SUSY Les Houches Accord I/O made easy

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August 25, 2004

Abstract

A library for reading and writing data in the SUSY Les Houches Accord format is presented. The implementation is in native Fortran 77. The data are contained in a single array conveniently indexed by preprocessor statements.

1 Introduction

The SUSY Les Houches Accord (SLHA) has standardized and significantly simplified the exchange of input and output parameters of SUSY models between such disparate applications as spectrum calculators and event generators.

While the SLHA specifications [1] include the precise formats for Fortran I/O, it is nevertheless not entirely straightforward to read or write a file in SLHA format. The present library provides the user with simple routines to read and write files in SLHA format, as well as a few utility routines. One thing the library does not do is modify the numbers, which means there is no routine to compute, say, a particular quantity at a new scale.

Sect. 2 describes the organization of the data structures, Sect. 3 gives the reference information for the library routines, Sect. 4 shows the usage in some examples, Sect. 5 contains download and build instructions, and Sect. 6 summarizes.

2 Data structures

The SLHA library is written in Fortran 77. All routines operate on a double-precision array, slhadata, which is about the simplest conceivable data format for this purpose in Fortran. For convenience of use, this array is accessed via preprocessor statements, so the user never needs to memorize any actual indices for the slhadata array. A file containing the preprocessor definitions must thus be included.

The slhadata array consists of a 'static' part containing the information from SLHA BLOCK sections and a 'dynamic' part containing the information from SLHA DECAY sections. The static part is indexed by preprocessor variables defined in SLHA.h, the dynamic part is accessed through the SLHAGetDecay, SLHANewDecay, and SLHAAddDecay functions and subroutines (see Sect. 3).

In addition, descriptive names for the PDG codes of the particles are declared in PDG.h. These are needed e.g. to access the decay information.

2.1 SLHA blocks

The explicit indexing of the slhadata need not (and should not) be done by the user. Rather, the members of the SLHA data structure are accessed through preprocessor variables. Tables 1, 2, 3, and 4 list the preprocessor variables defined in SLHA.h which follow closely the definition of the Accord [1]. Note that preprocessor symbols are case sensitive.

As far as there is overlap, the names for the block members have been chosen similar to the ones used in the MSSM model file of *FeynArts* [2]. The following index conventions are employed in the Tables:

```
t=1\dots 4 \qquad \text{(s)fermion type:} \\ 1=\text{(s)neutrinos,} \\ 2=\text{isospin-down (s)leptons,} \\ 3=\text{isospin-up (s)quarks,} \\ 4=\text{isospin-down (s)quarks} \\ g=1\dots 3 \qquad \text{(s)fermion generation} \\ s=1\dots 2 \qquad \text{number of sfermion mass-eigenstate,} \\ \text{in the absence of mixing } 1=\text{L, } 2=\text{R} \\ c=1\dots 2 \qquad \text{number of chargino mass-eigenstate} \\ n=1\dots 4 \qquad \text{number of neutralino mass-eigenstate}
```

Matrices have a "Flat" array superimposed for convenience, in Fortran's standard column-major convention, e.g. $USf(1,1) \equiv USfFlat(1)$, $USf(2,1) \equiv USfFlat(2)$, $USf(1,2) \equiv USfFlat(3)$, $USf(2,2) \equiv USfFlat(4)$. This makes it possible to e.g. copy such a matrix with just a single do-loop.

2.2 PDG particle identifiers

PDG.h defines the human-readable versions of the PDG codes listed in Table 5. These are needed e.g. to access the decay information. At run time, the subroutine SLHAPDGName can be used to translate a PDG code into a particle name (see Sect. 3.9).

Block name	Offset and length	Members	
MODSEL	OffsetModSel	ModSel_Model	
	LengthModSel	ModSel_Content	
		ModSel_GridPts	
		ModSel_Qmax	
		ModSel_PDG(i)	$i=1\dots 5$
SMINPUTS	OffsetSMInputs	SMInputs_AlfaMZ	
	LengthSMInputs	SMInputs_GF	
		SMInputs_AlfasMZ	
		SMInputs_MZ	
		${\tt SMInputs_Mf}(t)$	$t=2\dots 4$
		SMInputs_Mtau	\equiv SMInputs_Mf(2)
		SMInputs_Mt	\equiv SMInputs_Mf(3)
		SMInputs_Mb	\equiv SMInputs_Mf(4)
MINPAR	OffsetMinPar	MinPar_Q	
	LengthMinPar	MinPar_MO	
		MinPar_Lambda	\equiv MinPar_MO
		MinPar_M12	
		MinPar_Mmess	\equiv MinPar_M12
		MinPar_M32	\equiv MinPar_M12
		MinPar_TB	
		MinPar_signMUE	
		MinPar_A	
		MinPar_N5	≡ MinPar_A
		MinPar_cgrav	

Table 1: Preprocessor variables defined in SLHA.h to access the slhadata array.

Block name	Offset and length	Members	
EXTPAR	OffsetExtPar	ExtPar_Q	
	LengthExtPar	ExtPar_M1	
		ExtPar_M2	
		ExtPar_M3	
		$\texttt{ExtPar_Af}(t)$	$t=2\dots 4$
		ExtPar_Atau	$\equiv \text{ExtPar}_Af(2)$
		ExtPar_At	$\equiv \text{ExtPar}_Af(3)$
		ExtPar_Ab	$\equiv \text{ExtPar}_Af(4)$
		ExtPar_MHu2	
		ExtPar_MHd2	
		ExtPar_MUE	
		ExtPar_MA02	
		ExtPar_TB	1 0
		ExtPar_MSL(g)	$g=1\dots 3$
		ExtPar_MSE(g)	o .
		$ExtPar_MSQ(g)$	o .
		ExtPar_MSU(g)	_
		$ExtPar_MSD(g)$	$g=1\ldots 3$
	-	ExtPar_N5(g)	$g=1\dots 3$
MASS	OffsetMass	$\mathtt{Mass_Mf}(t,g)$	$t=1\ldots 4,$
	LengthMass		$g=1\dots 3$
		$\texttt{Mass_MSf}(s,t,g)$	$s=1\dots 2,$
			$t=1\ldots 4,$
			$g=1\dots 3$
		Mass_MZ	
		Mass_MW	
		Mass_Mh0	
		Mass_MHH	
		Mass_MAO Mass_MHp	
		Mass_MNeu(n)	n-1 1
		$Mass_Meu(n)$ $Mass_MCha(c)$	$n \equiv 1 \dots 4$ $c = 1 \dots 2$
		Mass_MGl	C — 1 <i>L</i>
		Mass_MGrav	
		TIGSS_TIGIAV	

Table 2: Preprocessor variables defined in SLHA.h to access the slhadata array (cont'd).

Block name	Offset and length	Members	
NMIX	OffsetNMix	$\mathtt{NMix}_\mathtt{ZNeu}(n_1,n_2)$	$n_1, n_2 = 1 \dots 4$
	LengthNMix	${\tt NMix_ZNeuFlat}(i)$	$i = 1 \dots 16$
UMIX	OffsetUMix	$\texttt{UMix_UCha}(c_1, c_2)$	$c_1, c_2 = 1 \dots 2$
	LengthUMix	${ t UMix_UChaFlat}(i)$	$i = 1 \dots 4$
VMIX	OffsetVMix	$\texttt{VMix_VCha}(c_1, c_2)$	$c_1, c_2 = 1 \dots 2$
	LengthVMix	${\tt VMix_VChaFlat}(i)$	$i=1\dots 4$
		$SfMix_USf(s_1, s_2, t)$	$s_1, s_2 = 1 \dots 2,$
			$t=2\dots 4$
		$SfMix_USfFlat(i,t)$	$i=1\ldots 4,$
			$t=2\dots 4$
STAUMIX	OffsetStauMix	$\mathtt{StauMix_USf}(s_1, s_2)$	\equiv SfMix_USf($s_1, s_2, 2$)
	LengthStauMix	StauMix_USfFlat(i)	\equiv SfMix_USfFlat(i ,2)
STOPMIX	OffsetStopMix	$StopMix_USf(s_1, s_2)$	\equiv SfMix_USf($s_1, s_2, 3$)
	LengthStopMix	StopMix_USfFlat(i)	\equiv SfMix_USfFlat(i ,3)
SBOTMIX	OffsetSbotMix	SbotMix_USf (s_1, s_2)	\equiv SfMix_USf($s_1, s_2, 4$)
	LengthSbotMix	SbotMix_USfFlat(i)	\equiv SfMix_USfFlat(i ,4)
ALPHA	OffsetAlpha	Alpha_Alpha	
	LengthAlpha		
HMIX	OffsetHMix	HMix_Q	
	LengthHMix	HMix_MUE	
		HMix_TB	
		HMix_VEV	
		HMix_MA02	
GAUGE	OffsetGauge	${\tt Gauge_Q}$	
	LengthGauge	Gauge_g1	
		Gauge_g2	
		Gauge_g3	
MSOFT	OffsetMSoft	MSoft_Q	
	LengthMSoft	MSoft_M1	
		MSoft_M2	
		MSoft_M3	
		MSoft_MHu2	
		MSoft_MHd2	1 0
		MSoft_MSL(g)	$g=1\dots 3$
		MSoft_MSE(g)	$g=1\ldots 3$
		$MSoft_MSQ(g)$	$g=1\ldots 3$
		MSoft_MSU(g)	$g=1\dots 3$
		$MSoft_MSD(g)$	$g=1\dots 3$

Table 3: Preprocessor variables defined in SLHA.h to access the slhadata array (cont'd).

Block name	Offset and length	Members	
		$Af_Q(t)$	$t=2\dots 4$
		$Af_Af(t)$	$t=2\dots 4$
AE	OffsetAe	Ae_Q	\equiv Af_Q(2)
	LengthAe	Ae_Atau	\equiv Af_Af(2)
AU	OffsetAu	Au_Q	$\equiv Af_Q(3)$
	LengthAu	Au_At	$\equiv Af_Af(3)$
AD	OffsetAd	Ad_Q	\equiv Af_Q(4)
	LengthAd	Ad_Ab	\equiv Af_Af(4)
		$Yf_Q(t)$	$t=2\dots 4$
		$Yf_Af(t)$	$t=2\dots 4$
YE	OffsetYe	Ye_Q	$\equiv \text{Yf}_{Q}(2)$
	LengthYe	Ye_Atau	$\equiv Yf_Yf(2)$
YU	OffsetYu	Yu_Q	$\equiv \text{Yf}_{Q}(3)$
	LengthYu	Yu_At	$\equiv Yf_Yf(3)$
YD	OffsetYd	Yd_Q	$\equiv \text{Yf}_{Q}(4)$
	LengthYd	Yd_Ab	$\equiv Yf_Yf(4)$

Table 4: Preprocessor variables defined in SLHA.h to access the slhadata array (cont'd).

fermions	sfermions		
PDG_nu_e	PDG_snu_e1	PDG_snu_e2	
PDG_electron	PDG_selectron1	PDG_selectron2	
PDG_up	PDG_sup1	PDG_sup2	
PDG_down	PDG_sdown1	PDG_sdown2	
PDG_nu_mu	PDG_snu_mu1	PDG_snu_mu2	
PDG_muon	PDG_smuon1	PDG_smuon2	
PDG_charm	PDG_scharm1	PDG_scharm2	
PDG_strange	PDG_sstrange1	PDG_sstrange2	
PDG_nu_tau	PDG_snu_tau1	PDG_snu_tau2	
PDG_tau	PDG_stau1	PDG_stau2	
PDG_top	PDG_stop1	PDG_stop2	
PDG_bottom	PDG_sbottom1	PDG_sbottom2	

bosons	gauginos
PDG_h0	PDG_neutralino1
PDG_HH	PDG_neutralino2
PDG_AO	PDG_neutralino3
PDG_Hp	PDG_neutralino4
PDG_photon	PDG_chargino1
PDG_Z	PDG_chargino2
PDG_W	PDG_gluino
PDG_gluon	PDG_gravitino
PDG_graviton	

Table 5: The PDG codes defined in PDG.h.

3 Routines provided by the SLHA library

3.1 SLHAClear

```
subroutine SLHAClear(slhadata)
double precision slhadata(nslhadata)
```

This subroutine sets all data in the slhadata array given as argument to the value invalid (defined in SLHA.h). It is important that this is done before using slhadata, or else any kind of junk that happens to be in the memory occupied by slhadata will later on be interpreted as valid data.

3.2 SLHARead

```
subroutine SLHARead(error, slhadata, filename, abort)
integer error, abort
double precision slhadata(nslhadata)
character*(*) filename
```

This subroutine reads the data in SLHA format from filename into the slhadata array. If the specified file cannot be opened, the function issues an error message and returns error = 1. The abort flag governs what happens when superfluous text is read, i.e. text that cannot be interpreted as SLHA data. If abort is 0, a warning is printed and reading continues. Otherwise, reading stops at the offending line and error = 2 is returned.

3.3 SLHAWrite

```
subroutine SLHAWrite(error, slhadata,

& program, version, filename)
integer error
double precision slhadata(nslhadata)
character*(*) program, version, filename
```

This subroutine writes the data in slhadata to filename. The name and version of the program that generates the output is given in program and version.

3.4 SLHAGetDecay

```
integer parent_id
integer nchildren, child1_id, child2_id, child3_id, child4_id
```

This function extracts the decay

```
parent_id \rightarrow child1_id child2_id child3_id child4_id
```

from the slhadata array, or the value invalid (defined in SLHA.h) if no such decay can be found. The parent and child particles are given by their PDG identifiers (see Sect. 2.2). The return value is the total decay width if nchildren = 0, otherwise the branching ratio of the specified channel.

Note that only the first nchildren of the $childn_id$ are actually accessed and Fortran allows to omit the remaining ones in the invocation (a strict syntax checker might issue a warning, though). Thus, for instance,

```
Zbb = SLHAGetDecay(slhadata, PDG_Z, 2, PDG_bottom, -PDG_bottom)
```

is a perfectly legitimate way to extract the $Z \to b\bar{b}$ decay.

3.5 SLHANewDecay

```
integer function SLHANewDecay(slhadata, width, parent_id)
double precision slhadata(nslhadata), width
integer parent_id
```

This function initiates the setting of decay information for the particle specified by the parent_id PDG code, whose total decay width is given by width. The integer index it returns is needed to subsequently add individual decay modes with SLHAAddDecay. If the fixed-length array slhadata becomes full, a warning is printed and zero is returned. If a decay of the given particle is already present in slhadata, it is first removed.

3.6 SLHAAddDecay

This subroutine adds the decay mode

```
(parent_id) \rightarrow child1_id child2_id child3_id child4_id
```

to the decay section previously initiated by SLHANewDecay. decay is the index obtained from SLHANewDecay (which also sets the parent_id) and $childn_id$ are the PDG codes

of the final-state particles. The branching ratio is given in br. If the fixed-length array slhadata becomes full, a warning is printed and decay is set to zero.

If decay is zero, an overflow of slhadata in an earlier invocation is silently assumed and no action is performed. It is therefore sufficient to check for overflow only once, after setting all decay modes (unless, of course, one needs to pinpoint the exact location of the overflow).

As with SLHAGetDecay (see Sect. 3.4), only the first nchildren of the child n_{id} are actually accessed and Fortran allows to omit the remaining ones in the invocation.

3.7 SLHAExist

```
logical function SLHAExist(slhablock, length)
double precision slhablock(*)
integer length
```

This function tests whether a given SLHA block is not entirely empty, i.e. it returns .TRUE. if at least one member of the block is valid. The SLHA blocks are most conveniently accessed using the Offset... and Length... definitions (see Sect. 2), e.g.

```
if( SLHAExist(slhadata(OffsetMass), LengthMass) ) ...
```

3.8 SLHAValid

```
logical function SLHAValid(slhablock, length)
double precision slhablock(*)
integer length
```

This function tests whether a given SLHA block consists entirely of valid data, i.e. it returns .FALSE. if at least one member of the block is invalid. The SLHA blocks are most conveniently accessed using the Offset... and Length... definitions (see Sect. 2), e.g.

```
if( SLHAValid(slhadata(OffsetNMix), LengthNMix) ) ...
```

3.9 SLHAPDGName

```
subroutine SLHAPDGName(code, name)
integer code
character*(PDGLen) name
```

This subroutine translates a PDG code into a particle name. The sign of the PDG code is ignored, hence the same name is returned for a particle and its antiparticle. The maximum length of the name, PDGLen, is defined in PDG.h.

4 Examples

Consider the following example program, which just copies one SLHA file to another:

```
program copy_slha_file
implicit none

#include "SLHA.h"

integer error
double precision slhadata(nslhadata)

call SLHAClear(slhadata)

call SLHARead(error, slhadata, "infile.slha", 0)
if( error .ne. 0 ) stop "Read error"

call SLHAWrite(error, slhadata,

& "My Test Program", "1.0", "outfile.slha")
if( error .ne. 0 ) stop "Write error"
end
```

Already in this simple program a couple of things can be seen:

- the file SLHA.h must be included in every function or subroutine that uses the SLHA routines and this must be done using the preprocessor #include (not Fortran's include), thus the program file should have the extension .F (capital F).
- slhadata must be declared as a double-precision array of length nslhadata.
- One should not continue with processing if a non-zero error flag is returned.

A more sensible application would add something to the slhadata before writing them out again. The next little program pretends to compute the fermionic Z decays (by calling a hypothetical subroutine MyCalculation) and adds them to slhadata:

```
program compute_decays
implicit none

#include "SLHA.h"
#include "PDG.h"

integer error, decay, t, g
double precision slhadata(nslhadata)
double precision total_width, br(4,3)
```

```
integer ferm_id(4,3)
        data ferm_id /
     &
          PDG_nu_e, PDG_electron, PDG_up, PDG_down,
     &
          PDG_nu_mu, PDG_muon, PDG_charm, PDG_strange,
          PDG_nu_tau, PDG_tau, PDG_top, PDG_bottom /
        call SLHAClear(slhadata)
        call SLHARead(error, slhadata, "infile.slha", 0)
        if( error .ne. 0 ) stop "Read error"
* compute the decays with parameters taken from the slhadata:
        call MyCalculation(SMInputs_MZ, MinPar_TB, ...,
     &
          total_width, br)
        decay = SLHANewDecay(slhadata, total_width, PDG_Z)
        do t = 1, 4
          do g = 1, 3
            call SLHAAddDecay(slhadata, br(t,g), decay,
     &
              2, ferm_id(t,g), -ferm_id(t,g))
          enddo
        enddo
        call SLHAWrite(error, slhadata,
          "My Test Program", "2.0", "outfile.slha")
        if( error .ne. 0 ) stop "Write error"
        end
```

Demonstrated here is the access of SLHA data (SMInputs_MZ, MinPar_TB) and the setting of decay information.

5 Building and Compiling

The SLHA library package can be downloaded as a gzipped tar archive from the Web site http://www.feynarts.de/slha. After unpacking the archive, change into the directory SLHALib-1.0 and type

```
./configure
```

A simple demonstration program (demo, source code in demo.F) is built together with the library libSLHA.a.

Compiling a program that uses the SLHA library is in principle equally straightforward. The only tricky thing is that one has to relax Fortran's 72-column limit. This is because even lines perfectly within the 72-column range may become longer after the preprocessor's substitutions. While essentially every Fortran compiler offers such an option, the name is quite different. A glance at the man page should suffice to find out. Here are a few common choices:

Compiler	Platform/OS	Option name
g77	any	-ffixed-line-length-none
pgf77	Linux x86	-Mextend
f77	Tru64 Alpha	-extend_source
f77	SunOS, Solaris	-e
fort77	HP-UX	+es

To compile and link your program, add this option and $\neg Ipath \neg Lpath \neg ISLHA$ to the compiler command line, where path is the location of the SLHA library, e.g.

All externally visible symbols of the SLHA library start with the prefix SLHA and should thus pretty much avoid symbol conflicts.

6 Summary

The SLHA library presented here provides simple functions to read and write files in SLHA format. Data are kept in a single double-precision array and accessed through preprocessor variables. The library is written in native Fortran 77 and is easy to build. The source code is openly available at http://www.feynarts.de/slha and is distributed under the GNU Library General Public License.

The author welcomes any kind of feedback, in particular bug and performance reports, at hahn@feynarts.de.

References

- [1] P. Skands et al., hep-ph/0311123.
- [2] T. Hahn and C. Schappacher, Comp. Phys. Commun. 143 (2002) 54 [hep-ph/0105349].