DarkSUSY 6

Tutorial – Part I

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2018-02-28 – 2018-03-02

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Question

- Have you managed to install DarkSUSY and run dstest?

Go to menti.com and enter the code 98 63 15 to answer

Question

- How well do you know Fortran?

Go to menti.com and enter the code 84 11 03 to answer

DarkSUSY 6.0.0

- DS 6.0.0 is a major re-organization and (partly) rewrite of the code.
  - It is tested on gfortran 5, 6 and 7 on Mac OS X and Ubuntu.
  - The manual is included in the distribution
- If you find problems/have questions, ask me during the school or e-mail me at edsjo@fysik.su.se

Main programs

- DarkSUSY is essentially a *library* of routines and functions
- You, as a user, provide a suitable *main program*
- Some examples of main programs exist and are good starting points

Fortran

- Fortran is rather basic, but gives fast code and should be fairly easy to follow/write
- DS6 consists of mainly Fortran 77 code, with some Fortran 95/03 additions

Typical Fortran program

6 chars

```
      program myprogram
      implicit none

      include 'dsver.h'
      real*8 oh2,xf
      integer unphys,war,ierr,iwar,nfc
      real*8 dsrdomega

      call dsinit
      call dsgive_model(500.0d0,1000.d0,300.d0,10.d0,
     &   3000.d0,0.d0,0.d0)
      call dsmodelsetup(unphys,war)
      oh2=dsrdomega(1,1,xf,ierr,iwar,nfc)
      write(*,*) 'Relic density, omega h^2 = ',oh2

      end
```

declarations

includes files, typically global variables (common blocks)

program

subroutine call

arguments (must match declaration)

exponent for double precision (real*8) number

function call

continuation characater (col 5)

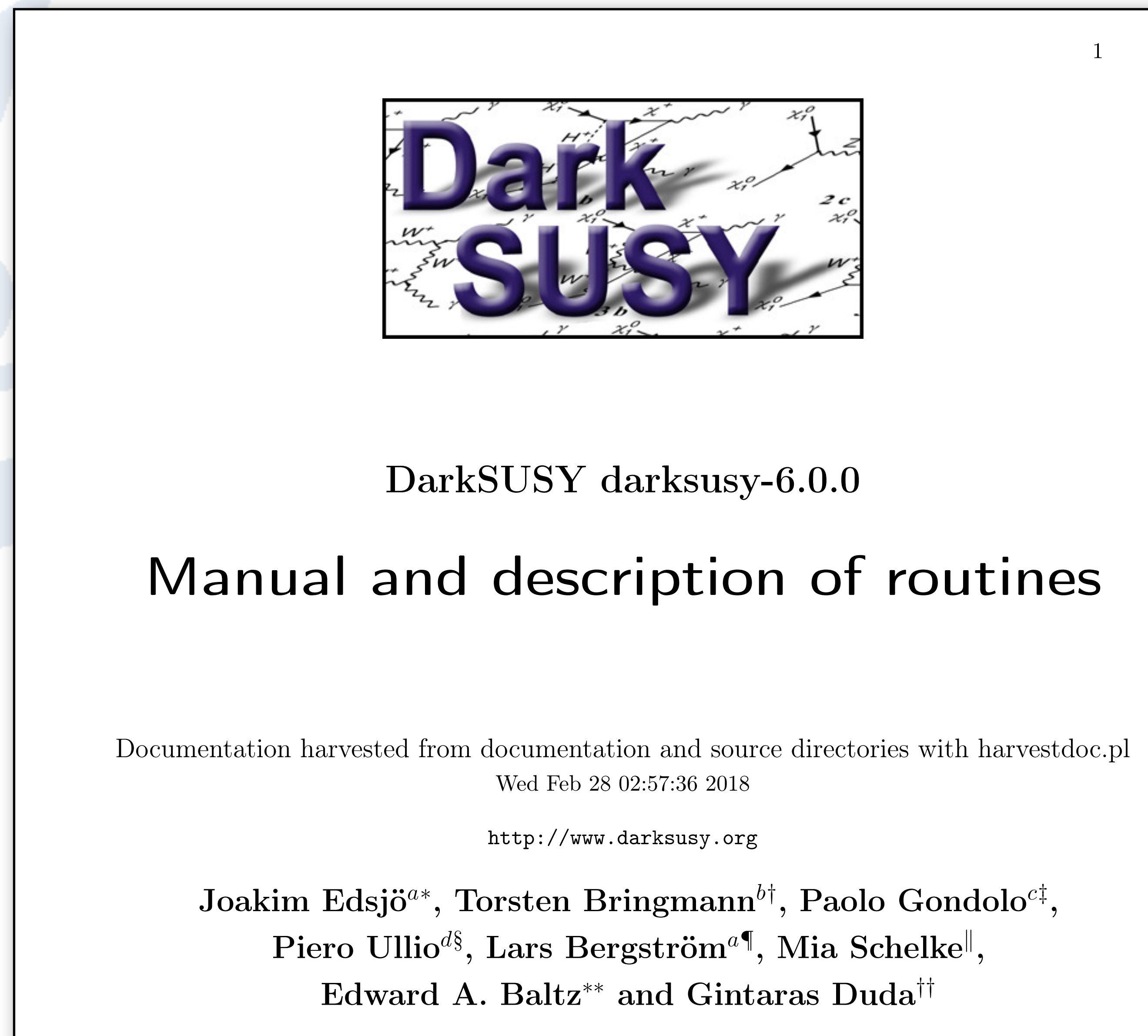
See example programs or tutorials on the web for more Fortran examples

Manual

- In the DarkSUSY root folder, type
  `make pdf-manual`
  to produce the manual. It is available in docs/Manual.pdf

- There is also a long version (with routine headers) that you create with
  make pdf-manual-long

Task: create the manual and look at it!


1

DarkSUSY darksusy-6.0.0

Manual and description of routines

Documentation harvested from documentation and source directories with harvestdoc.pl
Wed Feb 28 02:57:36 2018

http://www.darksusy.org

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Outline of hands-on

1. dstest program
2. dsmain_wimp program
   - MSSM
   - generic WIMP
3. Writing your own programs and using makefiles in DarkSUSY 6
4. Using dsmain_wimp with SLHA files
5. Other example programs
6. Replaceable functions
7. Direct detection example
8. Creating a new particle physics module

Part I (items 1–2)

Part II+III (items 3–8)

1. dstest program

- The dstest program is used to test your installation
- It calculates observables (masses, relic density, direct and indirect rates, …) and compares with pre-computed values

```
cd examples/test
./dstest
```

(already compiled with main make, takes about 60 seconds to run)

Output should end with

```
 Total number of errors in dstest:            0
```

[Show code]

2. dsmain_wimp.F

- In examples/ we have the file dsmain_wimp.F which essentially does what dstest does, but in a more user-friendly way.
- Task: run it with

```
./dsmain_wimp
```

- It will ask you which model you want to run:

```
What kind of SUSY model do you want to look at?
   1 = MSSM-7
   2 = cMSSM
   3 = as read from an SLHA2 file
```

MSSM-7 example

- Pick 1: MSSM-7 and enter (e.g.)
  mu: 1000
  M2: 1000
  MA: 400
  tan(β): 10
  m0: 3000
  At/m0: 0
  Ab/m0: 0
- Then answer 0 to not write out an SLHA file (or something else if you want to)
- Observables are then calculated…

Task: run dsmain_wimp and inspect the output to see what is calculated

Output

```
------------------------------------------------------------------------------
FeynHiggs 2.13.0
built on Feb 27, 2018
H. Bahl, T. Hahn, S. Heinemeyer, W. Hollik, S. Passehr, H. Rzehak, G. Weiglein
http://feynhiggs.de
------------------------------------------------------------------------------
FHHiggsCorr contains code by:
P. Slavich et al. (2L rMSSM Higgs self-energies)
H. Rzehak et al. (2L cMSSM asat Higgs self-energies)
S. Passehr et al. (2L cMSSM atat Higgs self-energies)
FHHiggsProd contains code by
- SM XS for VBF, WH, ZH, ttH are taken
  from the LHC Higgs Cross Section Working Group,
  https://twiki.cern.ch/twiki/bin/view/LHCPhysics/CrossSections
  see there for an extensive list of references
- SM bbH XS: Harlander et al. hep-ph/0304035
- SM ggH XS: Grazzini et al.
  http://theory.fi.infn.it/grazzini/hcalculators.html
  see there for an extensive list of references
- 2HDM charged Higgs XS: Plehn et al.
- heavy charged Higgs XS:
  Dittmaier et al. arXiv:0906.2648
  Flechl et al. arXiv:1307.1347

g-2 amplitude [a_mu = (g-2)/2 = ]:    3.8183990533120070E-011

Do you want to write out an SLHA2 file for your model?
  0 = no
  1 = yes, with full 6x6 sfermion mixing
  2 = yes, with minimal flavour violation
0
```

```
   ***** MODEL: INTMOD000001         *****
 istatus =           1  (=0 OK, <0 error, >0 warning, =1 experimentally excluded)
 info =         4512
 WIMP mass =    499.30971144910990

 Calculating relic density without coannihilations, please be patient...
   Oh2 =   0.96579250432421615                0           0
 Calculating omega h^2 with coannihilations, please be patient...
   with coannihilations Oh2 =   0.96579250432421615                0           0
   Chemical decoupling (freeze-out) occured at
   T_f =    22.879465168299642       GeV.

 Kinetic decoupling temperature, Tkd =    216.93575300730424       MeV
  The resulting cutoff in the power spectrum corresponds to a mass of M_cut/M_sun =
2.2909066986614345E-009

 Calculating DM-nucleon scattering cross sections...
   sigsip (pb) =    8.8992537784068590E-010
   sigsin (pb) =    9.2400044165495133E-010
   sigsdp (pb) =    1.9718137439575352E-007
   sigsdn (pb) =    1.4088379669121179E-007
  proton: sigsi (pb) =    8.8992537784068590E-010  sigsd (pb) =
1.9718137439575352E-007
   A=          23  Z=          11  sigsi (pb) =    2.3037796208861801E-004  sigsd (pb) =
5.1548841697066729E-006
  sigsi*ff(pb)=   2.2292275772657175E-004  sigsd*ff(pb)=   4.9743110005459323E-006
   A=         127  Z=          53  sigsi (pb) =   0.15253489069800388       sigsd (pb) =
1.7886424072791722E-005
  sigsi*ff(pb)=   9.5441464487036914E-002  sigsd*ff(pb)=   1.1823115084786536E-005
   A=          73  Z=          32  sigsi (pb) =    1.9706985553529958E-002  sigsd (pb) =
4.9292414333092543E-005
  sigsi*ff(pb)=   1.6068638785545389E-002  sigsd*ff(pb)=   3.8390286999876545E-005
   A=           1  Z=           1  sigsi (pb) =    8.8992537784068590E-010  sigsd (pb) =
1.9718137439575352E-007
  sigsi*ff(pb)=   0.0000000000000000       sigsd*ff(pb)=   0.0000000000000000
```

```
 Calculating gamma ray fluxes...
   fluxgacdiff =    1.8515008372241465E-013  ph/(cm^2 s GeV)
       fluxgac =    3.8000236750318762E-011  ph/(cm^2 s)

 Total number of photon lines in module MSSM:           2
 photon flux from line No.           1  =    1.6539906105554819E-018  ph/(cm^2 s)
        [at E =    499.30971144910990       +/-    0.0000000000000000       GeV]
 photon flux from line No.           2  =    2.6166109285505223E-019  ph/(cm^2 s)
        [at E =    495.14637444449431       +/-    2.4900000000000002       GeV]

  nsigvgacont =    8.3049860752652031E-026
  nsigvgacdiff =    3.6350954555843692E-026  GeV^-1
     nsigvline            1  =    1.8074057116456577E-033
     nsigvline            2  =    2.8593134128061127E-034

 Calculating antiproton fluxes...
 solar modulated pbar flux at 0.35 GeV [GeV^-1 cm^-2 s^-1 sr^-1]:
6.4724132322023058E-010
 solar modulated pbar flux at 1.76 GeV [GeV^-1 cm^-2 s^-1 sr^-1]:
1.0017260278195632E-009
 solar modulated pbar flux at 3.00 GeV [GeV^-1 cm^-2 s^-1 sr^-1]:
8.9088984206521731E-010
 Calculating antideuteron fluxes...
   solar modulated dbar flux at 1.00 GeV [GeV^-1 cm^-2 s^-1 sr^-1]:
2.3931160388253188E-013
 Calculating positron fluxes at 1 GeV...
   phiep=   7.8088318707756649E-008  GeV^-1 cm^-2 s^-1 sr^-1
 Calculating rates in neutrino telescopes
   Flux from the Earth =    1.9046606405318337E-008  km^-2 yr^-1
   Flux from the Sun =     0.57508123135314870       km^-2 yr^-1
 Calculating neutrino-induced muon fluxes from the halo...
   Muon flux from halo =    2.2035442898808658E-003  km^-2 yr^-1
```

Which module?

- At the end of the dsmain_wimp run we got

```
------------------------------------------------------------------
 The DarkSUSY example program has finished successfully.
 Particle module that was used: MSSM
 ------------------------------------------------------------------

 [simply call 'make -B dsmain_wimp DS_MODULE=<MY_MODULE>' if you want to try
with a different module <MY_MODULE>]
```

- Try compiling again with

```
make -B dsmain_wimp DS_MODULE=generic_wimp
./dsmain_wimp
```

- Enter e.g.

```
mass: 100
self-conjugate: 0
ann cross section: 3e-26
PDG: 5
scattering cross section: 1e-42
```

Output

```
Calculating omega h^2 without coannihilations, please be patient...
  without coannihilations Oh2 =    8.5782015186659649E-002           0           0
  Chemical decoupling (freeze-out) occured at
  T_f =    4.4034841137539358        GeV.
```

etc