Paolo Gondolo, Joakim Edsjö, Lars Bergström,
Piero Ullio and Edward A. Baltz

Introduction

- DarkSUSY is a set of Fortran routines for calculations of relic densities and different direct and indirect detection rates within the Minimal Supersymmetric Standard Model, MSSM

- It uses the phenomenological approach with parameters given at the low-energy scale.

MSSM parameters

μ - Higgsino mass parameter

M_2 - Gaugino mass paramter

m_A - mass of CP-odd Higgs boson

$\tan\beta$ - ratio of Higgs vacuum expectation values

m_q - scalar mass paramter

A_b - trilinear coupling, bottom sector

A_t - trilinear coupling, top sector

A more general set of parameters can also be used!

Calculable quantities

- Vertices
- Mass spectrum
- Accelerator bounds
- Relic density
- Scattering cross sections

- Rates in neutrino telescopes
- Fluxes from the halo: antiprotons, positrons, continuum gammas, gamma lines ($Z\gamma$ and $\gamma\gamma$) and neutrinos.

Vertices

- Most of the MSSM vertices are calculated numerically.

- They are available in the arrays gl and gr (see the upcoming manual for details)

Mass spectrum

- All the MSSM masses are calculated.
- For the Higgs bosons, different routines can be used, e.g. Carena et al, FeynHiggsFast, …
- For the neutralinos, loop corrections from Drees et al are included.

Accelerator bounds

- Routines to check current accelerator constraints are available:

  m_{H_2} $\quad b \rightarrow s\,\gamma$ $\quad m_{\chi^+}$

  sfermion masses $\quad$ etc

- It is easy to replace the standard routine with your own one.

Relic density

- The relic density is calculated by
  - solving the Boltzmann equation numerically
  - including all resonances and thresholds
  - including coannihilations between the neutralinos and charginos.
- All tree-level two-body final states and gg, $\gamma\gamma$ and $Z\gamma$ at the 1-loop level are included.
- The accuracy is of the order of ~1%, but a fast option with an accuracy of ~5% exists.

Halo model

- The dark matter density is parameterized as

$$\rho_\chi(\vec{x}) = \rho_0 \left(\frac{r_0}{|\vec{x}|} \right)^\gamma \left[\frac{1 + (r_0/a)^\alpha}{1 + (|\vec{x}|/a)^\alpha} \right]^{(\beta-\gamma)/\alpha}$$

  whereas the velocity distribution is assumed to be Maxwell-Boltzmann.

- **Remark:** If $\Omega_\chi h^2 < (\Omega h^2)_{\min}$ we need to rescale the local halo density. This is done with `dshmrescale_rho` and *affects all subsequent rate calculations*.

Scattering cross sections

- The scattering cross sections on protons and neutrons can calculated.

- The quark and spin content of the nucleons can be changed by the user.

Neutrino telescopes

- From WIMP annihilation in the Earth/Sun, we can calculate:
  – the neutrino flux
  – the neutrino to muon conversion rate
  – the neutrino-induced muon flux
- Both differential and integrated fluxes/rates can be obtained.
- The new population of WIMPs that have scattered in the outskirts of the Sun can be included.

Antiprotons from the halo

- Different propagation models can be used: Chardonnay et el, Bottino et al, Bergström et al*.
- Energy losses of antiprotons are included.
- Many diffusion model parameters are adjustable.
- Solar modulation can be included.
- Fluxes from a clumpy halo can be calculated.

*) Default

Positrons from the halo

- Different diffusion models included: Kamionkowski-Turner and Baltz-Edsjö with* and without a cut-off in the diffusion constant.

- Both integrated and differential fluxes can be obtained.

*) Default

Gammas from the halo

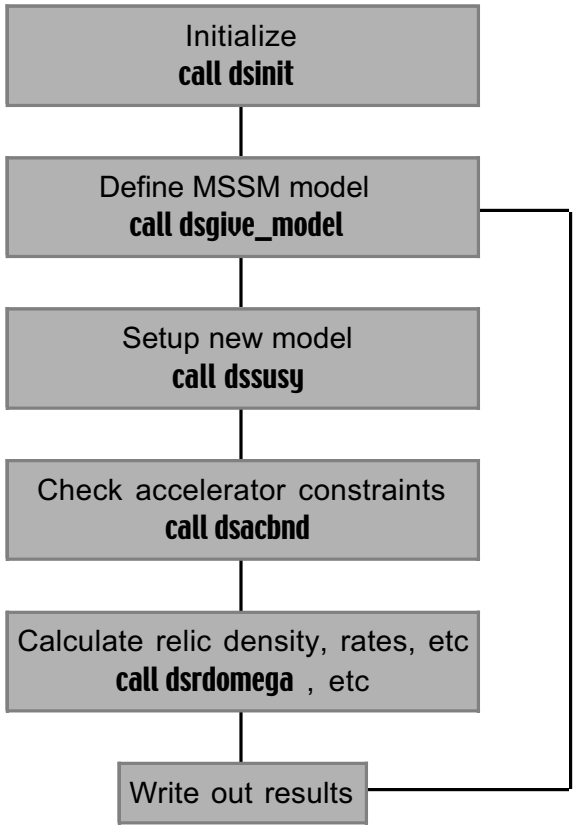
- The flux in a given direction (averaged or not averaged over detector resolution $\Delta\Omega$) can be obtained for
  - continuum gamma rays
  - monochromatic gamma lines from $\gamma\gamma$
  - monochromatic gamma lines from $Z\gamma$
- Both differential and integrated fluxes can be obtained.

Neutrinos from the halo

- From a given direction (averaged or not averaged over detector resolution $\Delta\Omega$) we can obtain the
  - neutrino flux
  - neutrino to muon conversion rate
  - neutrino-induced muon flux
- Both differential and integrated fluxes/rates can be obtained.

Code organization

- The code is written in Fortran.
- The user has to provide a main program – an example program is provided.
- A full manual and long paper are being written.



Release / download

- Major code reorganization to make it user-friendly.
- Tested on RedHat Linux 6.2, LinuxPPC and Alphas.
- Released now as a fully working *beta-version*.
- Full release later 2000 with manual and long paper.
- Download at
  http://www.physto.se/~edsjo/darksusy/
- If you use it, please sign up on the DarkSUSY mailing list on that page!

Future / Outlook

- Manual and long paper is being written for the full release later 2000.
- More refinements will be added later on, like more fancy direct detection routines, a simple web interface for quick calculations, ...
- If you write code that you think should be included, we can (after a careful review…) include it in the distribution as a contributed package.
- Conversion to C++...

Summary

- DarkSUSY contains code to calculate masses, relic densities and different direct and indirect detection rates in the MSSM.
- Beta version can be downloaded at

  http://www.physto.se/~edsjo/darksusy/
- Questions? Talk to any of the authors or send an e-mail to edsjo@physto.se.