Improving predictions of non-minimal supersymmetric models

Motivation

Softly broken supersymmetric models are attractive extensions of the Standard Model: They can provide gauge coupling unification, incorporation of gravity, cancellation of quadratic divergences and a solution of the hierarchy problem. However, the minimal supersymmetric extension of the Standard Model (MSSM) is not the theoretically and experimentally most favored. Therefore, non-minimal supersymmetric models as the NMSSM, CE_6SSM, USSM are often more attractive and hence have to be studied in detail.

The aim of my Ph.D. thesis is to

- improve the precision of the mass spectrum prediction
- calculate observables to set limits on the parameter space

of various non-minimal supersymmetric models.

Methods

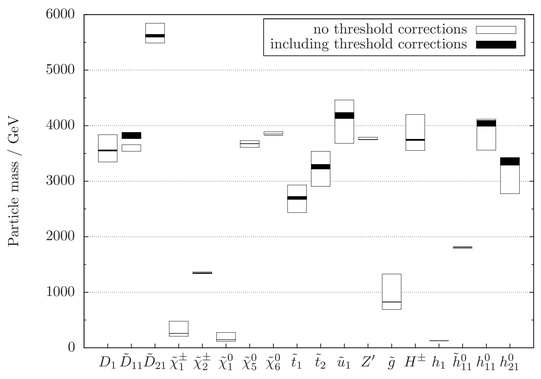
To improve the precision of the predictions of the various non-minimal supersymmetric models the following things are done:

- Calculate threshold corrections to renormalization group running of the gauge and Yukawa couplings in the E_6SSM and implement them into a CE_6SSM spectrum generator.
- Calculate observables (m_h, $m_{\tilde{q}_i}$, $m_{\tilde{\chi}_i^0}$, etc.) in well motivated CE_6SSM scenarios and compare with experimental data.
- Write a general spectrum generator for non-minimal supersymmetric models.
- Calculate $h \to \gamma\gamma$ in the E_6SSM to set limits on the allowed parameter space.
- Calculate the renormalization of $\delta v_i / v_i$ in a general spontaneously broken gauge theory. This will complete the list of β functions for all parameters in these theories. The result can be used to calculate the RGE of $\tan\beta$ in susy models with extended gauge groups.

Recent Results

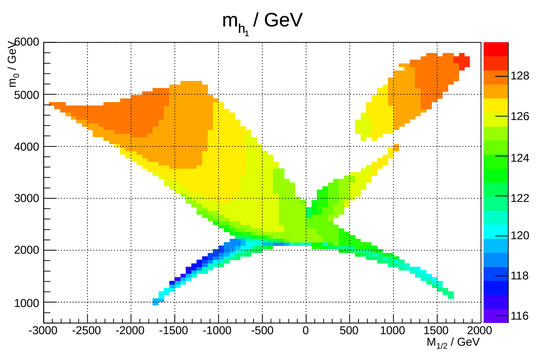
Threshold corrections in the E_6SSM

The calculation of threshold corrections to renormalization group running of the gauge and the Yukawa couplings in the E_6SSM led to a strongly improved precision of the CE_6SSM mass spectrum.

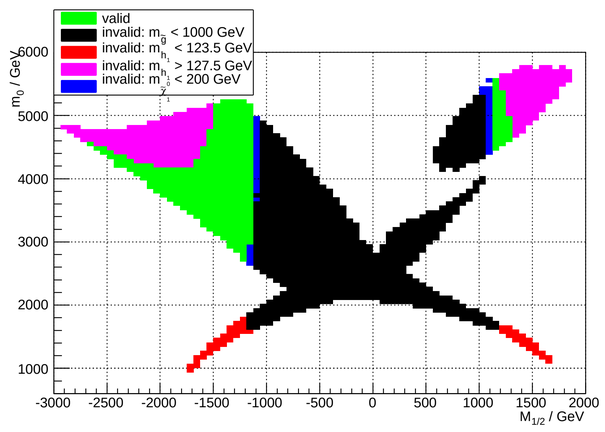


Study of the CE_6SSM parameter space

Observables as functions of CE_6SSM model parameters in well motivated scenarios were calculated.



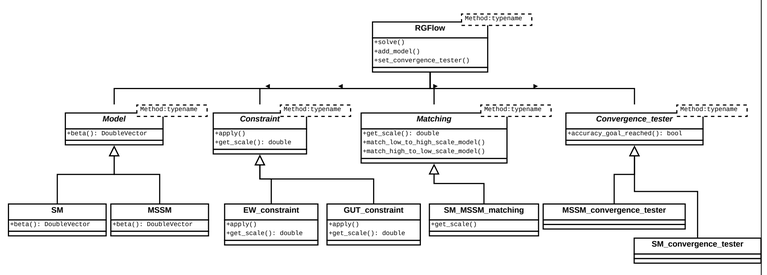
By applying the latest LHC limits on supersymmetric particles to the CE_6SSM it was possible to exclude large parts of the parameter space.



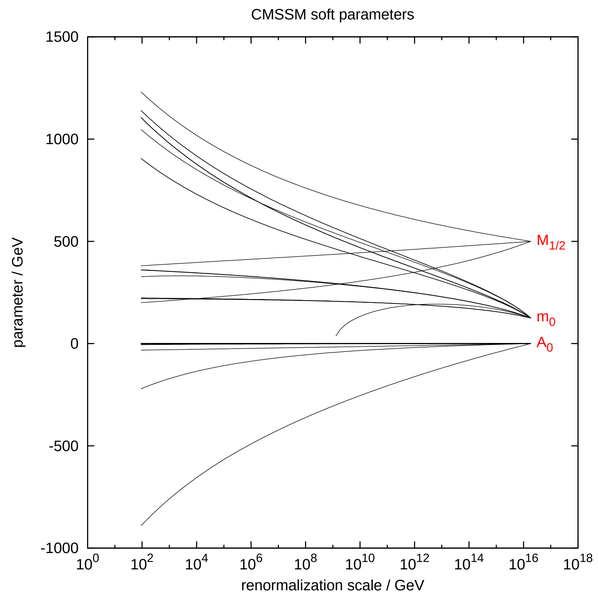
Spectrum generator for non-minimal susy models

The spectrum generator for non-minimal supersymmetric models is still under heavy development. Basic idea:

1. User specifies models and boundary conditions via an extended SARAH interface
2. Meta code calculates RGEs, particle mixing and generates C++ model classes
3. RG solvers try to find a numerical solution. Available algorithms:
   - Standard iterative "two scale" method
   - Lattice method (Jae-hyeon Park)



Working example: CMSSM with $m_0 = 125\,\text{GeV}$, $M_{1/2} = 500\,\text{GeV}$, $A_0 = 0$, $\tan\beta = 10$, $\text{sign}\,\mu = +1$



Publications

- Peter Athron, Dominik Stöckinger, Alexander Voigt: *Threshold Corrections in the Exceptional Supersymmetric Standard Model*, **Phys.Rev. D86 (2012) 095012**
- Dominik Dannheim, Alexander Voigt, Karl-Johan Grahn, Peter Speckmayer, Tancredi Carli: *PDE-Foam: A probability density estimation method using self-adapting phase-space binning*, **Nucl.Instrum.Meth. A606 (2009) 717-727**

Collaborations

- Writing a NMSSM spectrum generator based on SOFTSUSY together with the theory group at CoEPP, University of Adelaide and Ben Allanach, University of Cambridge
- Calculating $H \to \gamma\gamma$ in the CE_6SSM with the theory group SHEP, Southampton University

Selected Talks

- 29.02.2012, DPG Frühjahrstagung Göttingen: "Phenomenology of the CE_6SSM"
- 01.12.2010, Helmholtz Alliance Workshop Dresden: "Improved precision in the constrained Exceptional Supersymmetric Standard Model (CE_6SSM)"
- 15.03.2010, DPG Frühjahrstagung Bonn: "Calculation of threshold corrections in the CE_6SSM"

Profit from the GK

- I attended two lectures at HU Berlin: "Stringtheorie", "Pfadintegrale"
- Useful advanced lectures at the block courses.
- Easy to come into contact with students and professors from the other HEP groups in the GK.

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