqrt{s} = 7, 8, 13 \text{ TeV}$

*Only a selection of the available mass limits on new states or phenomena is shown. Many of the limits are based on simplified models, c.f. refs. for the assumptions made.

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Mass scale [TeV]

Beyond the MSSM

Full model

Simplified model

EFT



Beyond the MSSM

Full model

- > Look into non-minimal models for spectrum of alternative predictions
- > Containing features maybe missing in simplified models



Beyond the MSSM

Full model

- > Look into non-minimal models for spectrum of alternative predictions
- > Containing features maybe missing in simplified models
- > For my PhD: **R-Symmetry**
 - Includes solution to flavor problem of the MSSM
 - Dirac gauginos (esp. gluino) might explain SUSY non-discovery
 - Extended Higgs sector, different predictions than (N)MSSM



Phenomenology

- > Go calculate all interesting things!
- > Community has decades of experience studying BSM physics
- > In the last years, big efforts to generalize codes and availability see e.g. hepforge.org¹
- > Straight-forward application to full models?

¹FlexibleSUSY, SARAH/SPHeno, HiggsBounds, HiggsSignals, micrOMEGAs, Herwig++, CheckMATE, GoSam, MadGraph aMC



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- > Straight-forward application to full models?
- > Yes, if MSSM. Otherwise a bit work required.

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R-symmetry

- > Additional symmetry allowed by SUSY algebra described in “Haag-Łopuszański-Sohnius-Theorem”
- > For $N = 1$ SUSY it is a global $U(1)_R$ symmetry
→ charged Spinor coordinates:
 $Q_R(\theta) = 1, Q_R(\bar{\theta}) = -1; \quad (\theta \rightarrow e^{i\alpha}\theta, \bar{\theta} \rightarrow e^{-i\alpha}\bar{\theta})$
- > Lagrangian has to be invariant
- > SM fields have $Q_R = 0$
- > SUSY partners carry charge (MRSSM [Kribs et.al. \(Phys.Rev. D78 \(2008\) 055010\)](#))
- > Forbids Majorana mass terms and A terms

Assume R-symmetry to be unbroken.



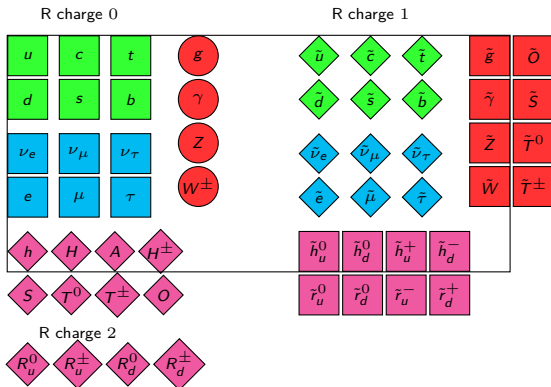
Particles of the MRSSM

Adding to the MSSM

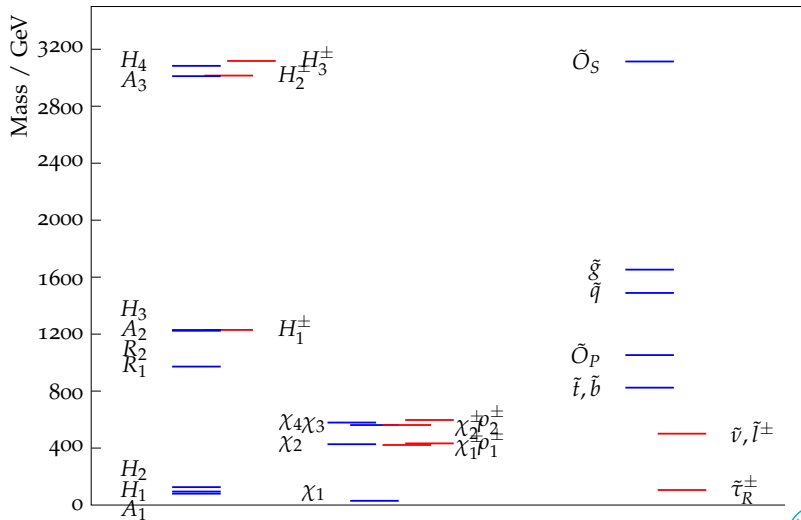
		$SU(3)_C$	$SU(2)_L$	$U(1)_Y$	$U(1)_R$
Singlet	$\hat{S}$	1	1	0	0
Triplet	$\hat{T}$	1	3	0	0
Octet	$\hat{O}$	8	1	0	0
R-Higgses	$\hat{R}_u$	1	2	$-1/2$	2
	$\hat{R}_d$	1	2	$1/2$	2



Particles of the MRSSM



Mass spectrum



Aspect one: 125 GeV Higgs boson

Known from MSSM: Loop contributions important

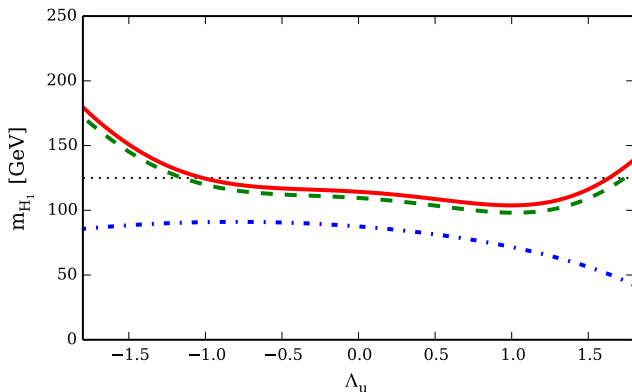
$$m_h^2 = m_Z^2 \cos^2 2\beta + \frac{6v_u^2}{16\pi^2} \left[Y_t^4 \log \frac{m_{\tilde{t}_1} m_{\tilde{t}_2}}{m_t^2} \right]$$



Aspect one: 125 GeV Higgs boson

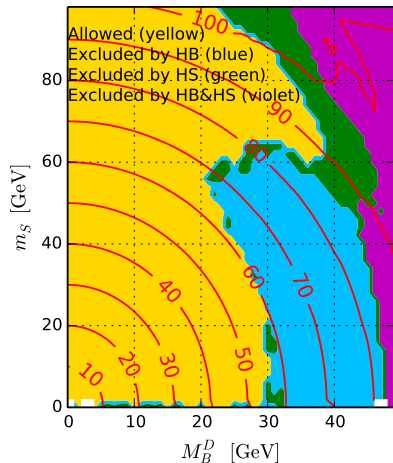
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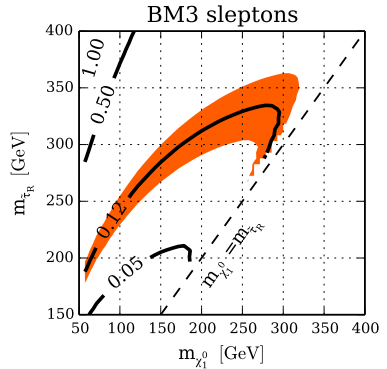
Phenomenology in other directions

- > Extended Higgs sector: What about a lighter Higgs boson?



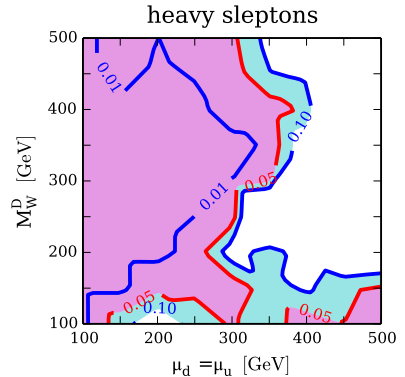
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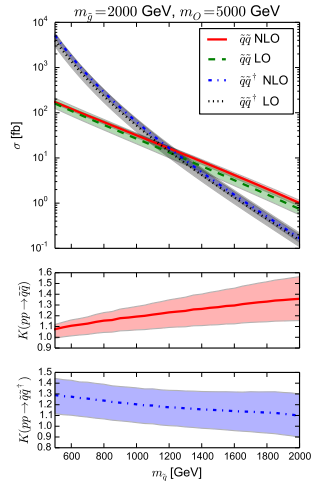
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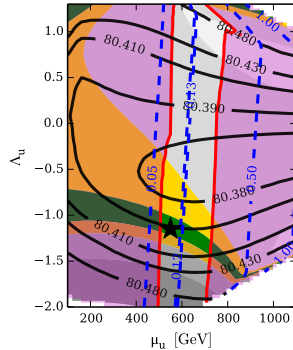
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Model parameter space non-trivially constrained but still allowed regions



On-going projects

- > How do MRSSM squarks and gluinos do at the LHC?
- > Using G_μ as model input, M_W is a prediction of a model
Low uncertainty on measurement and SM prediction
 $\Rightarrow$ Add BSM (not only MRSSM) correctly and with low uncertainty



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Thanks for the attention!

