Two component Dark Matter

with neutrino masses

Diego Restrepo

Sep 6, 2019 - Darkwin - Natal [PDF: http://bit.ly/darkwin]
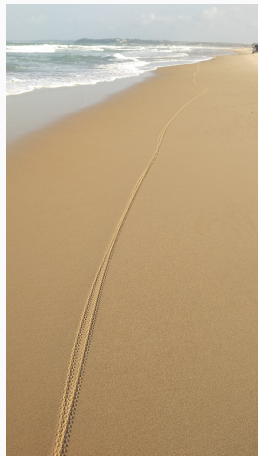
Instituto de Física
Universidad de Antioquia
Phenomenology Group
`http://gfif.udea.edu.co`

UNIVERSIDAD DE ANTIOQUIA
1803

Preliminars

Information

This is the website for the course 'Computer tools in particle physics' by Avelino Vicente.

- CINVESTAV, México City (México) 2015
- IFIC, Valencia (Spain) 2016
- Universidad de Antioquia, Medellín (Colombia) 2016
- IFIC, Valencia (Spain) 2017

References

The course focuses on the material contained in the following notes:

Computer tools in particle physics, A. Vicente, arXiv:1507.06349 [PDF]

For two-loops RGEs see also:

"Exploring new models in all detail with SARAH", Florian Staub, arXiv:1503.04200 [PDF]

SARAH:

"SARAH 4: A tool for (not only SUSY) model builders", Florian Staub, arXiv:1309.7223 [PDF]

About

This is the website for the course 'Computer tools in particle physics'.

Links

- SARAH

  V1.0 August 2009: Susy Only
  V4.0 September 2019: non-Susy
  V4.14.2 (Transfered to W.Porod)

- SPheno
- MicrOMEGAs
- MadGraph
- MadAnalysis
- FlavorKit

Contact

Avelino Vicente
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Office B-6-0

For questions and comments, you can send me an e-mail.

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Information

This is the website for the course Computer tools in particle physics by Avelino Vicente, to take place at Instituto de Física Corpuscular (CSIC/Universidad de Valencia).

Dates: Monday 22/05/2017 - Friday 26/05/2017
Place: IFIC - Sala de Audiovisuales (Nave experimental)
Time: 15:00
Duration: 1.5 h for the first session and 1 h for the rest

Material and required programs

This will be a hands-on course, where all participants are encouraged to run all codes in their own laptops. The only required programas are Mathematica, a LaTeX compiler and Fortran 90 and C++ compilers. If you wish to fully participate please download the following files:

- **For lecture 1:** run_sarah_Scotogenic.nb and Scotogenic.tar.gz
- **For lecture 2:** micromegas_4.2.5.tgz
- **For lecture 4:** run_sarah_DarkBS.nb, DarkBS.tar.gz and plotDarkBS.txt

You should also download the latest versions of the codes we are going to use (exception: for lecture 2 we will use an old version of MicrOMEGAs, see above). You can find them in their official websites (links on your right). Finally, the slides of the course are available here: introduction, lecture 1, lecture 2, lecture 3, lecture 4 and lecture 5.

References

The course will mainly focus on the material contained in the following notes:

Computer tools in particle physics, A. Vicente, arXiv:1507.06349

About

This is the website for the course Computer tools in particle physics. IFIC (CSIC/U. Valencia), May 22nd - 26th, 2017.

Links

Input/Output   Code

- SARAH
- SPheno
- MicrOMEGAs
- MadGraph
- MadAnalysis
- FlavorKit

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Observables already in FlavorKit

Lepton flavor	Quark flavor
$\ell_\alpha \to \ell_\beta \gamma$	$B^0_{s,d} \to \ell^+ \ell^-$
$\ell_\alpha \to 3\,\ell_\beta$	$\bar{B} \to X_s \gamma$
$\mu - e$ conversion in nuclei	$\bar{B} \to X_s \ell^+ \ell^-$
$\tau \to P\,\ell$	$\bar{B} \to X_{d,s} \nu \bar{\nu}$
$h \to \ell_\alpha \ell_\beta$	$B \to K \ell^+ \ell^-$
$Z \to \ell_\alpha \ell_\beta$	$K \to \pi \nu \bar{\nu}$
	$\Delta M_{B_{s,d}}$
	ΔM_K and ε_K
	$P \to \ell \nu$

Ready to be computed in your favourite model!

Observables already in FlavorKit

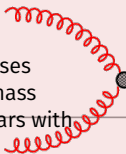| Lepton flavor	Quark flavor
$\ell_\alpha \to \ell_\beta \gamma$	$B_{s,d}^0 \to \ell^+ \ell^-$
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	$\Delta M_{B_{s,d}}$
	ΔM_K and ε_K
	$P \to \ell \nu$

Also in SARAH
S,T,U
   One-loop corrections to All masses
   Two-loop corrections to Higgs mass
   Gluon fusion production of scalars with
      proper output for MadGraph

Ready to be computed in your favourite model!

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Models already in SARAH

Supersymmetric Models

- MSSM [in several versions]
- NMSSM [in several versions]
- Near-to-minimal SSM (near-MSSM)
- General singlet extended SSM (SMSSM)
- DiracNMSSM
- Triplet extended MSSM/NMSSM
- Several models with R-parity violation
- Several U(1)-extended models
- Secluded MSSM
- Several B-L extended models
- Inverse and linear seesaws
- MSSM/NMSSM with Dirac Gauginos
- Minimal R-Symmetric SSM
- Minimal Dirac Gaugino SSM
- Seesaws I-II-III [SU(5) versions]
- Left-right symmetric model
- Quiver model
- Models with vector-like superfields

Non-Supersymmetric Models

- Standard Model
- Two Higgs doublet models (including inert)
- Singlet extensions
- Triplet extensions
- U(1) extensions
- SM extended by a scalar color octet
- Gauged Two Higgs doublet model
- Singlet extended SM
- Singlet Scalar DM
- Singlet-Doublet DM
- Models with vector-like fermions
- Model with a scalar SU(2) 7-plet
- Leptoquark models
- Left-right models
- 331 models (with and without exotics)
- Georgi-Machacek model

More info: http://sarah.hepforge.org/

Models already in SARAH

Supersymmetric Models

(overlaid starburst)
Always check any version of SARAH and SPheno with this one!

- MSSM
- NMSSM (in several versions)
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```
git clone
```

```
git clone
```

Parameter space

$$S = \frac{1}{\sqrt{2}} \left(v_1 + h_1 \right) + \frac{i}{\sqrt{2}} A_1$$

$$S' = \frac{1}{\sqrt{2}} \left(v_2 + h_2 \right) + \frac{i}{\sqrt{2}} A_2$$

Parameter space

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$$S' = \frac{1}{\sqrt{2}}(v_2 + h_2) + \frac{i}{\sqrt{2}}A_2$$

$$G', \; A$$

$$\begin{pmatrix} H_1 \\ H_2 \end{pmatrix} = \begin{pmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{pmatrix} \begin{pmatrix} h_1 \\ h_2 \end{pmatrix}$$

$$\tan\beta = \frac{v_2}{v_1}$$

$$M_{Z'}^2 = g_{BL}^2 v_2^2 \left(4 + \tan^2\beta\right)$$

$$S = \frac{1}{\sqrt{2}} (v_1 + h_1) + \frac{i}{\sqrt{2}} A_1$$

$$S' = \frac{1}{\sqrt{2}} (v_2 + h_2) + \frac{i}{\sqrt{2}} A_2$$

$$G', \; A$$

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$$\tan\beta = \frac{v_2}{v_1}$$

$$M_{Z'}^2 = g_{BL}^2 v_2^2 \left(4 + \tan^2\beta \right)$$

$$\mathcal{L} = M_1 \overline{\chi_1} \chi_1 + M_2 \overline{\chi_2} \chi_2 + M_{N1} \overline{N_{R1}^c} N_{R1} + M_{N2} \overline{N_{R2}^c} N_{R2}$$

Parameter space

$$S = \frac{1}{\sqrt{2}}\left(v_1 + h_1\right) + \frac{i}{\sqrt{2}}A_1$$

$$S' = \frac{1}{\sqrt{2}}\left(v_2 + h_2\right) + \frac{i}{\sqrt{2}}A_2 \implies G', A$$

$$\begin{pmatrix} H_1 \\ H_2 \end{pmatrix} = \begin{pmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{pmatrix} \begin{pmatrix} h_1 \\ h_2 \end{pmatrix}$$

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11 parameters

$$M_{Z'}^2 = g_{BL}^2 v_2^2 \left(4 + \tan^2\beta\right)$$

$$m_\chi = M_1 \text{ or } M_2 \qquad \mathcal{L} = M_1 \overline{\chi_1}\chi_1 + M_2 \overline{\chi_2}\chi_2 + M_{N1}\overline{N_{R1}^c}N_{R1} + M_{N2}\overline{N_{R2}^c}N_{R2}$$