The SUSY Les Houches Accord

Interfacing SUSY Spectrum Calculators, Decay Packages, and Event Generators


Writeup 10’th Nov: hep-ph/0311123
Overview

1. Why?

2. The SUSY Les Houches Accord (v1).

3. Examples.

4. Outlook.
1. Why?

- **SUSY model**
  - MSSM
  - SUGRA
  - GMSB
  - AMSB
  - RPV
  - CPV
  - NMSSM
  - ...

- **Spectrum Calculator**
  - FEYNHIGGS
  - ISASUSY
  - (PYTHIA)
  - SOFTSUSY
  - SPHENO
  - SUSPECT
  - ...

- **Parton Level Event Generator**
  - COMPHEP
  - GRACE
  - HERWIG
  - ISAJET
  - PROSPINO
  - PYTHIA
  - SHERPA
  - SUSYGEN
  - WHIZARD
  - ...

- **Decay Package**
  - MICRØS
  - Darksusy
  - NeutDriver
  - ...

- **C机动车 Package**
  - HDECAY
  - SDECAY
  - Mühlleitner et al.
  - hep-ph/0311167
  - NLO SUSY Decays

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**SUSY model**
- MSSM
- SUGRA
- GMSB
- AMSB
- RPV
- CPV
- NMSSM
- ...

**SLHA Input**

**Spectrum Calculator**
- FEYNHIGGS
- ISASUSY
- (PYTHIA)
- SOFTSUSY
- SPHENO
- SUSPECT
- ...

**SLHA Input + Spectrum**

**Parton Level Event Generator**
- COMPHEP
- GRACE
- HERWIG
- ISAJET
- PROSPINO
- PYTHIA
- SHERPA
- SUSYGEN
- WHIZARD
- ...

**Decay Package**
- MICRØS
- Darksusy
- Neutdriven
- ...

**SLHA Input + Spectrum + Decay table**

**CDM Package**

**CDM Package**
- CDM
- ...

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- **SUSY model**
  - MSSM✔
  - SUGRA✔
  - GMSB✔
  - AMSB✔
  - RPV
  - CPV
  - CPV
  - NMSSM ...

- **Spectrum Calculator**
  - FEYNHIGGS✔
  - ISASUSY ✔ (PYTHIA) ✔
  - SOFTSUSY✔
  - SPHENO✔
  - SUSPECT(✔)
  ...

- **Parton Level Event Generator**
  - COMHEP
  - GRACE
  - HERWIG
  - ISAJET
  - PROSPINO
  - PYTHIA✔
  - SHERPA
  - SUSYGEN
  - WHIZARD ...

- **CDM Package**
  - MICRØS
  - Darksusy
  - Neutdriver ...

- **Decay Package**
  - HDECAY
  - SDECAY✔
  - SDHDECAY
  ...

- **SLHA Input**
  - + Spectrum

- **Decay Package**
  - SLHA Input
  - + Spectrum
  - + Decay table
1. Why?

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2. The SUSY Les Houches Accord

Considerations:

✧ **Flexible/Extendable**
Structure should be general enough to *eventually* handle *any* model.

✧ **Consistency**
Parameters must be consistently and unambiguously defined.

✧ **Easy to implement and use**
Address what is actually on the market, and make sure humans can understand it too.
2. The SUSY Les Houches Accord

General Structure:

✧ A unique set of conventions for input/output, necessary for unambiguous interpretation of parameters.

\[ \text{CP} \implies \text{Real mixing matrices, } m_{\tilde{t}_1} < m_{\tilde{t}_2}, \text{phase choices, } \ldots \]

✧ Files are organized in named blocks:

\[ \text{BLOCK MODSEL, BLOCK MASS, BLOCK STOPMIX, BLOCK NMIX, } \ldots \]

✧ All particles are identified by PDG code:

\[ h^0 = 25, \tilde{t}_1 = 1000006, \tilde{c}_R = 2000011, \tilde{g} = 1000021, \ldots \]

✧ Running parameters: a grid of values may be provided.

\[ \text{BLOCK GAUGE } Q= 1.00000000E+02, \text{ BLOCK GAUGE } Q= 1.00000000E+03, \ldots \]
2. The SUSY Les Houches Accord

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- BLOCK GAUGE \( Q = 1.000000000E+02, \) BLOCK GAUGE \( Q = 1.000000000E+03, \ldots \)

All the gory details in the writeup:

\[ \text{hep-ph/0311123} \]
2. The SUSY Les Houches Accord

The Input File:

✧ **BLOCK MODSEL**
Model selection, e.g. which model of SUSY breaking to use.

✧ **BLOCK MINPAR**
Input parameters for a minimal type of the selected model, e.g. $m_0$, $m_{1/2}$, $\tan \beta$, ...

✧ **BLOCK EXTPAR**
Optional parameters for non-minimal/extended models, e.g. $M_1$, $M_2$, $M_3$, ...

✧ **BLOCK SMINPUTS**
Measured/fitted SM parameters, e.g. $m_b(m_b)$, $\alpha_s(m_Z)$, $m_t$, ...
2. The SUSY Les Houches Accord

The Spectrum File: (BLOCK is implicit)

- **MASS**: Mass spectrum.
- **NMIX**, **UMIX**, **VMIX**: $\tilde{\chi}^0$ and $\tilde{\chi}^\pm$ mixing.
- **STOPMIX***, **SBOTMIX***, **STAUMIX**: $\tilde{t}, \tilde{b}, \tilde{\tau}$ mixing.
- **ALPHA**: Higgs mixing ($\alpha$).
2. The SUSY Les Houches Accord

The Spectrum File: ( BLOCK is implicit )

- MASS  Mass spectrum.
- NMIX, UMIX, VMIX  $\tilde{\chi}^0$ and $\tilde{\chi}^\pm$ mixing.
- STOPMIX, SBOTMIX, STAUMIX  $\tilde{t}, \tilde{b}, \tilde{\tau}$ mixing.
- ALPHA  Higgs mixing ($\alpha$).
- HMIX Q=...  Higgs mixing ($\mu$).
- GAUGE Q=...  Gauge couplings.
- AU Q=..., AD Q=..., AE Q=...  Trilinear couplings.
- YU Q=..., YD Q=..., YE Q=...  Yukawa couplings.
2. The SUSY Les Houches Accord

The Spectrum File: (BLOCK is implicit)

- **MASS** Mass spectrum.
- **NMIX, UMIX, VMIX** $\tilde{\chi}^0$ and $\tilde{\chi}^\pm$ mixing.
- **STOPMIX, SBOTMIX, STAUMIX** $\tilde{t}, \tilde{b}, \tilde{\tau}$ mixing.
- **ALPHA** Higgs mixing ($\alpha$).
- **HMIX Q=...** Higgs mixing ($\mu$).
- **GAUGE Q=...** Gauge couplings.
- **AU Q=..., AD Q=..., AE Q=...** Trilinear couplings.
- **YU Q=..., YD Q=..., YE Q=...** Yukawa couplings.
- **SPINFO** Info from spectrum calculator, e.g. errors.
2. The SUSY Les Houches Accord

The Decay File:

✧ For each particle:
  • PDG code
  • Total width.
  • (Human readable translation of PDG code.)
  • + List of decay channels.

✧ For each decay channel:
  • Branching ratio.
  • Number of daughters.
  • PDG codes of daughters.
  • (Human readable translation of PDG codes.)

✧ + DCINFO (just like SPINFO above)
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3. Examples

```plaintext
# SUSY Les Houches Accord 1.0
# Example input file - Snowmass point 1a
Block MODSEL    # Model selection
  1  1    # SUGRA model
Block SMINPUTS # SM parameters
  5  4.25    # mb(mb)
  6  173.8   # t pole mass
Block MINPAR    # Model Parameters
  1  100.    # m0
  2  250.    # m12
  3  10.     # tanbeta
  4  1.      # sgnmu
  5 -100.    # A0
```
3. Examples

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3. Examples

```
# SUSY Les Houches Accord 1.0
# Example decay file - Gluino decays
Block DCINFO    # Program information
  1  SDECAY   # Decay package
  2  1.0     # version number
#  PDG     Width
DECAY  1000021   1.01752300e+00   # gluino decays
#  BR  NDA  ID1  ID2
  4.18313300E-02  2  1000001  -1  # BR(sg -> sd(L) dbar)
  1.55587600E-02  2  2000001  -1  # BR(sg -> sd(R) dbar)
  3.91391000E-02  2  1000002  -2  # BR(sg -> su(L) ubar)
  1.74358200E-02  2  2000002  -2  # BR(sg -> su(R) ubar)
  4.18313300E-02  2  1000003  -3  # BR(sg -> ss(L) sbar)
  1.55587600E-02  2  2000003  -3  # BR(sg -> ss(R) sbar)
  3.91391000E-02  2  1000004  -4  # BR(sg -> sc(L) cbar)
  1.74358200E-02  2  2000004  -4  # BR(sg -> sc(R) cbar)
  1.13021900E-01  2  1000005  -5  # BR(sg -> sb(1) bbar)
  6.30339800E-02  2  2000005  -5  # BR(sg -> sb(2) bbar)
  9.60140900E-02  2  1000006  -6  # BR(sg -> st(1) tbar)
  0.00000000E+00  2  2000006  -6  # BR(sg -> st(2) tbar)
  4.18313300E-02  2  -1000001  1  # BR(sg -> sdbar(L) d)
  1.55587600E-02  2  -2000001  1  # BR(sg -> sdbar(R) d)
  3.91391000E-02  2  -1000002  2  # BR(sg -> subar(L) u)
  1.74358200E-02  2  -2000002  2  # BR(sg -> subar(R) u)
  4.18313300E-02  2  -1000003  3  # BR(sg -> ssbar(L) s)
  1.55587600E-02  2  -2000003  3  # BR(sg -> ssbar(R) s)
  3.91391000E-02  2  -1000004  4  # BR(sg -> scbar(L) c)
  1.74358200E-02  2  -2000004  4  # BR(sg -> scbar(R) c)
  1.13021900E-01  2  -1000005  5  # BR(sg -> sbbar(1) b)
  6.30339800E-02  2  -2000005  5  # BR(sg -> sbbar(2) b)
  9.60140900E-02  2  -1000006  6  # BR(sg -> stbar(1) t)
  0.00000000E+00  2  -2000006  6  # BR(sg -> stbar(2) t)
```
Outlook

The SUSY Les Houches Accord (v1):

✧ A set of self–consistent conventions for MSSM models.
✧ Definite file structures for model input, mass and coupling spectra, and decay tables.
✧ Many programs already implemented SLHA, more on the way.

Future Plans:

✧ Higher orders ➝ more soft parameters.
✧ CPV, RPV.
✧ NMSSM, ... ?
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✧ NMSSM, ...

At Les Houches 2003, then implemented one simple case (CMSSM); it threw up problems in the interface design.

Design principles: general structure which can be extended, conventions for particular case etc., higher loops very thorny.