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A DESCRIPTION OF THE DRAGON DATA STRUCTURES

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SUMMARY

The code DRAGON contains a collection of models which can simulate the neutron field distribution inside a unit cell or a fuel assembly in a nuclear reactor. It includes all the functions that characterize a lattice cell code, namely: the interpolation in temperature and dilution of microscopic cross sections which are supplied by means of standard libraries; resonance self-shielding calculations in multidimensional geometries; multigroup and multidimensional neutron flux calculations which can take into account neutron leakage; transport-transport or transport-diffusion equivalence calculations as well as editing of condensed and homogenized nuclear properties for reactor calculations; and finally isotopic depletion calculations.

The transfer of information between the various DRAGON execution modules is ensured by well defined data structure. They are generally created or modified by one of the modules of DRAGON. Here we give a description of the contents of these data structures.

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1 INTRODUCTION

The transfer of information between the various DRAGON execution modules is ensured by well defined data structures.[1–3] They are generally created or modified directly by one of the modules of DRAGON.[4] These data structures are the DRAGON equivalent of a UNIX directory which can contain either files or sub-directory. They can be stored directly in memory or on a direct access binary file via the LCM utilities available in the GANLIB library.[5,6]

The main difference between a data structure and a UNIX directory is that the concept of files is now replaced by that of records where each record contains a specific number of elements of a fixed type. For example, consider the vector $\vec{V}$ of dimension $N = 5$ which contains real valued elements. This vector can be saved in the record named `VOLUME` of a data structure identified by `IPDATA` using the FORTRAN instruction:

```
INTEGER    LENGTH,ITREC,IPDATA,NVOL
PARAMETER (NVOL=5)
REAL       VOL(NVOL)
ITREC=2
LENGHT=NVOL
CALL LCMPUT(IPDATA,'VOLUME',LENGTH,ITREC,VOL)
```

where `NVOL`=5 is the length of the real vector `VOL`=$\vec{V}$. The variable `ITREC` is the record type which in this case takes the value of `ITREC`=2 for `VOL` to indicate that the information to be saved is of type real.[5] Such a record will be described in this report by the following table.

Table 1: The `VOLUME` record in the `IPDATA` structure

Name	Type	Condition	Units	Comment
`VOLUME␣␣␣␣␣␣`	R(N)		m^3	Contents of the volume vector V_i

In the general case we will have

Table 2: Example of records saved in a data structure

Name	Type	Condition	Units	Comment
`INTEGERDATA␣`	I(3)			Integer vector containing 3 elements
`VOLUME␣␣␣␣␣␣`	R(N)	$F \geq 1$	m^3	Optional real vector containing N elements. This vector appears only if $F \geq 1$ and it has dimensions cm^3
`NAMES␣␣␣␣␣␣␣`	C(N) $*$ 12			Contents of the names vector `NAME`$_i$
`DIRECTORY␣␣␣`	Dir			Sub-directory

where the first column contains a `CHARACTER*12` variable representing the name of the record, the second column (I(1), R(N), C(N) $*$ 12 and Dir) describes the type of record and its length, the third column provides the

condition required for the record to be present in the data structure (present only if $F \geq 1$), the fourth column describes the units (m^3) and finally the last column provides a brief description of the record contents. For `INTEGER`, `REAL` and `DOUBLE PRECISION` records of length N, we will use respectively I(N), R(N), and D(N) to identify the type of record and its length while for a `CHARACTER`$*L$ record of dimension N the notation C$(N)*L$ has been selected. The presence of a sub-directory is indicated by the type "Dir" as seen in the above table.

In this report we will first define what is meant by a data structure and a directory. Form the storage point of view both concepts are identical with the following exception. In a data structure two records namely the `SIGNATURE␣␣␣` and `STATE-VECTOR` records must always be present on the first level while the presence of these records is generally optional in directories. However, from the point of view of code execution a data structure also refers to an object located in memory or stored on a file which can be transferred from one execution module to the next while a directory also refers to the various hierarchical sublevels found inside this data structure. Here for simplicity we will distinguish between both concept. For example the data structure MACROLIB will refer to the object (a linked list or a direct access XSM file) which is transferred between the execution module while the directory with the same name will refer to the hierarchical contents of this object.

1.1 Notation used in this report

␣	represents a hard blank space required in a FORTRAN character variable.
DDS	represents a data structure of type "dds".
/dir/	represents a directory of type "dir".
{/dir/}	represents a list of directory of type "dir".
`RECORD␣DIR␣␣`	The explicit name of a record or directory including the hard blanks.

1.2 Units used in this report

cm	centimeters, a unit of distance.
b	barn, a unit of surface or microscopic cross section with 1 b=10^{-24} cm^2.
Kb	kilobarn, a unit of surface or microscopic cross section with 1 Kb=10^3 b.
s	second, a unit of time.
d	day, a unit of time with 1 d=86400 s.
J	joule, an unit of energy.
eV	electron volt, a unit of energy with 1 eV=1.602×10^{-19} J.
MeV	Megaelectron volt, a unit of energy with 1 MeV=10^6 eV.
W	watt, a unit of power with 1 W= 1 J/s.
MW	Megawatt, a power unit with 1 MW= 10^6 W.
g	gram, a unit of mass.
au	atomic unit, a unit of mass with 1 au=1.660381×10^{-24} g.
nau	neutron atomic unit, a unit of mass with 1 nau=1.008665 au.
T	tonne, a unit of mass with 1 T=10^6 g.
K	Kelvin, a unit of temperature.

2 DESCRIPTION OF THE DRAGON DATA STRUCTURES

In this section we will describe the various data structures used by DRAGON. The explicit records and directories present in each data structure will be described in later sections. We will also mention which DRAGON module affects the different data structures.[4]

2.1 The MACROLIB data structure

This data structure is used by DRAGON to transfer group ordered macroscopic cross sections between its modules. It is generally created by the MAC: module. Such a structure is required for a successful execution of the ASM:, FLU:, MOCC: and EDI: modules when no MICROLIB data structure is available. The information stored on this data structure is described in /macrolib/ (see Section 3).

2.2 The MICROLIB data structure

This data structure is used by DRAGON to transfer microscopic and macroscopic cross sections between its modules. It is generally created by the LIB: module. It can also be modified by the MAC:, SHI: and EVO: modules. Such a structure is always required for a successful execution of the SHI: and EVO: modules while it is required for the execution of the ASM:, FLU:, MOCC: and EDI: modules only when no MACROLIB data structure is available. The information stored on this data structure is described in /microlib/ (see Section 4). It always includes a /macrolib/ sub-directory (see Section 3) which can be transferred to an independent MACROLIB data structure.

2.3 The GEOMETRY data structure

This data structure is used by DRAGON to transfer the geometry between its modules. It is generally created by the GEO: module. Such a structure is required for a successful execution of the tracking modules (JPMT:, SYBILT: and EXCELT:). It can also be used by the PSP: module for graphical purpose (Release 3.04). The information stored on this data structure is described in /geometry/ (see Section 5). It can include a /geometry/ sub-directory which can be transferred to an independent GEOMETRY data structure.

2.4 The TRACKING data structure

This data structure is used by DRAGON to transfer the general tracking information between its modules including a description of region volumes and mixture contents. It is generally created by the JPMT:, SYBILT: and EXCELT: modules. It is required for a successful execution of the ASM:, FLU:, MOCC:, EDI: and EVO: modules. A new TRACKING data structure can also be created by the MRG: module from an old TRACKING (Release 3.03). It can also be used by the PSP: module for graphical purpose (Release 3.04). The information stored on this data structure is described in /tracking/ (see Section 6).

2.5 The ASMPIJ data structure

This data structure is used by DRAGON to transfer the multigroup response and collision probability matrices between its modules. It is generally created by the ASM: module. It is required for a successful execution of the FLU: module. The information stored on this data structure is described in /asmpij/ (see Section 7).

2.6 The FLUXUNK data structure

This data structure is used by DRAGON to transfer the computed neutron flux and current between its modules. It is generally created by the FLU: and MOCC: modules. It is required for a successful execution of the EDI: and EVO: modules. It can also be used by the PSP: module for graphical purpose (Release 3.04). The information stored on this data structure is described in /fluxunk/ (see Section 8).

2.7 The EDITION data structure

This data structure is used by DRAGON to store condensed and merged microscopic and macroscopic cross section results. It is created by the `EDI:` module. It is required for a successful execution of the `CPO:` module. The information stored on this data structure is described in /edition/ (see Section 9). It generally includes a set of /macrolib/ (see Section 3) and /microlib/ directories (see Section 4) which can be transferred to independent MACROLIB and MICROLIB data structures.

2.8 The BURNUP data structure

This data structure is used by DRAGON to store burnup information. It is created by the `EVO:` module. Such a structure may also be required for a successful execution of the `CPO:` module. It can also be used by the `LIB:` module. The information stored on this data structure is described in /burnup/ (see Section 10).

2.9 The CPO data structure

This data structure is used by DRAGON to store reactor related diffusion coefficients and microscopic and macroscopic cross sections. It is created by the `CPO:` module. The information stored on this data structure is described in /cpo/ (see Section 11).

2.10 The FBMXSDB data structure

This data structure is created by DRAGON for use in diffusion codes. It contains the full reactor database for different functioning situations characterized by different burnup and local parameters generated using the feedback model. The information stored on this data structure is described in /fbm/ (see Section 12).

3 CONTENTS OF A /MACROLIB/ DIRECTORY

A /macrolib/ directory always contains the set of macroscopic multigroup cross sections associated with a list of mixtures. The structure of this directory, is quite different to that associated with an /isotope/ directory (see Section 13). First, it is multi level, namely, it contains sub-directories. Moreover instead of having one directory per mixture which contains the associated multigroup cross section, one will have one directory per group containing multi-mixture information. Finally its contents will vary depending on the module which was used to create it. Here for convenience we will define the variable $\mathcal{M}$ to identify the creation module:

$$\mathcal{M} = \begin{cases} 0 & \text{if the directory is created by the MAC: module} \\ 1 & \text{if the directory is created by the LIB: module} \\ 2 & \text{if the directory is created by the EDI: module} \end{cases}$$

In the case where the MAC: module is used to create this directory, it appears on the first level of the MACROLIB data structure. For the two other cases it is embedded as a sub-directory in a /microlib/ or an /edition/ directory.

3.1 The main /macrolib/ directory

The following records and sub-directories will be found on the first level of a /macrolib/ directory:

Table 3: Main records and sub-directories in /macrolib/

Name	Type	Condition	Units	Comment
SIGNATURE␣␣␣	C∗12			Signature of the data structure (SIGNA)
STATE-VECTOR	I(20)			Vector describing the various parameters associated with this data structure $\mathcal{S}_i^M$
ADDXSNAME␣␣␣	C($\mathcal{S}_5^M$) ∗ 6	$\mathcal{S}_5^M \geq 1$		Name of the additional editing cross sections (ADDXS$_k$)
FISSIONNAMES	C($\mathcal{S}_4^M$) ∗ 8	$\mathcal{S}_4^M \geq 1$		Name of the fissile isotopes (FISNAM)
FISSIONNB␣␣␣	I($\mathcal{S}_2^M, \mathcal{S}_4^M$)	$\mathcal{S}_4^M \geq 1$		For each mixture i and fissile isotope j, $f_{i,j}$ contains a flag to indicate the presence ($f_{i,j} = i$) or absence ($f_{i,j} = 0$) of this fissile isotope in the mixture
FGWITHUPSCAT	I($\mathcal{S}_2^M, \mathcal{S}_3^M$)			For each mixture i and scattering anisotropy level l, the maximum group number for which upscattering takes place $u_{i,l}$
TIMESTAMP␣␣␣	R(3)			A vector T_j containing three elements. The first element $T_1 = t$ is the time in days, the second element $T_2 = B$ is the burnup in MW d T^{-1} and the third element $T_3 = w$ is the irradiation in Kb^{-1}
ENERGY␣␣␣␣␣␣	R($\mathcal{S}_1^M + 1$)	$\mathcal{M} \geq 1$	eV	Energy group limits E_g
DELTAU␣␣␣␣␣␣	R($\mathcal{S}_1^M$)	$\mathcal{M} \geq 1$		Lethargy width of each group U_g
EFISS␣␣␣␣␣␣␣	R($\mathcal{S}_2^M, \mathcal{S}_4^M$)		MeV	Average energy produced per fission $E_{i,j}$ (Release 3.04)
ALBEDO␣␣␣␣␣␣	R($\mathcal{S}_8^M$)	$\mathcal{M} = 0$	cm^3	Surface ordered and energy independent physical albedo $\beta_{p,j}$
VOLUME␣␣␣␣␣␣	R($\mathcal{S}_2^M$)	$\mathcal{M} = 2$	cm^3	Volume of region containing this mixture V_m
SPH-FACTORS␣	R($\mathcal{S}_2^M, \mathcal{S}_1^M$)	$\mathcal{M} = 2$		Multiregion and multigroup SPH factors μ_m^g

continued on next page

Main records and sub-directories in /macrolib/ continued from last page

Name	Type	Condition	Units	Comment
MATCOD$_{\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup}$	I($\mathcal{S}_2^M$)	$\mathcal{M}=2$		Mixture number associated with each region after homogenization
KEYFLX$_{\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup}$	I($\mathcal{S}_2^M$)	$\mathcal{M}=2$		Element number of the flux vector associated with each region after homogenization
K-EFFECTIVE$_{\sqcup}$	R(1)	$\mathcal{M}=2$		Effective multiplication constant $k_{\rm eff}$
FLUXDISAFACT	R($\mathcal{S}_1^M$)	$\mathcal{M}=2$		Ratio of the flux in the fuel to the flux in the cell F_g after homogenization
DIFFB1HOM$_{\sqcup\sqcup\sqcup}$	R($\mathcal{S}_1^M$)	$\mathcal{S}_9^M=2$	cm	Homogeneous diffusion coefficient D^g
B2$_{\sqcup\sqcup}$B1HOM$_{\sqcup\sqcup\sqcup}$	R(1)	$\mathcal{S}_9^M\geq 2$	cm^{-2}	Homogeneous Buckling $B_{\rm hom}$
B2$_{\sqcup\sqcup}$HETE$_{\sqcup\sqcup\sqcup}$	R(3)	$\mathcal{S}_9^M=2$	cm^{-2}	Directional Buckling B_j
{*/grpdir/*}	Dir			List of $G=\mathcal{S}_1^M$ sub-directories which contain the cross section information associated with a specific group g

The signature variable for this data structure must be SIGNA=L_MACROLIB$_{\sqcup\sqcup}$. The dimensioning parameters for this data structure, which are stored in the state vector $\mathcal{S}^M$, represents:

- The number of groups $G=\mathcal{S}_1^M$
- The number of mixtures $N_m=\mathcal{S}_2^M$
- The order for the scattering anisotropy $L=\mathcal{S}_3^M$
- The number of fissile mixtures $N_f=\mathcal{S}_4^M$
- The number of additional editing cross sections $N_e=\mathcal{S}_5^M$
- The transport correction option $I_{tr}=\mathcal{S}_6^M$

$$I_{tr}=\begin{cases}0 & \text{Do not use a transport correction}\\ 1 & \text{Transport correction from } P_1 \text{ scattering}\\ 2 & \text{Recover transport correction from the MACROLIB}\end{cases}$$

- The number of precursor groups for delayed neutron $N_d=\mathcal{S}_7^M$
- The number of physical albedo $N_A=\mathcal{S}_8^M$
- The type of leakage $I_l=\mathcal{S}_9^M$

The list of group directory {/grpdir/} names GRPDIR will be composed using the following FORTRAN instructions

WRITE(GRPDIR,$'$(A5,I3,A1,I3)$'$) $'$GROUP$'$, g, $'/'$, G

for $1\leq g\leq G$. For example, in the case where two group cross sections are considered ($G=2$), two such directory would be generated, namely

Table 4: Example of group sub-directories in /macrolib/

Name	Type	Condition	Units	Comment
GROUP␣␣1/␣␣2	Dir			Sub-directory which contains the information associated with group $g = 1$
GROUP␣␣2/␣␣2	Dir			Sub-directory which contains the information associated with group $g = 2$

3.2 The group sub-directory /grpdir/ in /macrolib/

Inside each group g directory the following records associated with vectorial cross sections will be found

Table 5: Vectorial cross section records in /grpdir/

Name	Type	Condition	Units	Comment
TOTAL␣␣␣␣␣␣␣	R(N_m)		cm^{-1}	The total cross section Σ_m^g
TRANC␣␣␣␣␣␣␣	R(N_m)	$\mathcal{S}_6^M = 2$	cm^{-1}	The transport correction $\Sigma_{tc,m}^g$
NUSIGF␣␣␣␣␣␣	R(N_m, N_f)	$N_f \geq 1$	cm^{-1}	The product of $\Sigma_{f,m}^g$, the fission cross section with ν_m^g, the averaged number of neutron produced per fission, $\nu\Sigma_{f,m}^g$
NFTOT␣␣␣␣␣␣␣	R(N_m, N_f)	$N_f \geq 1$	cm^{-1}	The fission cross section $\Sigma_{f,m}^g$
FIXE␣␣␣␣␣␣␣␣	R(N_m)		$\text{s}^{-1}\text{cm}^{-3}$	The fixed neutron source density
FIXA␣␣␣␣␣␣␣␣	R(N_m)		$\text{s}^{-1}\text{cm}^{-2}$	The adjoint fixed neutron source density (Release 3.04)
CHI␣␣␣␣␣␣␣␣␣	R(N_m, N_f)	$N_f = 1$		The energy spectrum of the neutron emitted by fission χ_m^g
FLUX-INTG␣␣␣	R(N_m)	$\mathcal{M} = 2$	cm s^{-1}	The integrated flux Φ_m^g
ABS␣␣␣␣␣␣␣␣␣	R(N_m)	$\mathcal{M} = 2$	cm^{-1}	The absorption cross section $\Sigma_{a,m}^g$
OVERV␣␣␣␣␣␣␣	R(N_m)	$\mathcal{M} = 2$	cm^{-1}s	The inverse of the average neutron velocity $1/v_m^g$
PRODUCTION␣␣	R(N_m)	$\mathcal{M} = 2$	cm^{-1}	The total neutron production cross section $\Sigma_{p,m}^g$
DIFFHOM␣␣␣␣␣	R(N_m)	$\mathcal{M} = 2$	cm	The homogeneous diffusion coefficient D_m^g
DIFFX␣␣␣␣␣␣␣	R(N_m)	$\mathcal{M} = 2$	cm	The X directed diffusion coefficient $D_{x,m}^g$
DIFFY␣␣␣␣␣␣␣	R(N_m)	$\mathcal{M} = 2$	cm	The Y directed diffusion coefficient $D_{y,m}^g$
DIFFZ␣␣␣␣␣␣␣	R(N_m)	$\mathcal{M} = 2$	cm	The Z directed diffusion coefficient $D_{z,m}^g$
{*xsname*}	R(N_m)	$N_e \geq 1$	cm^{-1}	List of cross section records specified by ADDXS_k

In the case where $N_e = 2$ and

$$\text{ADDXS}_k = \begin{cases} \text{NG} & \text{for} \quad k = 1 \\ \text{N2N} & \text{for} \quad k = 2 \end{cases}$$

the following cross section records will also be present in each group directory:

Table 6: Additional cross section records

Name	Type	Condition	Units	Comment
NG␣␣␣␣␣␣␣␣␣␣	R(N_m)		cm^{-1}	The neutron capture cross section $\Sigma^g_{c,m}$
N2N␣␣␣␣␣␣␣␣␣	R(N_m)		cm^{-1}	The cross section $\Sigma^g_{(n,2n),m}$ for the reaction ${}^A_Z X + n \rightarrow {}^{A-1}_Z X + 2n$

The information associated with the multigroup scattering matrix, which gives the probability for a neutron in group h to appear in group g after a collision with an isotope in mixture m is represented by the form:

$$\Sigma^{h\rightarrow g}_{s,m}(\vec{\Omega}\rightarrow\vec{\Omega}') = \sum_{l=0}^{L}\frac{2l+1}{4\pi}P_l(\vec{\Omega}\cdot\vec{\Omega}')\Sigma^{h\rightarrow g}_{l,m} = \sum_{l=0}^{L}\sum_{m=-l}^{l}Y^m_l(\vec{\Omega})Y^m_l(\vec{\Omega}')\Sigma^{h\rightarrow g}_{l,m}$$

using a series expansion to order L in spherical harmonic. Assuming that the spherical harmonic are orthonormalized, we can define $\Sigma^{h\rightarrow g}_{l,m}$ in terms of $\Sigma^{h\rightarrow g}_{s,m}(\vec{\Omega}\cdot\rightarrow\Omega')$ using the following integral:

$$\Sigma^{h\rightarrow g}_{l,m} = \int_{4\pi} d^2\Omega\Sigma^{h\rightarrow g}_{s,m}(\vec{\Omega}\rightarrow\vec{\Omega}')P_l(\vec{\Omega}\cdot\vec{\Omega}')$$

Note that this definition of $\Sigma^{h\rightarrow g}_{l,m}$ is not unique and some authors include the factor $2l+1$ directly in the different angular moments of the scattering cross section.

Here instead of storing the $G\times M$ matrix $\Sigma^{h\rightarrow g}_{l,m}$ associated with each final energy group g, a vector which contains a compress form of the scattering matrix will be considered. We will first define three integer vectors $n^g_{l,m,d}$, $h^g_{l,m,d}$ and $p^g_{l,m,d}$ for order l in the scattering cross section, final energy group g and mixture m. They will contain respectively the number of initial energy groups h for which the scattering cross section to group g does not vanish, the maximum energy group number for which scattering to the final group g does not vanishes and the position in the compressed scattering vector where the data associated with mixture m for each energy group g can be found. Here $p^g_{l,m,d}$ is directly related to $n^g_{l,m,d}$ by

$$p^g_{l,m,d} = 1 + \sum_{k=1}^{m-1} n^g_{l,k,d}$$

Now consider the following 4 groups isotropic scattering cross section matrix associated with mixture 1 and 2 ($N_m = 2$) respectively:

$\sigma_{0,m}^{h\to g}$	Mixture $m=1$				Mixture $m=2$			
	$g=1$	$g=2$	$g=3$	$g=4$	$g=1$	$g=2$	$g=3$	$g=4$
$h=1$	a_1	a_2	0	0	b_1	b_2	0	0
$h=2$	0	a_3	a_4	a_5	b_3	b_4	b_5	0
$h=3$	0	a_6	a_7	0	0	b_6	b_7	0
$h=4$	0	a_8	0	a_9	0	0	b_8	b_9
$h_{0,m,d}^g$	1	4	3	4	2	3	4	4
$n_{0,m,d}^g$	1	4	2	3	2	3	3	1
$p_{0,m,d}^g$	1	1	1	1	2	5	3	4
$h_{0,m,a}^g$	2	4	3	4	2	3	3	4
$n_{0,m,a}^g$	2	3	2	3	2	3	2	2
$p_{0,m,a}^g$	1	1	1	1	3	4	3	4

The compressed scattering matrix will then take the following form for each final group g:

$$\begin{aligned}
\Sigma_{0,k,d}^1 &= (a_1, b_3, b_1) \\
\Sigma_{0,k,d}^2 &= (a_8, a_6, a_3, a_2, b_6, b_4, b_2) \\
\Sigma_{0,k,d}^3 &= (a_7, a_4, b_8, b_7, b_5) \\
\Sigma_{0,k,d}^4 &= (a_9, 0, a_5, b_9)
\end{aligned}$$

Finally, we will also save independently the diagonal element of the scattering matrix:

$$\Sigma_{l,m,w}^g = \Sigma_{l,m}^{g\to g}$$

For the case where the adjoint transport problem is to be solved, the group transpose of the scattering matrix is required. Since $\Sigma_{0,k,d}^g$ is stored group by group, evaluating the transpose of this matrix requires a full reconstruction of the scattering matrix.

(Release 3.04)

One way to bypass this problem is to store, in addition to $\Sigma_{0,k,d}^g$ which is associated with the scattering to group g, a compress matrix $\Sigma_{0,k,a}^g$ associated with diffusion from group g. We will also define three integer vectors $n_{l,m,a}^g$, $h_{l,m,a}^g$ and $p_{l,m,a}^g$ in a way similar to $n_{l,m,d}^g$, $h_{l,m,d}^g$ and $p_{l,m,d}^g$. They will contain respectively the number of final energy groups h for which the scattering cross section from group g does not vanish, the maximum energy group number for which scattering from the initial group g does not vanishes and the position in the compressed scattering vector where the data associated with mixture m for each energy group g can be found. As before $p_{l,m,a}^g$ is directly related to $n_{l,m,a}^g$ by

$$p_{l,m,a}^g = 1 + \sum_{k=1}^{m-1} n_{l,k,a}^g$$

For the 4 groups isotropic scattering cross section matrix associated with mixture 1 and 2 ($N_m = 2$) defined above we will have:

$$\begin{aligned}
\Sigma_{0,k,a}^1 &= (a_2, a_1, b_2, b_1) \\
\Sigma_{0,k,a}^2 &= (a_5, a_4, a_3, b_5, b_4, b_3) \\
\Sigma_{0,k,a}^3 &= (a_7, a_6, b_7, b_6) \\
\Sigma_{0,k,a}^4 &= (a_9, 0, a_8, b_9, b_8)
\end{aligned}$$

In the case where only the order $l = 0$ and $l = 1$ moment of scattering cross section are non vanishing (isotropic and linearly anisotropic scattering) the following records can be found on the group directory.

Table 7: Scattering cross section records in /grpdir/

Name	Type	Condition	Units	Comment
SIGW␣0␣␣␣␣␣␣	R(N_m)		cm^{-1}	The isotropic component ($l = 0$) of the within group scattering cross section $\Sigma^g_{0,m,w}$
IJJD␣0␣␣␣␣␣␣	I(N_m)			Highest energy group number for which the isotropic component of the scattering cross section to group g does not vanish, $h^g_{0,m,d}$
NJJD␣0␣␣␣␣␣␣	I(N_m)			Number of energy groups for which the isotropic component of the scattering cross section to group g does not vanish, $n^g_{0,m,d}$
IPOD␣0␣␣␣␣␣␣	I(N_m)			Location in the isotropic compressed scattering matrix where information associated with mixture m begins $p^g_{0,m,d}$
SCAD␣0␣␣␣␣␣␣	R($N^g_{0,m,d}$)		cm^{-1}	Compressed isotropic component of the scattering matrix for scattering to group g ($\Sigma^g_{0,k,d}$)
IJJA␣0␣␣␣␣␣␣	I(N_m)			Highest energy group number for which the isotropic component of the scattering cross section from group g does not vanish, $h^g_{0,m,a}$
NJJA␣0␣␣␣␣␣␣	I(N_m)			Number of energy groups for which the isotropic component of the scattering cross section from group g does not vanish, $n^g_{0,m,a}$
IPOA␣0␣␣␣␣␣␣	I(N_m)			Location in the isotropic compressed scattering matrix where information associated with mixture m begins $p^g_{0,m,a}$
SCAA␣0␣␣␣␣␣␣	R($N^g_{0,m,a}$)		cm^{-1}	Compressed isotropic component of the scattering matrix for scattering from group g ($\Sigma^g_{0,k,a}$)
SIGW␣1␣␣␣␣␣␣	R(N_m)	$L \geq 1$	cm^{-1}	The linearly anisotropic component of the within group scattering cross section $\Sigma^g_{1,m,w}$
IJJD␣1␣␣␣␣␣␣	I(N_m)	$L \geq 1$		Highest energy group number for which the linearly anisotropic component of the scattering cross section to group g does not vanish, $h^g_{1,m,d}$
NJJD␣1␣␣␣␣␣␣	I(N_m)	$L \geq 1$		Number of energy groups for which the linearly anisotropic component of the scattering cross section to group g does not vanish, $n^g_{1,m,d}$
IPOD␣1␣␣␣␣␣␣	I(N_m)	$L \geq 1$		Location in the linearly anisotropic compressed scattering matrix where information associated with mixture m begins $p^g_{1,m}$
SCAD␣1␣␣␣␣␣␣	R($N^g_{1,m,d}$)	$L \geq 1$	cm^{-1}	Compressed linearly anisotropic component of the scattering matrix for scattering to group g ($\Sigma^g_{1,k,d}$)
IJJA␣1␣␣␣␣␣␣	I(N_m)	$L \geq 1$		Highest energy group number for which the linearly anisotropic component of the scattering cross section from group g does not vanish, $h^g_{1,m,a}$
NJJA␣1␣␣␣␣␣␣	I(N_m)	$L \geq 1$		Number of energy groups for which the linearly anisotropic component of the scattering cross section from group g does not vanish, $n^g_{1,m,a}$

continued on next page

Scattering cross section records in /grpdir/ continued from last page

Name	Type	Condition	Units	Comment
`IPOA␣1␣␣␣␣␣␣`	I(N_m)	$L \geq 1$		Location in the linearly anisotropic compressed scattering matrix where information associated with mixture m begins $p^g_{1,m,a}$
`SCAA␣1␣␣␣␣␣␣`	R($N^g_{1,m,a}$)	$L \geq 1$	cm^{-1}	Compressed linearly anisotropic component of the scattering matrix for scattering from group g ($\Sigma^g_{1,k,a}$)

where we have used:

$$N^g_{l,m,d} = \sum_{m=1}^{N_m} n^g_{l,m,d}$$

$$N^g_{l,m,a} = \sum_{m=1}^{N_m} n^g_{l,m,a}$$

4 CONTENTS OF A /MICROLIB/ DIRECTORY

A /microlib/ directory contains the set of multigroup microscopic cross sections associated with a list of isotopes. It also includes a /macrolib/ directory where the macroscopic cross sections for the mixtures to which are associated these isotopes are stored (see Section 3). Finally it may contain a /depletion/ directory (see Section 4.2) which is required for burnup calculation and a /selfshield/ directory which is generated by the SHI: module (see Section 4.3). It is therefore multi level, namely, it contains sub-directories. Note that the contents of such a directory will vary depending on the module which was used to create or modify it. Here for convenience we will define the variable $\mathcal{M}$ to identify the creation module:

$$\mathcal{M} = \begin{cases} 1 & \text{if the directory is created or modified by the LIB: module} \\ 2 & \text{if the directory is created or modified by the EDI: module} \\ 3 & \text{if the directory is modified by the SHI: module} \end{cases}$$

In the case where the LIB: module is used to create this directory, it appears on the first level of the MICROLIB data structure. For the other case it is embedded as a sub-directory in an /edition/ directory.

4.1 The main /microlib/ directory

The following records and sub-directories will be found on the first level of a /microlib/ directory:

Table 8: Main records and sub-directories in /microlib/

Name	Type	Condition	Units	Comment
SIGNATURE$_{\sqcup\sqcup\sqcup}$	C$*12$			Signature of the data structure SIGNA
STATE-VECTOR	I(20)			Vector describing the various parameters associated with this data structure $\mathcal{S}_i^m$
ENERGY$_{\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup}$	R($\mathcal{S}_3^m+1$)		eV	Energy groups limits E_g
DELTAU$_{\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup}$	R($\mathcal{S}_3^m$)			Lethargy width of each group U_g
ISOTOPESUSED	C($\mathcal{S}_2^m$) $*12$			Alias name of the isotopes NALIAS$_i$
ISOTOPERNAME	C($\mathcal{S}_2^m$) $*12$			Reference name of the isotopes NISO$_i$
ISOTOPESMIX$_\sqcup$	I($\mathcal{S}_2^m$)			Mixture number associated with each isotope M_i
ISOTOPESDENS	R($\mathcal{S}_2^m$)		(cm b)$^{-1}$	Isotopic density ρ_i
ISOTOPESTEMP	R($\mathcal{S}_2^m$)		K	Isotope temperature T_i
ISOTOPESAWR$_\sqcup$	R($\mathcal{S}_2^m$)		nau	Isotope weight m_i
ISOTOPESVOL$_\sqcup$	R($\mathcal{S}_2^m$)	$\mathcal{M}=2$	cm^3	Volume occupied by isotope V_i
ILIBRARYTYPE	C($\mathcal{S}_2^m$) $*8$	$\mathcal{S}_8^m \geq 1$		Library type associated with each isotope NLTY$_i$
ILIBRARYNAME	C($\mathcal{S}_2^m$) $*8$	$\mathcal{S}_8^m \geq 1$		Library name associated with each isotope NLIB$_i$
ISOTOPESCOH$_\sqcup$	C($\mathcal{S}_2^m$) $*8$	$\mathcal{S}_8^m \geq 1$		Name of coherent scattering type at thermal energies NCOH$_i$
ISOTOPESINC$_\sqcup$	C($\mathcal{S}_2^m$) $*8$	$\mathcal{S}_8^m \geq 1$		Name of incoherent scattering type at thermal energies NINC$_i$
ISOTOPESNTFG	I($\mathcal{S}_2^m$)	$\mathcal{S}_8^m \geq 1$		Number of thermal groups involved in coherent or incoherent scattering $G_{s,i}$
ISOTOPESHIN$_\sqcup$	C($\mathcal{S}_2^m$) $*8$	$\mathcal{S}_8^m * \mathcal{S}_{15}^m \geq 1$		Name of resonant isotope associated with each isotope NSHI$_i$

continued on next page

Main records and sub-directories in /microlib/ continued from last page

Name	Type	Condition	Units	Comment
ISOTOPESSHI␣	I($\mathcal{S}_2^m$)	$\mathcal{S}_8^m * \mathcal{S}_{15}^m \geq 1$		Resonant mixture associated with each isotope $I_{R,i}$
ISOTOPESDSN␣	R($\mathcal{S}_2^m$)	$\mathcal{S}_8^m * \mathcal{S}_{15}^m \geq 1$	b	Standard dilution cross section for isotope $\sigma_{\mathrm{dil},i}$
ISOTOPESDSB␣	R($\mathcal{S}_2^m$)	$\mathcal{S}_8^m * \mathcal{S}_{15}^m \geq 1$	b	Livolant and Jeanpierre dilution cross section for isotope $\sigma_{\mathrm{LJ},i}$
HVECT␣␣␣␣␣␣␣	C($\mathcal{S}_{13}^m$) $* 6$	$\mathcal{S}_{13}^m \geq 1$		Name of additional editing cross sections ADDXS$_k$ stored on /macrolib/
TIMESPER␣␣␣␣	R$(2,3)$	$\mathcal{M} = 2$		A vector $T_{j,i}$ containing six elements. The elements $T_{j,1} = t$, $T_{j,2} = B$ and $T_{j,3} = w$ are the lower ($j = 1$) and upper bounds ($j = 2$) for the reference time in days, burnup in MW d T^{-1} and irradiation in Kb^{-1} respectively for which the perturbative expansion is valid (Release 3.04)
MACROLIB␣␣␣␣	Dir			name of directory containing the /macrolib/ associated with this library
DEPL-CHAIN␣␣	Dir	$\mathcal{S}_{11}^m \geq 1$		name of directory containing the /depletion/ associated with this library
SHIBA␣␣␣␣␣␣␣	Dir	$\mathcal{M} = 3$		name of directory containing the /selfshield/ associated with this library
{*/isotope/*}	Dir			List of $\mathcal{S}_2^m$ sub-directories which contain the cross section information associated with a specific isotope. The name of these directory is specified by NALIAS$_i$

The signature variable for this data structure must be SIGNA=L_LIBRARY␣␣␣. The dimensioning parameters for this data structure, which are stored in the state vector $\mathcal{S}^m$, represents:

- The maximum number of mixtures $M_m = \mathcal{S}_1^m$
- The number of isotopes $N_I = \mathcal{S}_2^m$
- The number of groups $G = \mathcal{S}_3^m$
- The order for the scattering anisotropy $L + 1 = \mathcal{S}_4^m$
- The transport correction option $I_{tr} = \mathcal{S}_5^m$
- Type of the included /macrolib/ $I_t = \mathcal{S}_7^m$

$$I_p = \begin{cases} 1 & \text{include the delayed and prompt neutron effect} \\ 2 & \text{consider only the prompt neutrons} \end{cases}$$

- The number of independent libraries $N_{\mathrm{lib}} = \mathcal{S}_8^m$
- The number of fast groups $N_{g,f} = \mathcal{S}_9^m$

  Represents the number of energy groups above 4.0 eV to be treated without including resonance effects. It is automatically known for isotopes coming from WIMS–D4 or WIMS–AECL format libraries. For the other

types of libraries, this value is initialized to 0. This value, which is only used by the `SHI:` module, can be modified using the keyword `GRMAX`.

- The number of epithermal groups $N_{g,e} = \mathcal{S}_{10}^m$ including the fast groups.

  Represents the total number of energy groups above 4.0 eV. This value, is first used for the evaluation of the transport correction when it is not given explicitly in the original library. It is also used by the `SHI:` module and can be modified locally in this module using the keyword `GRMIN`.

- The number of depleting isotopes $N_d = \mathcal{S}_{11}^m$
- The number of fuel regions $N_{d,f} = \mathcal{S}_{12}^m$
- The number of additional editing cross sections $N_e = \mathcal{S}_{13}^m$
- The number of mixtures $N_m = \mathcal{S}_{14}^m$
- The number of resonant mixtures $N_r = \mathcal{S}_{15}^m$
- The maximum number of isotopes per mixture $M_I = \mathcal{S}_{16}^m$
- The number of cross section types to process $N_x = \mathcal{S}_{17}^m = 20 + \mathcal{S}_4^m$
- Reserved for the number of energy producing regions without burnup $N_e = \mathcal{S}_{18}^m$ (Release 3.04)
- Reserved for the maximum order for time dependent perturbations $N_p = \mathcal{S}_{19}^m$ (Release 3.04)

One will find in Section 3 the description of a /macrolib/ directory and in Section 13 the contents of an /isotope/ directory. Note that if $N_I = 2$ and

$$\texttt{NALIAS}_i = \begin{cases} \texttt{U235␣␣␣␣␣␣␣1} & \text{for} \quad i = 1 \\ \texttt{Pu239␣␣␣␣␣␣␣3} & \text{for} \quad i = 2 \end{cases}$$

then {/isotope/} will correspond to the following two directories:

Table 9: Examples of isotopes directory in a /microlib/

Name	Type	Condition	Units	Comment
`U235␣␣␣␣␣␣␣1`	Dir			Directory where the microscopic cross sections of ^{235}U are stored. These are self-shielded cross section already interpolated in temperature. They correspond to the properties of mixture 1
`Pu239␣␣␣␣␣␣␣3`	Dir			Directory where the microscopic cross sections of ^{239}Pu are stored. These are self-shielded cross section already interpolated in temperature. They correspond to the properties of mixture 3

4.2 The depletion sub-directory /depletion/ in /microlib/

The following records and sub-directories will be found on the first level of a /depletion/ directory:

Table 10: Main records in /depletion/

Name	Type	Condition	Units	Comment
STATE-VECTOR	I(20)			Vector describing the various parameters associated with this directory $\mathcal{S}_i^d$
ISOTOPESUSED	C($\mathcal{S}_1^d$) $*$ 8			Reference name of the isotopes NISOD$_i$ present in the depletion chain
CHARGEWEIGHT	I($\mathcal{S}_1^d$)			Integer identifier for the isotopes ${}_Z^A X$
DEPLETE-REAC	I($\mathcal{S}_8^d, \mathcal{S}_1^d$)			List of identifier for the depletion of an isotope $K_{r,i}^d$
DEPLETE-RATE	R($\mathcal{S}_8^d, \mathcal{S}_1^d$)			Decay parameters associated with each depletion reaction $R_{r,i}^d$
PRODUCE-REAC	I($\mathcal{S}_9^d, \mathcal{S}_1^d$)			List of identifier for the production of an isotope $K_{s,i}^p$
PRODUCE-RATE	R($\mathcal{S}_9^d, \mathcal{S}_1^d$)			Production rate associated with each production reaction $R_{s,i}^p$
FISSIONYIELD	R($\mathcal{S}_2^d, \mathcal{S}_3^d$)			Fission yield for each direct fissile isotope to each direct fission product $Y_{i\rightarrow j}$

The dimensioning parameters for this directory, which are stored in the state vector $\mathcal{S}$, represents:

- The number of depleting isotopes $N_{\text{depl}} = \mathcal{S}_1^d$
- The number of direct fissile isotopes $N_{\text{dfi}} = \mathcal{S}_2^d$
- The number of direct fission product $N_{\text{dfp}} = \mathcal{S}_3^d$
- The number of heavy isotopes $N_{\text{H}} = \mathcal{S}_4^d$

  This number represents the combination of fissile isotopes and the other isotopes produced from these isotopes by reactions other than fission.
- The number of light isotopes $N_{\text{L}} = \mathcal{S}_5^d$

  This number represents the combination of fission products and the other isotopes produced from these isotopes by any reaction.
- The number of other isotopes $N_{\text{O}} = \mathcal{S}_6^d$

  This number represents the other isotopes which are not produced by fission or by reaction with fission isotopes or fission products but have a depletion chain.
- The maximum number of isotopes generating energy without depleting $N_{\text{H}} = \mathcal{S}_7^d$
- The maximum number of independent depletion reaction considered in the depletion chain $M_{\text{R}} = \mathcal{S}_8^d$
- The maximum number of parent isotopes leading to the production of an isotope in the depletion chain $M_{\text{S}} = \mathcal{S}_9^d$

Note that contrarily to the information stored in the main /microlib/ directory where the reference name of an isotope (NISO$_i$) is represent by a CHARACTER*12 variable, here a CHARACTER*8 variable is considered for NISOD$_i$. As a result, an isotope specified by NISO$_i$ will be considered as being part of the depletion chain only if one can find a value of $1 \leq j \leq N_{\text{depl}}$ such that NISO$_i(1:8) =$ NISOD$_j$.

In general, the reaction types NREAD$_r$ associated with a given depletion mechanism will be identified by the microscopic cross section name associated with this reaction. Typically, the contents of the NREAD$_r$ will be the following:

- NREAD$_1$=DECAY$\sqcup\sqcup\sqcup$ to identify a radioactive decay reaction.
- NREAD$_2$=NG$\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup$ to identify a capture reaction

  $${}^1_0n + {}^A_Z X \longrightarrow {}^{A+1}_Z X + \gamma$$

- NREAD$_3$=NFTOT$\sqcup\sqcup\sqcup$ to identify a fission reaction

  $${}^1_0n + {}^A_Z X \longrightarrow \eta\ {}^1_0n + {}^{A+1-\eta-B}_{Z-Y} U + {}^B_Y V + \gamma$$

- NREAD$_4$=N2N$\sqcup\sqcup\sqcup\sqcup\sqcup$ to identify the reaction

  $${}^1_0n + {}^A_Z X \longrightarrow 2\ {}^1_0n + {}^{A-1}_Z X + \gamma$$

The contents of the variables $K^d_{r,i}$ is used to specify the properties of reaction r for each isotope i under consideration. Here $K^d_{r,i}$ contains two different types of informations namely D_r and I_r which are defined as follows:

$$\begin{aligned} d(r) &= K^d_{r,i} \bmod 100 \\ i(r) &= \frac{K^d_{r,i}}{100} \end{aligned}$$

where

$$d(r) = \begin{cases} 0 & \text{Isotope does not deplete by reaction NREAD}_r \\ 1 & \text{Isotope will deplete by reaction NREAD}_r \\ 2 & \text{Isotope does not deplete by reaction NREAD}_r \text{ but yields energy production} \\ 3 & \text{Isotope is fissile without fission yield. Valid only for } r \text{ such that NREAD}_r = \texttt{NFTOT} \\ 4 & \text{Isotope is fissile with fission yield. Valid only for } r \text{ such that NREAD}_r = \texttt{NFTOT} \\ 5 & \text{Isotope is a heavy fission product. Valid only for } r \text{ such that NREAD}_r = \texttt{NFTOT} \\ 6 & \text{Isotope is a light fission product. Valid only for } r \text{ such that NREAD}_r = \texttt{NFTOT} \end{cases}$$

and $i(r) = 0$ unless $4 \leq d(r) \leq 6$. When $d(r) = 4$, $i(r)$ represents the fissile isotope number while for $d(r) = 5$ or $d(r) = 6$, $i(r) =$ represents the direct fission product number. The fractional yield for the production of the direct fission product $i(r)$ from the fissile isotope $i(r')$ is stored in the matrix $Y_{i(r)\rightarrow i(r')}$. In the case where the reaction type r represent a radioactive decay, $R^d_{r,i} = \lambda$, the decay constant in units of 10^8 s^{-1}, otherwise it represents the energy generated by reaction in MeV.

The contents of the variables $K^p_{s,i}$ is used to identify explicitly the parent isotope which generated the current isotope i. The maximum number of parent reaction for this depletion chain is $M_{\rm S}$. As in the case of $K^d_{r,i}$, $K^p_{s,i}$ contains two different types of informations namely D_s and I_s which are defined as follows:

$$\begin{aligned} r(s) &= K^p_{s,i} \bmod 100 \\ i(s) &= \frac{K^p_{s,i}}{100} \end{aligned}$$

where $r(s) = 0$ indicates that the list of parent reaction is complete while $r(s) > 0$ refers to the reaction type NREAD$_{r(s)}$. In the case where $r(s) > 0$, $i(s)$ refers to the parent isotope NISOD$_{i(s)}$ and $R^p_{s,i}$ is the fractional branching ratio for the production of isotope NISOD$_i$ via reaction $r(s)$.

4.3 The self-shielding sub-directory /selfshield/ in /microlib/

The following records and sub-directories will be found on the first level of a /selfshield/ directory:

Table 11: Main records in /selfshield/

Name	Type	Condition	Units	Comment
STATE-VECTOR	I(20)			Vector describing the various parameters associated with this self-shielding $\mathcal{S}_i^s$
EPS-SHIBA$\sqcup\sqcup\sqcup$	R(1)			Value of the relative convergence criterion for the self-shielding iterations ϵ_r

The dimensioning parameters for this directory, which are stored in the state vector $\mathcal{S}$, represents:

- The first group for which self-shielding takes place $G_{\min} = \mathcal{S}_1^s$
  By default $G_{\min} = N_{g,f} + 1$
- The last group for which self-shielding takes place $G_{\max} = \mathcal{S}_2^s$
  By default $G_{\max} = N_{g,e}$
- The maximum number of iteration in the self-shielding calculation $M_r = \mathcal{S}_3^s$
- The type of self-shielding option $I_{\mathrm{LJ}} = \mathcal{S}_4^s$

$$I_{\mathrm{LJ}} = \begin{cases} 0 & \text{for standard self-shielding} \\ 1 & \text{for self-shielding with Livolant and Jeanpierre equivalence} \end{cases}$$

- The option for processing Goldstein–Cohen approximation $I_{\mathrm{GC}} = \mathcal{S}_5^s$

$$I_{\mathrm{GC}} = \begin{cases} 0 & \text{do not use the Goldstein–Cohen approximation} \\ 1 & \text{activate the Goldstein–Cohen approximation} \end{cases}$$

- The transport correction option used in self-shielding $I_{\mathrm{TC}} = \mathcal{S}_6^s$

$$I_{\mathrm{TC}} = \begin{cases} 0 & \text{no transport correction applied in self-shielding calculation} \\ 1 & \text{use transport corrected cross section in self-shielding calculation} \end{cases}$$

5 CONTENTS OF A /GEOMETRY/ DIRECTORY

This directory contains a compact description of a geometry.

5.1 The main /geometry/ directory

On its first level, the following records and sub-directories will be found in the /geometry/ directory:

Table 12: Main records and sub-directories in /geometry/

Name	Type	Condition	Units	Comment
SIGNATURE$_{\sqcup\sqcup\sqcup}$	C$*$12			Signature of the data structure (SIGNA)
STATE-VECTOR	I(20)			Vector describing the various parameters associated with this data structure $\mathcal{S}_i^G$
MIX$_{\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup}$	I($\mathcal{S}_6^G$)			The mixture associated with each mesh interval
RADIUS$_{\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup}$	R(N_r+1)	$N_r \geq 1$	cm	The radial mesh R_i position. The first element of this vector is identical to 0.0
OFFCENTER$_{\sqcup\sqcup\sqcup}$	R(3)	$N_r \geq 1$	cm	The displacement of the center of the annular mesh from the center of a Cartesian cell
MESHX$_{\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup}$	R(N_x+1)	$N_x \geq 1$	cm	The X directed mesh position X_i
MESHY$_{\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup}$	R(N_y+1)	$N_y \geq 1$	cm	The Y directed mesh position Y_i
MESHZ$_{\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup}$	R(N_z+1)	$N_z \geq 1$	cm	The Z directed mesh position Z_i
SIDE$_{\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup}$	R(1)	$8 \leq \mathcal{S}_1^G \leq 9$	cm	The width of the side of the hexagon H
SPLITR$_{\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup}$	I(N_r+1)	$N_r \geq 1$		Record containing the radial mesh splitting $S_{r,i}$. A negative value permits a splitting into equal volumes; a positive value permits a splitting into equal radius spacings
SPLITX$_{\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup}$	I(N_x)	$N_x \geq 1$		Record containing the X directed mesh splitting $S_{x,i}$
SPLITY$_{\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup}$	I(N_y)	$N_y \geq 1$		Record containing the Y directed mesh splitting $S_{y,i}$
SPLITZ$_{\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup}$	I(N_z)	$N_z \geq 1$		Record containing the Z directed mesh splitting $S_{z,i}$
IHEX$_{\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup}$	I(1)	$8 \leq \mathcal{S}_1^G \leq 9$		The type of hexagonal symmetry β_h
NCODE$_{\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup}$	I(6)			Record containing the types of boundary conditions on each surface $N_{\beta,j}$
ZCODE$_{\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup}$	R(6)			Record containing the albedo value on each surface β_j
ICODE$_{\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup}$	I(6)			Record containing the albedo index on each surface $I_{\beta,j}$. The vector β_j is used only if $I_{\beta,j} > 0$ and $N_{\beta,j} = 6$. In the case where $I_{\beta,j} < 0$ and $N_{\beta,j} = 6$ the vector $\beta_{p,j}$ in the directory /macrolib/ is used
NPIN$_{\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup}$	I(1)	$\mathcal{S}_1^G = 3$		Number of identical pins in the cluster ring $N_{\rm pin}$
RPIN$_{\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup}$	R(1)	$\mathcal{S}_1^G = 3$	cm	Radius of the cluster ring $R_{\rm pin}$
APIN$_{\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup}$	R(1)	$\mathcal{S}_1^G = 3$		Angle of the first pin in the cluster ring $\theta_{\rm pin}$
MICRO$_{\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup}$	I(1)	$\mathcal{S}_{12}^G = 1$		The type of micro structure $F_{\rm micro}$
NS$_{\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup}$	I($\mathcal{S}_{14}^G$)	$\mathcal{S}_{12}^G = 1$		The number of regions in the micro structures $N_{{\rm micro},i}$

continued on next page

Main records and sub-directories in /geometry/ continued from last page

Name	Type	Condition	Units	Comment
RS$\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup$	R($\mathcal{S}^G_{15}, \mathcal{S}^G_{14}$)	$\mathcal{S}^G_{12} = 1$	cm	The radii of the tubes or spherical shells making up the micro structures $R_{\mathrm{micro},i,j}$
MILIE$\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup$	I($\mathcal{S}^G_{16}$)	$\mathcal{S}^G_{12} = 1$		The composite mixture number associated with each region in the micro structures $C_{\mathrm{micro},i,j}$
MIXDIL$\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup$	I($\mathcal{S}^G_{16}$)	$\mathcal{S}^G_{12} = 1$		The mixture number associated with each region of the geometry where the micro structure is to be inserted $D_{\mathrm{micro},i,j}$
MIXGR$\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup$	I($\mathcal{S}^G_{17}, \mathcal{S}^G_{16}$)	$\mathcal{S}^G_{12} = 1$		The mixture number associated with each region of the micro structures $M_{\mathrm{micro},i,j}$
FRACT$\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup$	R($\mathcal{S}^G_{16}, \mathcal{S}^G_{14}$)	$\mathcal{S}^G_{12} = 1$		The volumetric concentration of each micro structure $\rho_{\mathrm{micro},i,j}$
POURCE$\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup$	R($\mathcal{S}^G_3$)	$\mathcal{S}^G_1 = 30$		The proportion of each cell type in the lattice P_j
PROCEL$\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup$	R($\mathcal{S}^G_3, \mathcal{S}^G_3$)	$\mathcal{S}^G_1 = 30$		The pre-calculated probability for a neutron leaving a cell of type i to enter in a cell of type j without crossing any other cell $P_{i,j}$
CELL$\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup$	C($\mathcal{S}^G_9$) $* 12$	$\mathcal{S}^G_8 = 1$		The names of the sub-geometry (CELL$_k$)
GENERATING$\sqcup\sqcup$	I($\mathcal{S}^G_6$)	$\mathcal{S}^G_8 = 1$		The generating sub-geometry index corresponding to each region $G_{c,i}$
MERGE$\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup$	I($\mathcal{S}^G_6$)	$\mathcal{S}^G_{10} = 1$		The merging index corresponding to each region $G_{m,i}$
TURN$\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup$	I($\mathcal{S}^G_6$)	$\mathcal{S}^G_{11} = 1$		The orientation index corresponding to each region $G_{t,i}$
CLUSTER$\sqcup\sqcup\sqcup\sqcup\sqcup$	C($\mathcal{S}^G_{13}$) $* 12$	$\mathcal{S}^G_{13} \geq 1$		The names of the sub-geometry making up the cluster (CLUSTER$_k$)
{*/subgeo/*}	Dir			List of sub-directories which contain a subgeometry

The signature variable for this data structure must be SIGNA=L_GEOM$\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup$. The dimensioning parameters for this data structure, which are stored in the state vector $\mathcal{S}^G$, represents:

- The type of geometry $\mathcal{S}_1^G$ where

$$\mathcal{S}_1^G = \begin{cases} 0 & \text{Virtual geometry} \\ 1 & \text{Homogeneous geometry} \\ 2 & \text{Cartesian 1–D geometry} \\ 3 & \text{Tube 1–D geometry} \\ 4 & \text{Sphere 1–D geometry} \\ 5 & \text{Cartesian 2–D geometry} \\ 6 & \text{Tube 2–D geometry with } Z \text{ directed cylindrical submesh} \\ 7 & \text{Cartesian 3–D geometry} \\ 8 & \text{Hexagonal 2–D geometry} \\ 9 & \text{Hexagonal 3–D geometry} \\ 10 & \text{Tube 2–D geometry with } X \text{ directed cylindrical submesh (Release 3.04)} \\ 11 & \text{Tube 2–D geometry with } Y \text{ directed cylindrical submesh (Release 3.04)} \\ 20 & \text{Cartesian 2–D geometry with annular submesh} \\ 21 & \text{Cartesian 3–D geometry with } X \text{ directed cylindrical submesh} \\ 22 & \text{Cartesian 3–D geometry with } Y \text{ directed cylindrical submesh} \\ 23 & \text{Cartesian 3–D geometry with } Z \text{ directed cylindrical submesh} \\ 24 & \text{Hexagonal 2–D geometry with annular submesh} \\ 25 & \text{Hexagonal 3–D geometry with } Z \text{ directed cylindrical submesh} \\ 30 & \text{Do-it-yourself geometry} \end{cases}$$

- The number of annular or cylindric mesh intervals in the geometry $N_r = \mathcal{S}_2^G$
- The number of X directed mesh intervals or hexagon in the geometry $N_x = \mathcal{S}_3^G$
- The number of Y directed mesh intervals in the geometry $N_y = \mathcal{S}_4^G$
- The number of Z directed mesh intervals in the geometry $N_z = \mathcal{S}_5^G$
- The total number of mesh intervals in the geometry $N_k = \mathcal{S}_6^G$

$$N_k = N_r \times N_x \times N_y \times N_x$$

- The maximum number of mixtures used in this geometry $M_m = \mathcal{S}_7^G$
- The cell flag $F_C = \mathcal{S}_8^G$

$$F_c = \begin{cases} 0 & \text{Cell option not activated} \\ 1 & \text{Cell option present} \end{cases}$$

- The number of sub-geometries defined in this geometry $N_s = \mathcal{S}_9^G$
- The merge flag $F_m = \mathcal{S}_{10}^G$

$$F_m = \begin{cases} 0 & \text{Merge option not activated} \\ 1 & \text{Merge option present} \end{cases}$$

- The split flag $F_s = \mathcal{S}_{11}^G$

$$F_m = \begin{cases} 0 & \text{Split option not activated} \\ 1 & \text{Split option present} \end{cases}$$

- The double heterogeneity flag $F_{\rm dh} = \mathcal{S}^G_{12}$

$$F_{\rm dh} = \begin{cases} 0 & \text{Double heterogeneity option not activated} \\ 1 & \text{Double heterogeneity option present} \end{cases}$$

- The number of cluster sub-geometry $N_{\rm cl} = \mathcal{S}^G_{13}$
- The number of regions in the micro structures $\mathcal{S}^G_{14}$
- The maximum number of annular regions in any micro structure $\mathcal{S}^G_{15}$
- The number of micro structures $\mathcal{S}^G_{16}$
- The total number of annular regions in the micro structure $\mathcal{S}^G_{17}$

The type of hexagonal symmetry β_h is defined as:

$$\beta_h = \begin{cases} 1 & \text{S30} \\ 2 & \text{SA60} \\ 3 & \text{SB60} \\ 4 & \text{S90} \\ 5 & \text{R120} \\ 6 & \text{R180} \\ 7 & \text{SA180} \\ 8 & \text{SB180} \\ 9 & \text{COMPLETE} \end{cases}$$

where the definition of these symmetry can be found in the DRAGON users guide.[4] Similarly the type of boundary conditions used will be defined in the following way

$$N_{\beta,j} = \begin{cases} 0 & \text{Not used} \\ 1 & \text{Void boundary condition} \\ 2 & \text{Reflection boundary condition} \\ 3 & \text{Diagonal reflection boundary condition} \\ 4 & \text{Translation boundary condition condition} \\ 5 & \text{Symmetric reflection boundary condition} \\ 6 & \text{Albedo boundary condition} \end{cases}$$

The type of micro structure $F_{\rm micro}$ is defined as

$$F_{\rm micro} = \begin{cases} 3 & \text{Tubular micro structure} \\ 4 & \text{Spherical micro structure} \end{cases}$$

In the case where $\mathcal{S}^G_8 = 1$, the list of directory $\{$/subgeo/$\}$ will have the same name as the variable CELL_k. For example, in the case where $\mathcal{S}^G_9 = 2$ and

$$\mathsf{CELL}_k = \begin{cases} \texttt{GEO1} & \text{for} \quad k = 1 \\ \texttt{GEO2} & \text{for} \quad k = 2 \end{cases}$$

then the following directories will also be present in the main geometry directory:

Table 13: Cell sub-geometry directory

Name	Type	Condition	Units	Comment
GEO1␣␣␣␣␣␣␣␣	Dir			A first /geometry/ directory
GEO2␣␣␣␣␣␣␣␣	Dir			A second /geometry/ directory

In the case where $\mathcal{S}_{13}^{G} \geq 1$, the list of directory {/subgeo/} will have the same name as the variable $\mathsf{CLUSTER}_k$. For example, in the case where $\mathcal{S}_{13}^{G} = 2$ and

$$\mathsf{CLUSTER}_k = \begin{cases} \texttt{RODS1} & \text{for} \quad k = 1 \\ \texttt{RODS2} & \text{for} \quad k = 2 \end{cases}$$

then the following directories will also be present in the main geometry directory:

Table 14: Cluster sub-geometry directory

Name	Type	Condition	Units	Comment
RODS1␣␣␣␣␣␣␣	Dir			A first /geometry/ directory
RODS2␣␣␣␣␣␣␣	Dir			A second /geometry/ directory

6 CONTENTS OF A /TRACKING/ DIRECTORY

This directory contains the information resulting from an analysis of a geometry using a specific tracking module of DRAGON.

6.1 The main /tracking/ directory

On its first level, the following records and sub-directories will be found in the /tracking/ directory:

Table 15: Main records in /tracking/

Name	Type	Condition	Units	Comment
SIGNATURE$\sqcup\sqcup\sqcup$	C$*$12			Signature of the data structure (SIGNA)
STATE-VECTOR	I(20)			Vector describing the various parameters associated with this data structure $\mathcal{S}_i^t$
TRACK-TYPE$\sqcup\sqcup$	C$*$12			Type of tracking considered (TRKT)
TITLE$\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup$	C$*$72			Title of the last editing performed (TITLE)
MATCOD$\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup$	I($\mathcal{S}_1^t$)			Region material M_r
KEYFLX$\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup$	I($\mathcal{S}_1^t$)			Location in unknown vector of integrated regional flux I_r
VOLUME$\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup$	R($\mathcal{S}_1^t$)		cm^3	Region volumes V_r

The signature variable for this data structure must be SIGNA=L_TRACK$\sqcup\sqcup\sqcup\sqcup\sqcup$.

(Release 3.04)

The type of tracking considered TRKT can take the following values:

$$\text{TRKT} = \begin{cases} \texttt{EXCELL} & \text{for EXCELT: or EXCELL: tracking and } \mathcal{M}=1 \\ \texttt{SYBIL} & \text{for SYBILT: tracking and } \mathcal{M}=2 \\ \texttt{JPM} & \text{for JPMT: tracking and } \mathcal{M}=3 \\ \texttt{BIVAC} & \text{for BIVACT: tracking and } \mathcal{M}=4 \end{cases}$$

The dimensioning parameters for this data structure, which are stored in the state vector $\mathcal{S}$, represents:

- The number of regions $N_r = \mathcal{S}_1^t$
- The number of unknown $N_u = \mathcal{S}_2^t$
- The leakage flag $I_L = \mathcal{S}_3^t$

$$I_L = \begin{cases} 0 & \text{Leakage is present} \\ 1 & \text{Leakage is absent} \end{cases}$$

- The maximum number of mixture used $M_m = \mathcal{S}_4^t$
- Number of outer surfaces $\mathcal{S}_5^t$
- The isotropy level for flux calculation $\mathcal{S}_6^t$

$$\mathcal{S}_6^t = \begin{cases} 0 & \text{Isotropic} \\ 1 & \text{Linearly anisotropic} \end{cases}$$

In addition to the above records, the main /tracking/ directory will also contain information which is specific to each tracking module. This information will be described in the following subsections. Also note that the contents of the $\mathcal{S}_i^t$ vector for $i \geq 7$ will depend on the specific tracking module and will be defined in the next three subsections.

6.2 The `EXCELT:` and `EXCELL:` dependent records on a /tracking/ directory

When the `EXCELT:` and `EXCELL:` modules are used ($\mathcal{M} = 1$), the following elements in the vector $\mathcal{S}_i^t$ will also be defined.

(Release 3.04)

- The main EXCELL model $\mathcal{S}_7^t$

$$\mathcal{S}_7^t = \begin{cases} 1 & \text{Cartesian} \\ 2 & \text{Hexagonal} \\ 3 & \text{Cluster} \end{cases}$$

- The track normalization flag $\mathcal{S}_8^t$

$$\mathcal{S}_8^t = \begin{cases} -1 & \text{No normalization} \\ 0 & \text{Track normalization to original volumes} \\ 1 & \text{Track normalization to merged volumes} \end{cases}$$

- The tracking type $\mathcal{S}_9^t$

$$\mathcal{S}_9^t = \begin{cases} 0 & \text{Finite tracking (}\texttt{TISO}\text{)} \\ 1 & \text{Cyclic tracking (}\texttt{TSPC}\text{)} \end{cases}$$

- The boundary conditions type $\mathcal{S}_{10}^t$

$$\mathcal{S}_{10}^t = \begin{cases} 0 & \text{Use isotropic boundary conditions (}\texttt{PISO}\text{)} \\ 1 & \text{Use specular boundary conditions (}\texttt{PSPC}\text{)} \end{cases}$$

  Note that specular boundary conditions can be used only if $\mathcal{S}_9^t = 1$.

- Number of tracking angles $\mathcal{S}_{11}^t$
- Angular symmetry factor $\mathcal{S}_{12}^t$

The following records will also be present on the main level of a /tracking/ directory.[4].

Table 16: The EXCELT: and EXCELL: records in /tracking/

Name	Type	Condition	Units	Comment
EXCELTRACKOP	R(3)			Tracking options including the maximum error allowed on the exponential function R_1, the tracking density R_2 in cm^{-1} and in cm^{-2} for 2–D and 3–D calculations respectively, and the maximum distance between an integration line and a surface permitted R_3 in cm
ALBEDO␣␣␣␣␣␣	R(6)			Surface albedo β_k
BC-REFL+TRAN	I($\mathcal{S}_5^t$)			Reflection/transmission matrix localization operator T_s (Release 3.04)
EXCELL␣␣␣␣␣␣	Dir	$\mathcal{M}=1$		Directory containing the EXCELL tracking information

6.3 The SYBILT: dependent records and sub-directories on a /tracking/ directory

When the SYBILT: module is used ($\mathcal{M}=2$), the following elements in the vector $\mathcal{S}_i^t$ will also be defined. (Release 3.04)

- The main SYBIL model $\mathcal{S}_7^t$

$$\mathcal{S}_7^t = \begin{cases} 2 & \text{Pure geometry} \\ 3 & \text{Do-it-yourself geometry} \\ 4 & \text{2–D assembly geometry} \\ 10 & \text{Double heterogeneity geometry} \end{cases}$$

- Minimum space required to store tracks for assembly geometry $\mathcal{S}_8^t$
- Minimum space required to store interface currents for assembly geometry $\mathcal{S}_9^t$

The following sub-directories will also be present on the main level of a /tracking/ directory.[4]

Table 17: The SYBILT: records and directories in /tracking/

Name	Type	Condition	Units	Comment
PURE-GEOM␣␣␣	Dir	$\mathcal{S}_7^t=2$		Directory containing the data related to a pure geometry
DOITYOURSELF	Dir	$\mathcal{S}_7^t=3$		Directory containing the data related to a do-it-yourself geometry
EURYDICE␣␣␣␣	Dir	$\mathcal{S}_7^t=4$		Directory containing the data related to an assembly geometry
BIHET␣␣␣␣␣␣␣	Dir	$\mathcal{S}_7^t=10$		Directory containing the data related to a double heterogeneity geometry

where the directories `/PURE-GEOM/`, `/DOITYOURSELF/`, `/EURYDICE/` and `/BIHET/` contain respectively:

Table 18: The contents of the `SYBILT: /PURE-GEOM/` directory

Name	Type	Condition	Units	Comment
`PARAM␣␣␣␣␣␣␣`	I(6)			Record containing the parameters for a SYBIL tracking on a pure geometry $\mathcal{P}_i$
`XXX␣␣␣␣␣␣␣␣␣`	R($\mathcal{P}_4+1$)		cm	X directed mesh coordinates after mesh splitting for type 2, 5 and 7 geometries. Region ordered radius after mesh splitting for type 3 and 6 geometries
`YYY␣␣␣␣␣␣␣␣␣`	R($\mathcal{P}_5+1$)		cm	Y directed mesh coordinates after mesh splitting for type 5, 6 and 7 geometries
`ZZZ␣␣␣␣␣␣␣␣␣`	R($\mathcal{P}_6+1$)		cm	Z directed mesh coordinates after mesh splitting for type 7 and 9 geometries
`SIDE␣␣␣␣␣␣␣␣`	R(1)		cm	Side of a hexagon for type 8 and 9 geometries
`NCODE␣␣␣␣␣␣␣`	I(6)			Record containing the types of boundary conditions on each surface $N_{\beta,j}$
`ZCODE␣␣␣␣␣␣␣`	R(6)			Record containing the albedo value on each surface

with the dimension parameter $\mathcal{P}_i$, representing:

- The type of geometry $\mathcal{P}_1$

$$\mathcal{P}_1 = \begin{cases} 2 & \text{Cartesian 1–D geometry} \\ 3 & \text{Tube 1–D geometry} \\ 5 & \text{Cartesian 2–D geometry} \\ 6 & \text{Tube 2–D geometry} \\ 7 & \text{Cartesian 3–D geometry} \\ 8 & \text{Hexagonal 2–D geometry} \\ 9 & \text{Hexagonal 3–D geometry} \end{cases}$$

- The type of hexagonal symmetry $\beta_h = \mathcal{P}_2$

$$\beta_h = \begin{cases} 1 & \text{S30} \\ 2 & \text{SA60} \\ 3 & \text{SB60} \\ 4 & \text{S90} \\ 5 & \text{R120} \\ 6 & \text{R180} \\ 7 & \text{SA180} \\ 8 & \text{SB180} \\ 9 & \text{COMPLETE} \end{cases}$$

- The quadrature parameter $\mathcal{P}_3$
- The number of X directed or radial mesh intervals in the geometry $\mathcal{P}_4$

- The number of Y directed mesh intervals in the geometry $\mathcal{P}_5$
- The number of Z directed mesh intervals in the geometry $\mathcal{P}_6$

The type of boundary conditions used will be defined in the following way

$$N_{\beta,j} = \begin{cases} 0 & \text{Not used} \\ 1 & \text{Void boundary condition} \\ 2 & \text{Reflection boundary condition} \\ 3 & \text{Diagonal reflection boundary condition} \\ 4 & \text{Translation boundary condition condition} \\ 5 & \text{Symmetric reflection boundary condition} \\ 6 & \text{Albedo boundary condition} \end{cases}$$

Table 19: The contents of the `SYBILT: /DOITYOURSELF/` directory

Name	Type	Condition	Units	Comment
`PARAM␣␣␣␣␣␣␣`	I(3)			Record containing the parameters for a SYBIL tracking on a do-it-yourself geometry $\mathcal{P}_i$
`NMC␣␣␣␣␣␣␣␣␣`	I(M)			Offset of the first region in each cell
`RAYRE␣␣␣␣␣␣␣`	R(N, M)		cm	Radius of the tubes in each cell
`PROCEL␣␣␣␣␣␣`	R(M, M)			Geometric matrix
`POURCE␣␣␣␣␣␣`	R(M)			Weight assign to each cell
`SURFA␣␣␣␣␣␣␣`	R(M)		cm^2	Surface of each cell

with the dimension parameter $\mathcal{P}_i$, representing:

- The number of cell $\mathcal{P}_1 = M - 1$
- The quadrature parameter $\mathcal{P}_2$
- The statistical option $\mathcal{P}_3$
- The maximum number of region per cell $\mathcal{P}_4 = N$

Table 20: The contents of the `SYBILT: /EURYDICE/` directory

Name	Type	Condition	Units	Comment
`PARAM␣␣␣␣␣␣␣`	I(15)			Record containing the parameters for a SYBIL tracking on an assembly geometry $\mathcal{P}_i$
`XX␣␣␣␣␣␣␣␣␣␣`	R($\mathcal{P}_6$)		cm	X thickness of the generating cells

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The contents of the SYBILT: /EURYDICE/ directory continued from last page

Name	Type	Condition	Units	Comment
YY	R($\mathcal{P}_6$)		cm	Y thickness of the generating cells
NMC	I($\mathcal{P}_6$)			Offset of the first region in each generating cell
RAYRE	R(M)		cm	Radius of the tubes in each generating cell
MAIL	I($\mathcal{P}_6$)			Offset of the first tracking information in each generating cell
ZMAILI	I($\mathcal{P}_{15}$)			The integer tracking information
ZMAILR	R($\mathcal{P}_{15}$)		cm	The tracking length
IFR	I($\mathcal{P}_4, \mathcal{P}_{14}$)			Index numbers of incoming currents
ALB	R($\mathcal{P}_4, \mathcal{P}_{14}$)			Albedo or transmission factors corresponding to incoming currents
INUM	I($\mathcal{P}_4$)			Index number of the merge cell associated to each cell of the assembly
MIX	I($\mathcal{P}_5, \mathcal{P}_{14}$)			Index numbers of outgoing currents
DVX	R($\mathcal{P}_5, \mathcal{P}_{14}$)			Weights corresponding to outgoing currents
IGEN	I($\mathcal{P}_5$)			Index number of the generating cell associated to each merged cell

with the dimension parameter $\mathcal{P}_i$, representing:

- The type of hexagonal symmetry $\mathcal{P}_1$

$$\mathcal{P}_1 = \begin{cases} 0 & \text{Cartesian assembly} \\ 1 & \text{S30} \\ 2 & \text{SA60} \\ 3 & \text{SB60} \\ 4 & \text{S90} \\ 5 & \text{R120} \\ 6 & \text{R180} \\ 7 & \text{SA180} \\ 8 & \text{SB180} \\ 9 & \text{COMPLETE} \end{cases}$$

- The type of multicell approximation $\mathcal{P}_2$
- The type of cylindrization $\mathcal{P}_3$
- The total number of cells $\mathcal{P}_4$
- The number of merged cells $\mathcal{P}_5$
- The number of generating cells $\mathcal{P}_6$
- The number of distinct interface currents $\mathcal{P}_6$
- The number of angles for 2–D quadrature $\mathcal{P}_8$
- The number of segments for 2–D quadrature $\mathcal{P}_9$

- The number of segments for homogeneous 2–D cells $\mathcal{P}_{10}$
- The number of segments for 1–D cells $\mathcal{P}_{11}$
- The track normalization option $\mathcal{P}_{12}$

$$\mathcal{P}_{12} = \begin{cases} 0 & \text{Normalize the tracks} \\ 1 & \text{Do not normalize the tracks} \end{cases}$$

- The type of quadrature in angle and space $\mathcal{P}_{13}$

$$\mathcal{P}_{13} = \begin{cases} 0 & \text{Gauss quadrature} \\ 1 & \text{Equal weight quadrature} \end{cases}$$

- The number of outgoing interface currents per cell $\mathcal{P}_{14}$
- The number of array elements in the tracking arrays $\mathcal{P}_{15}$

Table 21: The contents of the `SYBILT: /BIHET/` directory

Name	Type	Condition	Units	Comment
`PARAM␣␣␣␣␣␣␣`	I(8)			Record containing the parameters for a SYBIL tracking on a double heterogeneity geometry $\mathcal{P}_i$
`NS␣␣␣␣␣␣␣␣␣␣`	I($\mathcal{P}_4$)			Number of tubes or shells in each kind of micro structure
`IBI␣␣␣␣␣␣␣␣␣`	I($\mathcal{P}_3$)			Type of mixture in each generating region of the macro geometry
`RS␣␣␣␣␣␣␣␣␣␣`	R($\mathcal{P}_4, M$)		cm	Radii of the micro regions
`FRACT␣␣␣␣␣␣␣`	R($\mathcal{P}_4, \mathcal{P}_2$)			Volume fraction of each type of micro region in each composite mixture
`VOLK␣␣␣␣␣␣␣␣`	R($\mathcal{P}_4, \mathcal{P}_5$)			Volume fractions of the tubes or shells in the micro regions

with the dimension parameter $\mathcal{P}_i$, representing:

- The number of ordinary mixtures pointing to the MACROLIB. $\mathcal{P}_1$
- The number of mixtures, including the composite mixtures (i.e., containing micro structures) $\mathcal{P}_2$
- The number of regions in the macro geometry $\mathcal{P}_3$
- The number of different kinds of macro structures $\mathcal{P}_4$

  A kind of macro structure is characterized by the radii of its tubes or shells. All the micro region of the same kind should own the same nuclear properties in a given macro region.
- The maximum number of regions (tubes or shells) in each kind of macro structure $\mathcal{P}_5 = M - 1$
- The main SYBIL model for the macro geometry $\mathcal{P}_6$

- The type of micro regions $\mathcal{P}_7$

$$\mathcal{P}_7 = \begin{cases} 3 & \text{Cylinder} \\ 4 & \text{Sphere} \end{cases}$$

- The quadrature parameter for the 1–D collision probability calculation in the micro structures $\mathcal{P}_8$

6.4 The JPMT: dependent records and sub-directories on a /tracking/ directory

When the JPMT: module is used ($\mathcal{M} = 3$), the following elements in the vector $\mathcal{S}_i^t$ will also be defined.
(Release 3.04)

- The main JPM model $\mathcal{S}_7^t$

$$\mathcal{S}_7^t = \begin{cases} 2 & \text{Pure geometry} \\ 3 & \text{Do-it-yourself geometry} \\ 4 & \text{2–D assembly geometry} \\ 5 & \text{2–D cluster geometry} \\ 10 & \text{Double heterogeneity geometry} \end{cases}$$

- Minimum space required to store tracks for assembly geometry $\mathcal{S}_8^t$
- Minimum space required to store interface currents for assembly geometry $\mathcal{S}_9^t$
- Flag to specify if the individual cell collision probability must all be recomputed even if the properties of specific cells have not been modified $\mathcal{S}_{10}^t$

$$\mathcal{S}_{10}^t = \begin{cases} 0 & \text{Always recompute all blocks probabilities} \\ 1 & \text{Recompute probabilities only for modified blocks} \end{cases}$$

- Total number of blocks in the domain $\mathcal{S}_{11}^t$
- Total number of generating blocks $\mathcal{S}_{12}^t$
- Total number of distinct outgoing currents $\mathcal{S}_{13}^t$
- Total number of incoming currents $\mathcal{S}_{14}^t$
- Total number of outgoing currents $\mathcal{S}_{15}^t$
- Dimension of PSS vector $\mathcal{S}_{16}^t$
- Dimension of ICM vector $\mathcal{S}_{17}^t$

The following records and directories will also be present on the main level of a /tracking/ directory.[4]

Table 22: The JPMT: records and directories in /tracking/

Name	Type	Condition	Units	Comment
IFR␣␣␣␣␣␣␣␣␣	I($\mathcal{S}_{14}^t$)			Index numbers of incoming currents

continued on next page

The JPMT: records and directories in /tracking/ continued from last page

Name	Type	Condition	Units	Comment
ALB$_____$	R($\mathcal{S}^t_{14}$)			Albedo or transmission factors corresponding to incoming currents
INUM$_____$	I($\mathcal{S}^t_{11}$)			Index number of the merge cell associated to each cell of the assembly
MIX$_____$	I($\mathcal{S}^t_{15}$)			Index numbers of outgoing currents
DVX$_____$	R($\mathcal{S}^t_{15}$)			Weights corresponding to outgoing currents
IGEN$_____$	I($\mathcal{S}^t_{11}$)			Index number of the generating cell associated to each merged block
ISURF$_____$	I($\mathcal{S}^t_{12}$)			Number of surfaces associated with a generating block
CHORD$_____$	R($\mathcal{S}^t_{4}$)			Mean chord length associated with each block
MU1$_____$	I($\mathcal{S}^t_{13}$)			Position of diagonal element in compress response matrix
IMA$_____$	I($\mathcal{S}^t_{13}$)			Position of first non zero element in compress response matrix
/PURE-GEOM/	Dir	$\mathcal{S}^t_7 = 2$		Directory containing the data related to a pure geometry
/DOITYOURSELF/	Dir	$\mathcal{S}^t_7 = 3$		Directory containing the data related to a do-it-yourself geometry
/EURYDICE/	Dir	$\mathcal{S}^t_7 = 4$		Directory containing the data related to an assembly geometry
/CLUSTER/	Dir	$\mathcal{S}^t_7 = 5$		Directory containing the data related to a cluster geometry
/BIHET/	Dir	$\mathcal{S}^t_7 = 10$		Directory containing the data related to a double heterogeneity geometry

where the directories /PURE-GEOM/, /DOITYOURSELF/, /EURYDICE/, /BIHET/ and /CLUSTER/ contain respectively:

Table 23: The contents of the JPMT: /PURE-GEOM/ directory

Name	Type	Condition	Units	Comment
PARAM$_____$	I(6)			Record containing the parameters for a JPM tracking on a pure geometry $\mathcal{P}_i$
XX$_____$	R($\mathcal{P}_5$)		cm	X directed mesh coordinates after mesh splitting for type 2, 5 and 7 geometries. Region ordered radius after mesh splitting for type 3 and 6 geometries
YY$_____$	R($\mathcal{P}_5$)		cm	Y directed mesh coordinates after mesh splitting for type 5, 6 and 7 geometries
ZZ$_____$	R($\mathcal{P}_5$)		cm	Z directed mesh coordinates after mesh splitting for type 7 and 9 geometries

with the dimension parameter $\mathcal{P}_i$, representing:

- The type of geometry $\mathcal{P}_1$

$$\mathcal{P}_1 = \begin{cases} 2 & \text{Cartesian 1–D geometry} \\ 3 & \text{Tube 1–D geometry} \\ 5 & \text{Cartesian 2–D geometry} \\ 6 & \text{Tube 2–D geometry} \\ 7 & \text{Cartesian 3–D geometry} \\ 8 & \text{Hexagonal 2–D geometry} \\ 9 & \text{Hexagonal 3–D geometry} \end{cases}$$

- The type of hexagonal symmetry $\beta_h = \mathcal{P}_2$

$$\beta_h = \begin{cases} 1 & \text{S30} \\ 2 & \text{SA60} \\ 3 & \text{SB60} \\ 4 & \text{S90} \\ 5 & \text{R120} \\ 6 & \text{R180} \\ 7 & \text{SA180} \\ 8 & \text{SB180} \\ 9 & \text{COMPLETE} \end{cases}$$

- The type of IC approximation between the blocks $\mathcal{P}_3$

$$\mathcal{P}_3 = \begin{cases} 1 & DP_0 \text{ for all surfaces} \\ 2 & DP_1 \text{ for all surfaces} \\ 3 & DP_1 \text{ for inner surfaces with } DP_0 \text{ for outer surfaces} \end{cases}$$

- The quadrature parameter $\mathcal{P}_4$
- The number of mesh intervals in the geometry $\mathcal{P}_5$

Table 24: The contents of the `JPMT: /DOITYOURSELF/` directory

Name	Type	Condition	Units	Comment
`PARAM␣␣␣␣␣␣␣`	I(5)			Record containing the parameters for a JPM tracking on a do-it-yourself geometry $\mathcal{P}_i$
`NMC␣␣␣␣␣␣␣␣␣`	I(M)			Offset of the first region in each cell
`RAYRE␣␣␣␣␣␣␣`	R(N, M)		cm	Radius of the tubes in each cell
`PROCEL␣␣␣␣␣␣`	R(M, M)			Geometric matrix

with the dimension parameter $\mathcal{P}_i$, representing:

- The number of cell $\mathcal{P}_1 = M - 1$

- The type of IC approximation between the blocks $\mathcal{P}_2$

$$\mathcal{P}_2 = \begin{cases} 1 & DP_0 \text{ for all surfaces} \\ 2 & DP_1 \text{ for all surfaces} \\ 3 & DP_1 \text{ for inner surfaces with } DP_0 \text{ for outer surfaces} \end{cases}$$

- The quadrature parameter $\mathcal{P}_3$
- The statistical option $\mathcal{P}_4$
- The maximum number of region per cell $\mathcal{P}_5 = N$

Table 25: The contents of the `JPMT: /EURYDICE/` directory

Name	Type	Condition	Units	Comment
`PARAM␣␣␣␣␣␣␣`	I(11)			Record containing the parameters for a JPM tracking on an assembly geometry $\mathcal{P}_i$
`ITGEN␣␣␣␣␣␣␣`	I(M)			The type of generating block
`COORD␣␣␣␣␣␣␣`	R($3, M$)		cm	Dimensions of the generating blocks
`MAIL␣␣␣␣␣␣␣␣`	I(M)			Offset of the first tracking information in each generating cell
`ZMAILI␣␣␣␣␣␣`	I($\mathcal{P}_{10}$)			The integer tracking information
`ZMAILR␣␣␣␣␣␣`	R($\mathcal{P}_{10}$)		cm	The tracking length

with the dimension parameter $\mathcal{P}_i$, representing:

- The type of multicell approximation $\mathcal{P}_1$
- The type of cylindrization $\mathcal{P}_2$
- The type of IC approximation between the blocks $\mathcal{P}_3$

$$\mathcal{P}_3 = \begin{cases} 1 & DP_0 \text{ for all surfaces} \\ 2 & DP_1 \text{ for all surfaces} \\ 3 & DP_1 \text{ for inner surfaces with } DP_0 \text{ for outer surfaces} \end{cases}$$

- The number of angles for 2–D quadrature $\mathcal{P}_4$
- The number of segments for 2–D quadrature $\mathcal{P}_5$
- The number of segments for homogeneous 2–D cells $\mathcal{P}_6$
- The number of segments for 1–D cells $\mathcal{P}_7$
- The track normalization option $\mathcal{P}_8$

$$\mathcal{P}_8 = \begin{cases} 0 & \text{Normalize the tracks} \\ 1 & \text{Do not normalize the tracks} \end{cases}$$

- The type of quadrature in angle and space $\mathcal{P}_9$

$$\mathcal{P}_9 = \begin{cases} 0 & \text{Gauss quadrature} \\ 1 & \text{Equal weight quadrature} \end{cases}$$

- The number of array elements in the tracking arrays $\mathcal{P}_{10}$
- The number of cell elements $\mathcal{P}_{11} = M$

Table 26: The contents of the `JPMT: /CLUSTER/` directory

Name	Type	Condition	Units	Comment
`PARAM␣␣␣␣␣␣␣`	I(11)			Record containing the parameters for a JPM tracking on a cluster geometry $\mathcal{P}_i$
`YSIDE␣␣␣␣␣␣␣`	R(1)		cm	Y directed side of a Cartesian geometry
`NRINFO␣␣␣␣␣␣`	I($2, \mathcal{P}_6$)			Rod location information
`RAN␣␣␣␣␣␣␣␣␣`	R($\mathcal{P}_6$)		cm	Radii of the annular regions
`NRODS␣␣␣␣␣␣␣`	I($\mathcal{P}_3, \mathcal{P}_1$)			Rod information
`ROD␣␣␣␣␣␣␣␣␣`	R($3, \mathcal{P}_7$)			Rod location
`RODR␣␣␣␣␣␣␣␣`	R($\mathcal{P}_8, \mathcal{P}_7$)		cm	Rod radii

with the dimension parameter $\mathcal{P}_i$, representing:

- The type of IC approximation between the blocks $\mathcal{P}_1$

$$\mathcal{P}_1 = \begin{cases} 1 & DP_0 \text{ for all surfaces} \\ 2 & DP_1 \text{ for all surfaces} \\ 3 & DP_1 \text{ for inner surfaces with } DP_0 \text{ for outer surfaces} \end{cases}$$

- The type of cluster reconstruction $\mathcal{P}_2$

$$\mathcal{P}_2 = \begin{cases} 1 & \text{Direct} \\ 2 & \text{Surface splitting} \end{cases}$$

- The number of 2–D quadrature angles $\mathcal{P}_3$
- The number of 2–D integration segments $\mathcal{P}_4$
- The number of 1–D quadrature segments $\mathcal{P}_5$
- The number of annular regions $\mathcal{P}_6$
- The number of rod types $\mathcal{P}_7$
- The maximum number of subrods per rod $\mathcal{P}_8$
- The total number of surfaces $\mathcal{P}_9$
- The number of outer surfaces $\mathcal{P}_{10}$

- The maximum track length $\mathcal{P}_{11}$

Table 27: The contents of the `JPMT: /BIHET/` directory

Name	Type	Condition	Units	Comment
`PARAM␣␣␣␣␣␣␣`	I(9)			Record containing the parameters for a JPM tracking on a double heterogeneity geometry $\mathcal{P}_i$
`NS␣␣␣␣␣␣␣␣␣␣`	I($\mathcal{P}_3$)			Number of tubes or shells in each kind of micro structure
`IGI␣␣␣␣␣␣␣␣␣`	I($\mathcal{P}_2$)			Type of mixture in each generating region of the macro geometry
`RS␣␣␣␣␣␣␣␣␣␣`	R($\mathcal{P}_3, M$)		cm	Radii of the micro regions
`FRACT␣␣␣␣␣␣␣`	R($\mathcal{P}_3, \mathcal{P}_1$)			Volume fraction of each type of micro region in each composite mixture
`ISURF2␣␣␣␣␣␣`	I($\mathcal{P}_2$)			Number of surfaces associated with a generating block
`CHORD2␣␣␣␣␣␣`	R($\mathcal{P}_9$)			Mean chord length associated with each block

with the dimension parameter $\mathcal{P}_i$, representing:

- The number of ordinary mixtures pointing to the MACROLIB. $\mathcal{P}_1$
- The number of regions in the macro geometry $\mathcal{P}_2$
- The number of different kinds of macro structures $\mathcal{P}_3$

  A kind of macro structure is characterized by the radii of its tubes or shells. All the micro region of the same kind should own the same nuclear properties in a given macro region.
- The maximum number of regions (tubes or shells) in each kind of macro structure $\mathcal{P}_4 = M - 1$
- The main JPM model for the macro geometry $\mathcal{P}_5$
- The type of micro regions $\mathcal{P}_6$

$$\mathcal{P}_7 = \begin{cases} 3 & \text{Cylinder} \\ 4 & \text{Sphere} \end{cases}$$

- The quadrature parameter for the 1–D collision probability calculation in the micro structures $\mathcal{P}_7$
- The type of IC approximation between the blocks $\mathcal{P}_8$

$$\mathcal{P}_8 = \begin{cases} 1 & DP_0 \text{ for all surfaces} \\ 2 & DP_1 \text{ for all surfaces} \\ 3 & DP_1 \text{ for inner surfaces with } DP_0 \text{ for outer surfaces} \end{cases}$$

- The total number of surfaces $\mathcal{P}_9$

7 CONTENTS OF A /ASMPIJ/ DIRECTORY

This directory contains the multigroup collision probability and response matrices required in the solution of the transport equation.

7.1 The main /asmpij/ directory

On its first level, the following records and sub-directories will be found in the /asmpij/ directory:

Table 28: Main records and sub-directories in /asmpij/

Name	Type	Condition	Units	Comment
SIGNATURE$\sqcup\sqcup\sqcup$	C$*$12			Signature of the data structure (SIGNA)
STATE-VECTOR	I(20)			Vector describing the various parameters associated with this data structure $\mathcal{S}_i^a$
{*/grpdir/*}	Dir			List of $\mathcal{S}_8^a$ sub-directories which contain the properties associated with each energy group g

The signature variable for this data structure must be SIGNA=L_PIJ$\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup$. The dimensioning parameters for this data structure, which are stored in the state vector $\mathcal{S}_i^a$, represents:

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- The option to indicate the type of system matrix to be stored. It can be an isotropic collision probability a directional collision probability or a response matrix are stored on the structure (see PIJ, PIJK, ARM in DRAGON user manual). Here $I_P = \mathcal{S}_1^a$ can take the following values:

$$I_P = \begin{cases} -1 & \text{the system responses matrices will be stored (see ARM)} \\ 0 & \text{only isotropic collision probability matrices will be stored (see PIJ)} \\ 1 & \text{isotropic and directional collision probability matrices will be stored (see PIJK)} \end{cases}$$

- The type of collision probabilities considered $I_S = \mathcal{S}_2^a$ where

$$I_S = \begin{cases} 0 & \text{scattering reduced collision probability or response matrix} \\ 1 & \text{direct collision probability or response matrix (see SKIP)} \end{cases}$$

- The residual system matrix presence $I_R = \mathcal{S}_3^a$ where

$$I_R = \begin{cases} 0 & \text{residual system matrix present} \\ 1 & \text{residual system matrix not stored (see NOR2)} \end{cases}$$

- The type of collision probability closure relation used $I_C = \mathcal{S}_4^a$

$$I_C = \begin{cases} -1 & \text{no closure relation used on cell with leakage} \\ 0 & \text{no closure relation used on cell without leakage} \\ 1 & \text{total reflection closure relation (see NORM)} \\ 2 & \text{Selengut closure relation (see ALBS)} \end{cases}$$

- The type of collision probability normalization method used (see keyword PNOR in DRAGON). Here $I_N = \mathcal{S}_5^a$ can take the following values

$$I_N = \begin{cases} -1 & \text{no normalization} \\ 0 & \text{HELIOS type normalization} \\ 1 & \text{Gelbard normalization algorithm} \\ 2 & \text{diagonal element normalization} \\ 3 & \text{non linear normalization} \end{cases}$$

- The collision probability calculation grouping algorithm (see keyword SUBG in DRAGON). Here $N_g = \mathcal{S}_6^a$ is the number of simultaneous groups to process for each integration line.
- Number of groups $G = \mathcal{S}_7^a$
- Number of unknown in flux system $N_u = \mathcal{S}_8^a$
- Number of mixtures $N_m = \mathcal{S}_9^a$
- Anisotropy order $N_l = \mathcal{S}_{10}^a$
- Number of generating cells $N_{\text{gen}} = \mathcal{S}_{11}^a$
- Number of regions $N_r = \mathcal{S}_{12}^a$
- Number of surfaces $N_s = \mathcal{S}_{13}^a$
- Dimension P_{ss} matrix $N_{\text{pss}} = \mathcal{S}_{14}^a$
- Dimension of ICM matrix $N_{\text{icm}} = \mathcal{S}_{15}^a$

The list of group directory {/grpdir/} names GRPDIR will be composed using the following FORTRAN instructions

$$\texttt{WRITE}(\text{GRPDIR},'(\texttt{A5},\texttt{I3},\texttt{A1},\texttt{I3})')\,'\texttt{GROUP}',g,'/',G$$

for $1 \leq g \leq G$. For example, in the case where two group collision probability matrices are considered ($G = 2$), two such directory would be generated, namely

Table 29: Example of collision probability directories

Name	Type	Condition	Units	Comment
GROUP␣␣1/␣␣2	Dir			Sub-directories which contain the information associated with group $g = 1$
GROUP␣␣2/␣␣2	Dir			Sub-directories which contain the information associated with group $g = 2$

7.2 The group sub-directory /grpdir/ in /asmpij/

Inside each group g directory the following records will be found

Table 30: Collision probability directories

Name	Type	Condition	Units	Comment
DRAGON-TXSC$\sqcup$	R(N_m+1)		cm^{-1}	The total cross section Σ_m^g for N_m+1 mixtures assuming that the first mixture represents void ($\Sigma_m^g=0$)
DRAGON-S0XSC	R(N_m+1)		cm^{-1}	The within group scattering cross section $\Sigma_{0,m,w}$ (see Section 3.2) for N_m+1 mixtures assuming that the first mixture represents void ($\Sigma_{0,m,w}^g=0$)
DRAGON-PCSCT	R(N_r,N_r)	$I_P\geq 0$		The scattering modified collision probability matrix $P_{s,ij}^g$ or direct collision probability matrix P_{ij}^g
DRAGON1PCSCT	R(N_r,N_r)	$I_P=1$		The X directed scattering modified collision probability matrix $P_{s,ij,x}^g$ or direct collision probability matrix $P_{ij,x}^g$
DRAGON2PCSCT	R(N_r,N_r)	$I_P=1$		The Y directed scattering modified collision probability matrix $P_{s,ij,y}^g$ or direct collision probability matrix $P_{ij,y}^g$
DRAGON3PCSCT	R(N_r,N_r)	$I_P=1$		The Z directed scattering modified collision probability matrix $P_{s,ij,z}^g$ or direct collision probability matrix $P_{ij,z}^g$
DRAGON1P*SCT	R(N_r,N_r)	$I_P=1$		The isotropic current X directed scattering modified collision probability matrix $P_{s,ij,x}^{g,*}$ or direct collision probability matrix $P_{ij,x}^{g,*}$
DRAGON2P*SCT	R(N_r,N_r)	$I_P=1$		The isotropic current Y directed scattering modified collision probability matrix $P_{s,ij,y}^{g,*}$ or direct collision probability matrix $P_{ij,y}^{g,*}$
DRAGON3P*SCT	R(N_r,N_r)	$I_P=1$		The isotropic current Z directed scattering modified collision probability matrix $P_{s,ij,z}^{g,*}$ or direct collision probability matrix $P_{ij,z}^{g,*}$
DRAGON-PIS$\sqcup\sqcup$	R(N_r)	$I_C\neq 0,1$		The leakage matrix P_{is}^g

8 CONTENTS OF A /FLUXUNK/ DIRECTORY

This directory contains the main flux calculations results, including the multigroup flux, the eigenvalue for the problem and the diffusion coefficients when computed.

8.1 The main /fluxunk/ directory

On its first level, the following records and sub-directories will be found in the /fluxunk/ directory:

Table 31: Main records and sub-directories in /fluxunk/

Name	Type	Condition	Units	Comment
SIGNATURE␣␣␣	C∗12			Signature of the data structure (SIGNA)
STATE-VECTOR	I(20)			Vector describing the various parameters associated with this data structure $\mathcal{S}_i^f$
EPS-CONVERGE	R(3)			Convergence parameters Δ_i^ϵ
K-EFFECTIVE␣	R(1)	$1 \leq \mathcal{S}_1^f \leq 5$		Computed or imposed effective multiplication constant for eigenvalue problem
FLUXDIRECT␣␣	Dir			/flux/ directory containing the direct solution to the transport equation
PSEUDOADJ␣␣␣	Dir	$\mathcal{S}_i^f \geq 1$		/flux/ directory containing the pseudo-adjoint solution to the transport equation
FLUXADJ␣␣␣␣␣	Dir	$\mathcal{S}_i^f \geq 2$		/flux/ directory containing the adjoint solution to the transport equation
PSEUDOGENADJ	Dir	$\mathcal{S}_i^f \geq 3$		/flux/ directory containing the generalized pseudo-adjoint solution to the transport equation
FLUXGENADJ␣␣	Dir	$\mathcal{S}_i^f \geq 4$		/flux/ directory containing the generalized adjoint solution to the transport equation

where each /flux/ directory contains

Table 32: Contents of a /flux/ directory

Name	Type	Condition	Units	Comment
1/EIGENVALUE	R(1)	$1 \leq \mathcal{S}_1^f \leq 5$		Computed or imposed effective multiplication constant for eigenvalue problem
B2␣␣B1HOM␣␣␣	R(1)	$2 \leq \mathcal{S}_1^f \leq 5$	cm^{-2}	Homogeneous buckling B^2
DIFFB1HOM␣␣␣	R(G)	$2 \leq \mathcal{S}_1^f \leq 5$	cm	Multigroup homogeneous leakage coefficients d^g
PNL␣␣␣␣␣␣␣␣␣	R(G)	$1 \leq \mathcal{S}_1^f \leq 2$		Non-leakage probabilities P^g_{NL} (absent if $\mathcal{S}_8^f \neq 0$)

continued on next page

Contents of a /flux/ directory continued from last page

Name	Type	Condition	Units	Comment
B2␣␣HETE␣␣␣␣	R(3)	$\mathcal{S}_2^f \geq 5$	cm^{-2}	Directional buckling components B_i^2
{*flxcur*}	R(N_U)		$\text{cm}^{-2}\text{s}^{-1}$	Multiregion flux/current vector Φ_u

The signature variable for this data structure must be SIGNA=L_FLUX␣␣␣␣␣␣. The dimensioning parameters for this data structure, which are stored in the state vector $\mathcal{S}_i^f$, represents:

- The type of solution considered $I_s = \mathcal{S}_1^f$ where

$$I_s = \begin{cases} 0 & \text{No flux calculation, fluxes taken from input file} \\ 1 & k_{\mathit{eff}} \text{ eigenvalue problem with fission and no leakage} \\ 2 & k_{\mathit{eff}} \text{ eigenvalue problem with fission and fixed leakage } (dB^2) \\ 3 & k_{\mathit{eff}} \text{ eigenvalue problem with fission and fixed } B^2 \\ 4 & \text{Buckling eigenvalue problem with fission and leakage} \\ 5 & \text{Buckling eigenvalue problem without fission but with leakage} \\ 6 & \text{Fixed source problem, no eigenvalue} \end{cases}$$

- The type of leakage model $I_l = \mathcal{S}_2^f$ where

$$I_l = \begin{cases} 0 & \text{No leakage model} \\ 1 & \text{Homogeneous PNLR calculation} \\ 2 & \text{Homogeneous PNL calculation} \\ 3 & \text{Homogeneous SIGS calculation} \\ 4 & \text{Homogeneous ALSB calculation} \\ 5 & \text{Heterogeneous leakage with imposed buckling} \\ 6 & \text{Heterogeneous leakage with } X \text{ Buckling search} \\ 7 & \text{Heterogeneous leakage with } Y \text{ Buckling search} \\ 8 & \text{Heterogeneous leakage with } Z \text{ Buckling search} \\ 9 & \text{Heterogeneous leakage with radial Buckling search} \\ 10 & \text{Heterogeneous leakage with total Buckling search} \end{cases}$$

- Number of free iteration per variational acceleration cycle $N_f = \mathcal{S}_3^f$
- Number of accelerated iteration per variational acceleration cycle $N_a = \mathcal{S}_4^f$
- Thermal rebalancing option $I_r = \mathcal{S}_5^f$ where

$$I_r = \begin{cases} 0 & \text{No thermal iteration rebalancing} \\ 1 & \text{Thermal iteration rebalancing activated} \end{cases}$$

- Maximum number of inner (thermal) iterations $M_{\text{in}} = \mathcal{S}_6^f$ where
- Maximum number of outer iterations $M_{\text{out}} = \mathcal{S}_7^f$ where

- Adjoint calculation option $I_A = \mathcal{S}_8^f$ where

$$I_A = \begin{cases} 0 & \text{no adjoint} \\ 1 & \text{pseudo-adjoint calculation} \\ 2 & \text{pseudo-adjoint and adjoint calculation} \\ 3 & \text{generalized pseudo-adjoint calculation} \\ 4 & \text{generalized pseudo-adjoint and adjoint calculation} \end{cases}$$

- The number of groups $N_G = \mathcal{S}_9^f$ where
- The number of unknowns $N_U = \mathcal{S}_{10}^f$ where

The convergence parameters Δ_i^ϵ represents:

- Δ_1^ϵ is the inner iteration flux convergence parameter
- Δ_2^ϵ is the outer iteration eigenvalue convergence parameter
- Δ_3^ϵ is the outer iteration flux convergence parameter

In the case of a G group calculation, G *flxcur* records will be present on this directory, one for each group g. The explicit name of these records is created using the following FORTRAN instruction:

$$\texttt{WRITE}(\textit{flxcur},'\,(\texttt{A4},\texttt{I3})'\,)\,'\texttt{FLUX}',g$$

In the case of a two group calculation ($N_G = 2$) we will then find on /fluxunk/ the following records:

Table 33: Two groups flux/current records on /fluxunk/

Name	Type	Condition	Units	Comment
FLUX␣␣1␣␣␣␣	R(N_U)		$\text{cm}^{-2}\text{s}^{-1}$	Multiregion flux/current vector Φ_u in group $g = 1$
FLUX␣␣2␣␣␣␣	R(N_U)		$\text{cm}^{-2}\text{s}^{-1}$	Multiregion flux/current vector Φ_u in group $g = 2$

9 CONTENTS OF A /EDITION/ DIRECTORY

This directory contains the main editing results. For the purpose of illustration we will assume that the EDI: module is executed using the following data:

```
EDITING := EDI: FLUX LIBRARY VOLMAT ::
  MERG COMP COND 27 69 FLIB ALL
  SAVE ON EDITCELL2G ;
```

where EDITING is the final EDITION data structure. The data structures FLUX, LIBRARY and VOLMAT are respectively of type FLUXUNK, MICROLIB and TRACKING. Assuming that the initial number of regions VOLMAT is N and the number of groups in LIBRARY is $G = 69$, then the final information that will be stored in the EDITING data structure will represent a two group ($G_c = 2$) one mixture N_h /microlib/.

9.1 The main /edition/ directory

On its first level, the following records and sub-directories will be found in the /edition/ directory:

Table 34: Main records and sub-directories in /edition/

Name	Type	Condition	Units	Comment
SIGNATURE$_{\sqcup\sqcup\sqcup}$	C$*12$			Signature of the data structure (SIGNA)
STATE-VECTOR	I(20)			Vector describing the various parameters associated with this data structure $\mathcal{S}_i^e$
TITLE$_{\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup}$	C$*72$			Title of the last editing performed (TITLE)
LAST-EDIT$_{\sqcup\sqcup\sqcup}$	C$*12$			Name of the last editing sub-directory saved (LAST)
REF-IMERGE$_{\sqcup\sqcup}$	I($\mathcal{S}_{15}^e$)			Merged region number associated with each of the original original region number M_r
REF-IGCOND$_{\sqcup\sqcup}$	I($\mathcal{S}_2^e$)			Old group limits associated with the merged groups C_g
CARISO$_{\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup}$	C($\lvert\mathcal{S}_9^e\rvert - 1$)$*12$	$\lvert\mathcal{S}_9^e\rvert \geq 2$		Name of isotopes save during the last editing (NAMI)
IACTI$_{\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup}$	I($\mathcal{S}_5^e$)	$\lvert\mathcal{S}_5^e\rvert \geq 1$		Original mixture numbers for which activation data was generated (A_m)
{*/micdir/*}	Dir			List of sub-directories which contain the editing information

The signature variable for this data structure must be SIGNA=L_EDIT$_{\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup}$. The dimensioning parameters for this data structure, which are stored in the state vector $\mathcal{S}_i^e$, represents:

- The number of homogeneous mixtures saved $N_H = \mathcal{S}_1^e$ for the last editing step
- The number of condensed groups considered $M_G = \mathcal{S}_2^e$ for the last editing step
- An editing flag to indicate the presence of 4 factor editing $I_{4f} = \mathcal{S}_3^e$ for the last editing step

- An editing flag to indicate that the upscattering contributions have all been transferred to the diagonal part of the scattering matrix $IU = \mathcal{S}_4^e$ for the last editing step
- The number of mixture activated $N_A = \mathcal{S}_5^e$ for the last editing step
- An editing flag to indicate the types of statistics generated by `EDI:` $I_S = \mathcal{S}_6^e$ for the last editing step
- An editing flag to indicate the type of SPH equivalence factor used in `EDI:` $I_{EF} = \mathcal{S}_7^e$ for the last editing step
- An editing flag to indicate the type of SPH equivalence normalization considered used in `EDI:` $I_{EN} = \mathcal{S}_8^e$ for the last editing step
- The type of microscopic cross section $I_m = \mathcal{S}_9^e$ for the last editing step
- The print level considered $I_p = \mathcal{S}_{10}^e$ for the last editing step
- An editing flag to indicate the types of cross section saved in `EDI:` $I_x = \mathcal{S}_{11}^e$ for the last editing step
- The type of flux weighting used for anisotropic scattering $I_w = \mathcal{S}_{12}^e$ for the last editing step
- The maximum number of isotopes per mixture $M_I = \mathcal{S}_{13}^e$
- The maximum number of condensed groups in all editing $M_g = \mathcal{S}_{14}^e$
- The maximum number of homogeneous mixtures in all editing $M_h = \mathcal{S}_{15}^e$
- The total number of ISOTXS files generated $M_F = \mathcal{S}_{16}^e$

The list of directory {/micdir/} names EDIDIR will be composed according to the following laws. In the case where the set of keywords `SAVE ON` are used followed by a directory name as above, the contents of EDIDIR will be identical the name of the specified directory (here `EDITCELL2G␣␣`). If the `SAVE` option is used without specifying a specific directory, then the first eight characters of EDIDIR (EDIDIR`(1:8)`) will be given as `REF-CASE` while the last four character (EDIDIR`(9:12)`) will be a unique character variable representing the successive directory saved. This character variable will be created as follows:

$$\texttt{WRITE}(\text{EDIDIR}(\texttt{9:12}),'(\texttt{I4})')\ J$$

where $1 \leq J$ represents the J^{th} execution of the `EDI:` module. In the case above, we would have a single editing directory of the form:

Table 35: Example of an editing directory

Name	Type	Condition	Units	Comment
`EDITCELL2G␣␣`	Dir			Two groups /microlib/ sub-directory

10 CONTENTS OF A /BURNUP/ DIRECTORY

This directory contains the main burnup information, namely the multigroup flux and the isotopic concentration at each time or burnup step.

10.1 The main /burnup/ directory

On its first level, the following records and sub-directories will be found in the /burnup/ directory:

Table 36: Main records and sub-directories in /burnup/

Name	Type	Condition	Units	Comment
SIGNATURE␣␣␣	C∗12			Signature of the data structure (SIGNA)
STATE-VECTOR	I(20)			Vector describing the various parameters associated with this data structure $\mathcal{S}_i^b$
EVOLUTION-R␣	R(5)			Vector describing the various parameters associated with the burnup calculation options R_i
DEPL-TIMES␣␣	R($\mathcal{S}_3^b$)		10^8 s	Vector describing the various time steps at which burnup information has been saved T_i
FUELDEN-INIT	R(2)			Vector giving the initial density of heavy element in the fuel ρ_f (g cm^{-3}) the initial mass of heavy element in the fuel m_f (g)
{*/depldir/*}	Dir			List of $\mathcal{S}_3^b$ sub-directories which contain the properties associated with each burnup step T_i

The signature variable for this data structure must be SIGNA=L_BURNUP␣␣␣␣. The dimensioning parameters for this data structure, which are stored in the state vector $\mathcal{S}_i^b$, represents:

- The type of solution considered $I_s = \mathcal{S}_1^b$ where

$$I_s = \begin{cases} 1 & \text{Fifth order Runge–Kutta method} \\ 2 & \text{Forth order Kaps–Rentrop method} \end{cases}$$

- The type of burnup considered $I_t = \mathcal{S}_2^b$

$$I_t = \begin{cases} 0 & \text{Out of core or zero flux/power depletion} \\ 1 & \text{Constant flux depletion} \\ 2 & \text{Constant power depletion} \end{cases}$$

- Number of time steps for which burnup properties are present in this directory $N_t = \mathcal{S}_3^b$
- Number of isotopes $N_I = \mathcal{S}_4^b$
- Number of groups $G = \mathcal{S}_5^b$ where
- Number of regions $N_r = \mathcal{S}_6^b$ where

The list of directory {/depldir/} names DEPLDIR will be composed according to the following laws. The first eight character (DEPLDIR(1:8)) will always be given by DEPL-DAT. The last four character (DEPLDIR(9:12)) represents time step saved. For the case where N_t time steps were saved we would use the following FORTRAN instructions to create the last four character of each of the directory names:

$$\texttt{WRITE}(\texttt{DEPLDIR}(9:12),'(\texttt{I4})')\ J$$

for $1 \leq J \leq N_t$ with the time stamp associated with each directory being given by T_J. For the case where ($N_t = 2$), two such directory would be generated, namely

Table 37: Example of depletion directories

Name	Type	Condition	Units	Comment
DEPL-DAT␣␣␣1	Dir			Sub-directories which contain the information associated with time step 1
DEPL-DAT␣␣␣2	Dir			Sub-directories which contain the information associated with time step 2

10.2 The depletion sub-directory /depldir/ in /burnup/

Inside each depletion directory the following records and sub-directories will be found:

Table 38: Contents of a depletion sub-directory in /burnup/

Name	Type	Condition	Units	Comment
ISOTOPESDENS	R(N_I)		(cm b)$^{-1}$	Isotopic densities ρ_i for each of the isotopes described in the /microlib/ directory where the order of the isotopes is also specified
FLXDIR␣␣␣␣␣␣	R(N_r, G)		cm^{-2} s^{-1}	Multiregion and multigroup flux ϕ_r^g where for each energy group the flux associated with the region are stored successively
FLUX-NORM␣␣␣	R(1)			Flux normalization constant. It is zero for out of core depletion and represent the normalization of the flux ϕ_r^g that is used to ensure that the cell integrated flux or power is that required when fixed flux or power burnup is requested
DELTA␣␣␣␣␣␣␣	R(2)			Fuel burnup (MW d T^{-1}) and irradiation (Kb^{-1}) increments between the current time step and the preceding time step
BURNUP-IRRAD	R(2)			Fuel burnup (MW d T^{-1}) and irradiation (Kb^{-1}) reached at this time step

11 CONTENTS OF A /CPO/ DIRECTORY

This directory contains a burnup dependent hierarchical reactor data base. For the purpose of illustration we will assume that the CPO: module is executed using the following data:

```
COMPO := CPO: EDITING BURN ::
  BURNUP REF-CASE
  EXTRACT ALL
  NAME MIXTH ;
```

where EDITING is a EDITION data structure which contains 2 homogeneous mixtures, evaluated and saved at 2 time steps, BURN is a BURNUP data structure containing information for the successive burnup calculations required to generate EDITING and finally COMPO is the final CPO data structure which contains the resulting reactor database directory.

11.1 The main /cpo/ directory

On its first level, the following records and sub-directories will be found in the /cpo/ directory:

Table 39: Main records and sub-directories in /cpo/

Name	Type	Condition	Units	Comment
SIGNATURE$_{\sqcup\sqcup\sqcup}$	C$*$12			Signature of the data structure (SIGNA)
STATE-VECTOR	I(20)			Vector describing the various parameters associated with this data structure $\mathcal{S}_i^c$
{*/mixdir/*}	Dir			List of $\mathcal{S}_1^c$ sub-directories which contain the homogeneous mixture information

The signature variable for this data structure must be SIGNA=L_COMPO$_{\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup}$. The dimensioning parameters for this data structure, which are stored in the state vector $\mathcal{S}_i^c$, represents:

- The total number of homogeneous mixtures saved $N_H = \mathcal{S}_1^c$
- The maximum number of groups considered $M_G = \mathcal{S}_2^c$
- The maximum number of isotopes $M_I = \mathcal{S}_3^c$
- The maximum order for the scattering anisotropy $M_L = \mathcal{S}_4^c$
- The maximum number of burnup steps per mixtures $M_B = \mathcal{S}_5^c$

The list of directory {/mixdir/} names MIXDIR will be composed according to the following laws. The first eight character (MIXDIR(1:8)) will be identical to the first 8 character of the user data following the keyword NAME in the CPO: module (here MIXTH$_{\sqcup\sqcup\sqcup}$ and by default COMPO$_{\sqcup\sqcup\sqcup}$). The last four character (MIXDIR(9:12)) represents the various homogeneous mixture number saved on the EDITION data structure. For the case where N_H such mixtures were available we would use the following FORTRAN instructions to create the last four character of each of the directory names:

$$\texttt{WRITE}(\texttt{MIXDIR}(9:12),'(\texttt{I4})')\ J$$

for $1 \leq J \leq N_H$. For the example given above ($N_H = 2$), two such directory would be generated, namely

Table 40: Example of homogeneous mixture directories

Name	Type	Condition	Units	Comment
MIXTH␣␣␣␣␣␣1	Dir			Sub-directories which contain the information associated with homogeneous mixture 1
MIXTH␣␣␣␣␣␣2	Dir			Sub-directories which contain the information associated with homogeneous mixture 2

11.2 The mixture sub-directory /mixdir/ in /cpo/

Inside each mixture directory the following records and sub-directories will be found:

Table 41: Contents of a mixture sub-directory in /cpo/

Name	Type	Condition	Units	Comment
TITLE␣␣␣␣␣␣␣	C$*$72			Title of the run which produced this mixture T
PARAM␣␣␣␣␣␣␣	I(4)			Vector describing the various parameters associated with this data structure $\mathcal{P}_i$
VOLUME␣␣␣␣␣␣	R(1)		cm^3	Volume of the region to which was associated this homogeneous mixture in the EDITION data structure V
ENERGY␣␣␣␣␣␣	R($G+1$)		eV	Energy groups limits E_g
BURNUP␣␣␣␣␣␣	R($\mathcal{P}_4$)		MW d T^{-1}	Burnup reached at the different burnup steps B_k
N/KB␣␣␣␣␣␣␣	R($\mathcal{P}_4$)		Kb^{-1}	Fuel irradiation reached at the different burnup steps w_k
ISOTOPESNAME	C($\mathcal{P}_2$) $*$ 12			Name of the various isotopes saved for this mixture ISO$_i$
{*/brndir/*}	Dir			List of sub-directories which contain the burnup dependent properties associated with an homogeneous mixture

The following parameters are stored $\mathcal{P}$:

- The number of groups for this homogeneous mixture $G = \mathcal{P}_1$ such that $G \leq M_G$
- The number of isotopes in this mixture $N_I = \mathcal{P}_2$ such that $1 \leq N_I \leq M_I$
- The order of the scattering anisotropy for this mixture $N_L = \mathcal{P}_3$ such that $N_L \leq M_L$

- The number of burnup steps for this mixture $N_B = \mathcal{P}_4$ such that $1 \leq N_B \leq M_B$

The list of directory {/brndir/} names BRNDIR will be composed according to the following laws. The first eight character (BRNDIR(1:8)) will all be identical and equal to BURN␣␣␣␣. The last four character (MIXDIR(9:12)) will represents the different burnup steps saved on the EDITION data structure. For the case where N_B steps were available, the following FORTRAN instructions are used to generate the last four character of each of the directory names:

$$\texttt{WRITE}(\texttt{BRNDIR}(\texttt{9}:\texttt{12}),'(\texttt{I4})')\ J$$

for $1 \leq J \leq N_B$. For the example given above ($N_B = 2$), two such directory would be generated, namely

Table 42: Example of homogeneous mixture directories

Name	Type	Condition	Units	Comment
BURN␣␣␣␣␣␣␣1	Dir			Sub-directories which contain the information associated with burnup step 1
BURN␣␣␣␣␣␣␣2	Dir			Sub-directories which contain the information associated with burnup step 2

11.3 The burnup sub-directory /brndir/ in /cpo/

Inside each burnup directory the following records and sub-directories will be found:

Table 43: Contents of a burnup sub-directory in /cpo/

Name	Type	Condition	Units	Comment
ISOTOPESDENS	R(N_I)		(cm b)$^{-1}$	Isotopic densities ρ_i
ISOTOPES-EFJ	R(N_I)		J	Energy produced per fission in joule (W s) for this isotope H_i
FLUX-INTG␣␣␣	R(G)		cm s^{-1}	The integrated flux Φ_m^g
OVERV␣␣␣␣␣␣␣	R(G)		cm^{-1}s	The inverse of the average neutron velocity $1/v_m^g$
FLUXDISAFACT	R(G)			Ratio of the flux in the fuel to the flux in the cell F_g
{*/isotope/*}	Dir			List of N_I sub-directories which contain the isotopic microscopic cross section properties for this burnup step

The list of directory {/isotope/} names ISODIR is that specified by the ISODIR = ISO$_i$ for $i = 1$ to N_I. Note that the first isotope isotope always represents an equivalent macroscopic isotope. The name of this isotope is always ISODIR=MACR␣␣␣␣␣␣␣␣ and it has a constant density of 1.0 (cm b)$^{-1}$. The content of the isotopic multigroup cross section directory is given in Section 13.

12 CONTENTS OF A /FBM/ DIRECTORY

(Release 3.03)

This directory contains a burnup and local parameter dependent hierarchical reactor data base. For the purpose of illustration we will assume that the CFC: module was execute for a CANDU reactor.

12.1 The main /fbm/ directory

On its first level, the following records and sub-directories will be found in the /fbm/ directory:

Table 44: Main records and sub-directories in /fbm/

Name	Type	Condition	Units	Comment
SIGNATURE␣␣␣	C∗12			Signature of the data structure (SIGNA)
INFORMATION␣	C∗72			Name of the database (NAMDB)
{*/matdir/*}	Dir			List of material sub-directories containing a homogeneous material

The signature variable for this data structure must be SIGNA=REACTOR_XSDB. The list of directory {/matdir/} names MATDIR will be composed according to the following laws. The first eight character (MATDIR(1:8)) will be identical to the first 8 character of the user data following the keyword DNAME in the CFC: module. The last four character (MATDIR(9:12)) represents the various homogeneous mixture number saved on the FBMDBXS data structure. For the case where N_H such mixtures were available we would use the following FORTRAN instructions to create the last four character of each of the directory names:

$$\texttt{WRITE}(\texttt{MATDIR}(9:12),'(\texttt{I4})')\ J$$

for $1 \leq J \leq N_H$. As an example, if we specified DNAME MATH in the execution of the CFC: and we considered $N_H = 2$, two such directory would be generated, namely

Table 45: Example of homogeneous mixture directories

Name	Type	Condition	Units	Comment
MATH␣␣␣␣␣␣␣1	Dir			Sub-directories which contain the information associated with homogeneous material 1
MATH␣␣␣␣␣␣␣2	Dir			Sub-directories which contain the information associated with homogeneous material 2

12.2 The material sub-directory /matdir/ in /fbm/

Inside each material directory the following records and sub-directories will be found:

Table 46: Contents of a material sub-directory in /fbm/

Name	Type	Condition	Units	Comment
PARAM$_{\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup}$	I(4)			Vector describing the various parameters associated with this data structure $\mathcal{P}_i$
HITAB$_{\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup}$	C($\mathcal{P}_2$) $*$ 12			Name of the isotopic sub-directories ISO$_i$
VOLUME$_{\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup}$	R(1)		cm^3	Volume of the region to which was associated this homogeneous material in the EDITION data structure V
MASS$_{\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup}$	R(1)		kg	Initial mass M of heavy elements used for the burnup procedure
ENERGY$_{\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup}$	R($\mathcal{P}_1 + 1$)		eV	Energy groups limits E_g
BURNUP$_{\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup}$	R($\mathcal{P}_4$)		MW d T^{-1}	Burnup reached at the different burnup steps B_k
N/KB$_{\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup}$	R($\mathcal{P}_4$)		Kb^{-1}	Fuel irradiation reached at the different burnup steps w_k
JTAB$_{\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup}$	I($\mathcal{P}_2$)			Record containing the type of data stored in each isotopic sub-directory I_i
ISOTOPESNAME	C($\mathcal{P}_2$) $*$ 12			Name of the various isotopes saved for this mixture ISO$_i$
INFO-NOMINAL	Dir			Information sub-directories containing the nominal local parameters, date of execution and DRAGON version. It may also contain informations about the geometry, tracking and the library used
{*/brndir/*}	Dir			List of sub-directories which contain the burnup dependent properties associated with an homogeneous mixture

The following parameters are stored in $\mathcal{P}$:

- The number of groups for this homogeneous mixture $G = \mathcal{P}_1$ such that $G \leq M_G$
- The number of isotopes in this material $N_I = \mathcal{P}_2$ such that $1 \leq N_I \leq M_I$
- The order of the scattering anisotropy for this mixture $N_L = \mathcal{P}_3$ such that $N_L \leq M_L$
- The number of burnup steps for this mixture $N_B = \mathcal{P}_4$ such that $1 \leq N_B \leq M_B$

The list of directory {/brndir/} names BRNDIR will be composed according to the following laws. The first eight character (BRNDIR(1:8)) will all be identical and equal to BURN$_{\sqcup\sqcup\sqcup\sqcup}$. The last four character (BRNDIR(9:12)) will represents the different burnup steps saved on the EDITION data structure. For the case where N_B steps were available, the following FORTRAN instructions are used to generate the last four character of each of the directory names:

$$\texttt{WRITE}(\texttt{BRNDIR}(9:12),'(\texttt{I4})')\ J$$

for $1 \leq J \leq N_B$. For the example given above ($N_B = 2$), two such directory would be generated, namely BURN␣␣␣␣␣␣␣1 and BURN␣␣␣␣␣␣␣2 containing the information associated with burnup step 1 and 2 respectively.

12.3 The information sub-directory /INFO-NOMINAL/ in /fbm/

Inside each such information directory the following records will be found:

Table 47: Contents of the information sub-directory of /fbm/

Name	Type	Condition	Units	Comment
NOMINALP␣␣␣␣	R(4)			A Vector P_i containing 4 elements. The first element $P_1 = P$ is the burnup power in kW/kg, the second element $P_1 = T_c$ is the coolant temperature in K, the third element $P_3 = T_m$ is the moderator temperature in K and the last element $P_4 = T_f$ represents the fuel temperature in K
NOMINALN␣␣␣␣	C(4) ∗ 12			A vector NP_i containing the name of the nominal parameters. The first element is NP_1 =PW, the second element is NP_1 =TCOOL, the third element is NP_3 =TMOD and the last element is NP_4 =TFUEL.
DATE-VERSION	C∗72			Date and version of DRAGON used to create this database DV
LIB-TRK-GEO␣	C∗72			DRAGON options used to create this database OP

12.4 The burnup sub-directory /brndir/ in /fbm/

Inside each burnup directory the following records and sub-directories will be found:

Table 48: Contents of a burnup sub-directory in /fbm/

Name	Type	Condition	Units	Comment
ISOTOPESDENS	R(N_I)		(cm b)$^{-1}$	Isotopic densities ρ_i
DCR␣␣␣␣␣␣␣␣␣	R(N_I)		s^{-1}	Radioactive decay constant for each isotope λ_i
FLUX-INTG␣␣␣	R(G)		cm s^{-1}	The integrated flux Φ_m^g
OVERV␣␣␣␣␣␣␣	R(G)		cm^{-1}s	The inverse of the average neutron velocity $1/v_m^g$
FLUXDISAFACT	R(G)			Ratio of the flux in the fuel to the flux in the cell F_g
HISTORY␣␣␣␣␣	Dir			Sub-directory containing the pseudo-fissile isotope history coefficients.

continued on next page

Contents of a burnup sub-directory in /fbm/ continued from last page

Name	Type	Condition	Units	Comment
{*/fbmiso/*}	Dir			List of N_I sub-directories which contain the isotopic microscopic cross section properties for this burnup step

The list of directory {/fbmiso/} names ISODIR is that specified by the ISODIR $=$ ISO$_i$ for $i = 1$ to N_I in Section 11. Note that the first isotope isotope always represents an equivalent macroscopic isotope. The name of this isotope is always ISODIR=MACR␣␣␣␣␣␣␣␣ and it has a constant density of 1.0 (cm b)$^{-1}$. The content of the isotopic multigroup cross section directory is given in Section 14.

12.5 The history sub-directory /HISTORY/ in /brndir/

Inside each history directory the following records and sub-directories will be found:

Table 49: Contents of an history sub-directory /HISTORY/ in /brndir/

Name	Type	Condition	Units	Comment
CHIS␣␣␣␣␣␣␣␣	R(1)		(cm b)$^{-1}$	Coolant density history H_d
FHIS␣␣␣␣␣␣␣␣	R(1)		K	Coolant temperature history H_T
PHIL1␣␣␣␣␣␣␣␣	R(1)		kW/kg	First high power level history $H_{1,1}$
PHIL2␣␣␣␣␣␣␣␣	R(1)		kW/kg	Second high power level history $H_{1,2}$
PHIS1␣␣␣␣␣␣␣␣	R(1)		kW/kg	First low power level history $H_{2,1}$
PHIS2␣␣␣␣␣␣␣␣	R(1)		kW/kg	Second low power level history $H_{2,2}$

13 CONTENTS OF A /ISOTOPE/ DIRECTORY

Each isotope directory always contains a cross section identifier record which must be used to verify if a given cross section type has been saved for this isotope. For the case where the scattering cross section is expanded up to order L in Legendre polynomial, this record has the form:

Table 50: Isotopic cross section identifier record

Name	Type	Condition	Units	Comment
XS-SAVED$\sqcup\sqcup\sqcup\sqcup$	I($21+L$)			Vector κ_k to identify the various type of cross sections saved for this isotope

The first 20 components of κ_k indicate the presence of different vector properties for this isotope while the last $L+1$ components refer to information pertaining to the scattering matrix. Because we can store on this isotopic directory in addition to constant vector properties, time dependent isotopic vector properties in the form of the coefficients of a power series expansion:

$$v_k^g(t) = \sum_{i=0}^{I} v_{k,i}^g t^i$$

we must be able to specify explicitly presence of these various terms using κ_k. The presence of the record $v_{k,i}^g$ in this directory is ensured if the condition

$$F_i(\kappa_k) = 1$$

is satisfied, with $F_i(\kappa_k)$ being defined in terms of the modulo function mod as follows

$$F_i(\kappa_k) = \frac{\kappa_k}{2^i} \bmod 2$$

We will describe later in this section how the different terms $v_{k,i}^g$ are stored for $i = 1, I$. Here we will first consider the more usual case where constant vector reactions are stored on the isotopic directory. Moreover, the maximum value of I permitted for each isotope is specified by N_p as defined in Section 4.1. (Release 3.04)

Table 51: Isotopic vector reaction records

Name	Type	Condition	Units	Comment
TOTAL$\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup$	R(G)	$F_0(\kappa_1)=1$	b	The multigroup total cross section σ^g
TRANC$\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup$	R(G)	$F_0(\kappa_2)=1$	b	The multigroup transport correction σ_{tc}^g
NUSIGF$\sqcup\sqcup\sqcup\sqcup\sqcup\sqcup$	R(G)	$F_0(\kappa_3)=1$	b	The product of σ_f^g, the multigroup fission cross section with ν^g, the averaged number of neutron produced per fission, $\nu\sigma_f^g$

continued on next page

Isotopic vector reaction records continued from last page

Name	Type	Condition	Units	Comment
NFTOT␣␣␣␣␣␣␣	R(G)	$F_0(\kappa_4)=1$	b	The multigroup fission cross section σ_f^g
CHI␣␣␣␣␣␣␣␣	R(G)	$F_0(\kappa_5)=1$		The multigroup energy spectrum of the neutron emitted by fission χ^g
NU␣␣␣␣␣␣␣␣␣	R(G)	$F_0(\kappa_6)=1$		The multigroup averaged number of neutron produced per fission ν^g
NG␣␣␣␣␣␣␣␣␣	R(G)	$F_0(\kappa_7)=1$	b	The multigroup neutron capture cross section σ_c^g
NHEAT␣␣␣␣␣␣	R(G)	$F_0(\kappa_8)=1$	MeV b	The product of σ_f^g, the multigroup fission cross section with H^g, the averaged energy emitted per fission, $H\sigma_f^g$
N2N␣␣␣␣␣␣␣␣	R(G)	$F_0(\kappa_9)=1$	b	The multigroup cross section $\sigma^g_{(n,2n)}$ for the reaction ${}^A_Z X + n \rightarrow {}^{A-1}_{Z} X + 2n$
N3N␣␣␣␣␣␣␣␣	R(G)	$F_0(\kappa_{10})=1$	b	The multigroup cross section $\sigma^g_{(n,3n)}$ for the reaction ${}^A_Z X + n \rightarrow {}^{A-2}_{Z} X + 3n$
N4N␣␣␣␣␣␣␣␣	R(G)	$F_0(\kappa_{11})=1$	b	The multigroup cross section $\sigma^g_{(n,4n)}$ for the reaction ${}^A_Z X + n \rightarrow {}^{A-3}_{Z} X + 4n$
NP␣␣␣␣␣␣␣␣␣	R(G)	$F_0(\kappa_{12})=1$	b	The multigroup cross section $\sigma^g_{(n,p)}$ for the reaction ${}^A_Z X + n \rightarrow {}^{A}_{Z-1} X + p$
NA␣␣␣␣␣␣␣␣␣	R(G)	$F_0(\kappa_{13})=1$	b	The multigroup cross section $\sigma^g_{(n,\alpha)}$ for the reaction ${}^A_Z X + n \rightarrow {}^{A-3}_{Z-2} X + \alpha$
GOLD␣␣␣␣␣␣␣	R(G)	$F_0(\kappa_{14})=1$		The multigroup Goldstein–Cohen parameters λ^g
ABS␣␣␣␣␣␣␣␣	R(G)	$F_0(\kappa_{15})=1$	b	The multigroup absorption cross section σ_a^g
NWT0␣␣␣␣␣␣␣	R(G)	$F_0(\kappa_{16})=1$	$\mathrm{s}^{-1}\mathrm{cm}^{-2}$	The multigroup weighted neutron flux spectrum, ϕ_w^g
STRD␣␣␣␣␣␣␣	R(G)	$F_0(\kappa_{17})=1$	b	The multigroup transport cross section homogenized over all directions σ_{tr}^g
STRD␣X␣␣␣␣␣	R(G)	$F_0(\kappa_{18})=1$	b	The X directed multigroup transport cross section $\sigma_{tr,x}^g$
STRD␣Y␣␣␣␣␣	R(G)	$F_0(\kappa_{19})=1$	b	The Y directed multigroup transport cross section $\sigma_{tr,y}^g$
STRD␣Z␣␣␣␣␣	R(G)	$F_0(\kappa_{20})=1$	b	The Z directed multigroup transport cross section $\sigma_{tr,z}^g$

The multigroup scattering cross section matrix, which gives the probability for a neutron in group h to appear in group g after a collision with this isotope is represented by the form:

$$\sigma_s^{h\rightarrow g}(\vec{\Omega}\rightarrow\vec{\Omega}') = \sum_{l=0}^{L}\frac{2l+1}{4\pi}P_l(\vec{\Omega}\cdot\vec{\Omega}')\sigma_l^{h\rightarrow g} = \sum_{l=0}^{L}\sum_{m=-l}^{l} Y_l^m(\vec{\Omega})Y_l^m(\vec{\Omega}')\sigma_l^{h\rightarrow g}$$

using a spherical harmonic series expansion to order L. Assuming these spherical harmonic are orthonormalized, namely:

$$\int_{4\pi} d^2\Omega Y_l^m(\vec{\Omega})Y_{l'}^{m'}(\vec{\Omega}) = \delta_{m,m'}\delta_{l,l'}$$

we can define $\sigma_l^{h\to g}$ in terms of $\sigma_s^{h\to g}(\vec{\Omega}\to\vec{\Omega}')$ using the following integral:

$$\sigma_l^{h\to g} = \int_{4\pi} d^2\Omega \sigma_s^{h\to g}(\vec{\Omega}\to\vec{\Omega}')P_l(\vec{\Omega}\cdot\vec{\Omega}')$$

Note that this definition of $\sigma_l^{h\to g}$ is not unique and some authors include the factor $2l+1$ directly in different angular moments of the scattering cross section.

Here instead of storing on the these $G\times G$ matrices $\sigma_l^{h\to g}$, a vector which contains a compress form for this matrix will be considered. This choice is justified by the fact that the number of energy groups which will lead to scattering in a specific group is generally relatively small compared to the total number of groups in the library and that these groups are clustered around the final energy group. Here we will first define two different integer vectors n_l^g and h_l^g for each order in the scattering cross section and for each final energy group g which will contain respectively the number of successive initial energy groups for which the scattering cross section does not vanish and the maximum energy group number for which scattering to the final group g does not vanishes. Accordingly, for a scattering cross section of the form:

$\sigma_0^{h\to g}$	$g=1$	$g=2$	$g=3$	$g=4$
$h=1$	a_1	a_2	0	0
$h=2$	0	a_3	a_4	a_5
$h=3$	0	a_6	a_7	0
$h=4$	0	a_8	0	a_9
h_0^g	1	4	3	4
n_0^g	1	4	2	3

The compress scattering matrix will then contain the following information:

$$\sigma_{l,c} = \left(\sigma_l^{h^1\to 1}, \sigma_l^{h^1-1\to 1}, \ldots, \sigma_l^{h^1-n_1+1\to 1}, \sigma_l^{h^2\to 2}, \ldots, \sigma_l^{h^G-n_G+1\to G}\right)$$

which for the example above leads to

$$\sigma_{l,c} = (a_1, a_8, a_6, a_3, a_2, a_7, a_4, a_9, 0, a_5)$$

As a result $\sigma_l^{h\to g}$ can be reconstructed using

$$\sigma_l^{h\to g} = \begin{cases} 0 & \text{if} \quad h > h_l^g \\ 0 & \text{if} \quad h < h_l^g - n_l^g + 1 \\ \sigma_{l,c}^k & \text{otherwise} \quad k = \sum_{h=1}^{g-1} n_l^h + h_l^g - h + 1 \end{cases}$$

Finally, we will also save the total scattering cross section vector of order l which is defined as

$$\sigma_{l,s}^h = \sum_{g=1}^{G} \sigma_l^{h\to g}$$

In the case where only the order $l=0$ moment of scattering cross section is non vanishing (isotropic scattering) the following records can be found on the isotopic directory.

Table 52: Optional scattering records

Name	Type	Condition	Units	Comment
`SIGS␣0␣␣␣␣␣␣`	R(G)	$F_0(\kappa_{21}) = 1$	b	The isotropic component ($l = 0$) of the multigroup total scattering cross section $\sigma^g_{0,s}$
`IJJ␣␣0␣␣␣␣␣␣`	I(G)	$F_0(\kappa_{21}) = 1$		Highest energy group number for which the isotropic component of the scattering cross section to group g does not vanish, h^g_0
`NJJ␣␣0␣␣␣␣␣␣`	I(G)	$F_0(\kappa_{21}) = 1$		Number of energy groups for which the isotropic component of the scattering cross section to group g does not vanish, n^g_0
`SCAT␣0␣␣␣␣␣␣`	R($\sum_{g=1}^{G} n^g_0$)	$F_0(\kappa_{21}) = 1$	b	Compressed isotropic component of the scattering matrix $\sigma^k_{0,c}$

If the scattering cross section is expanded to order $L \neq 0$ in legendre polynomials, additional set of scattering records similar to those described above will be present in the case where the condition

$$F_0(\kappa_{21+l}) = 1$$

is satisfied. The first four character and last 6 characters in the names of these records will again be identical to those described above while character 5 and 6 will differ from level to level. For example, the order $l = 5$ compressed scattering matrix will be identified by `SCAT␣5␣␣␣␣␣␣` while for order $l = 50$ we will use `SCAT50␣␣␣␣␣␣`.

Finally, consider the case where higher order time dependent perturbations are considered, for example order $I = 2$. In this case, the first and second order correction record corresponding to κ_k will be present in the directory if the condition:

$$F_i(\kappa_k) = 1$$

is satisfied for $i = 1$ and $i = 2$. The name associated with these records will be similar to that of the time independent contribution to this record except that last three characters (`␣␣␣`) are replaced by `LIN` for $i = 1$ and `QUA` for $i = 2$. Moreover the units associated with each of the real records will be multiplied respectively by d^{-1} and d^{-2} (assuming t in the power series expansion is given in days). For example, assuming $L = 1$ and $I = 1$, for an isotope with only total and scattering cross sections, we will find the following records on the directory.

Table 53: Example of isotopic cross section records for $L = 1$ and $I = 1$

Name	Type	Condition	Units	Comment
`TOTAL␣␣␣␣␣␣␣`	R(G)	$F_0(\kappa_1) = 1$	b	The multigroup total cross section σ^g
`TOTAL␣␣␣␣LIN`	R(G)	$F_1(\kappa_1) = 1$	d^{-1}b	The first order perturbation in the multigroup total cross section $\Delta(\sigma^g)$
`SIGS␣0␣␣␣␣␣␣`	R(G)	$F_0(\kappa_{21}) = 1$	b	The isotropic component ($l = 1$)of the multigroup total scattering cross section $\sigma^g_{0,s}$

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Example of isotopic cross section records for $L = 1$ and $I = 1$ continued from last page

Name	Type	Condition	Units	Comment
`SIGS␣0␣␣␣LIN`	R(G)	$F_1(\kappa_{21}) = 1$	$d^{-1}b$	The first order perturbation in the isotropic component of the multigroup total scattering cross section $\Delta(\sigma^g_{0,s})$
`IJJ␣␣0␣␣␣␣␣`	I(G)	$F_0(\kappa_{21}) = 1$		Highest energy group number for which the isotropic component of the scattering cross section to group g does not vanishes, h^g_0
`IJJ␣␣0␣␣␣LIN`	I(G)	$F_1(\kappa_{21}) = 1$		Highest energy group number for which the first order perturbation in the isotropic component of the scattering cross section to group g does not vanishes, $h^g_{0,1}$
`NJJ␣␣0␣␣␣␣␣`	I(G)	$F_0(\kappa_{21}) = 1$		Number of energy groups for which the isotropic component of the scattering cross section to group g does not vanishes, n^g_0
`NJJ␣␣0␣␣␣LIN`	I(G)	$F_1(\kappa_{21}) = 1$		Number of energy groups for which the first order perturbation in the isotropic component of the scattering cross section to group g does not vanishes, $n^g_{0,1}$
`SCAT␣0␣␣␣␣␣`	R($\sum_{g=1}^{G} n^g_0$)	$F_0(\kappa_{21}) = 1$	b	Compressed isotropic component of the scattering matrix $\sigma^k_{0,c}$
`SCAT␣0␣␣␣LIN`	R($\sum_{g=1}^{G} n^g_{0,1}$)	$F_1(\kappa_{21}) = 1$	$d^{-1}b$	Compressed first order perturbation in the isotropic component of the scattering matrix $\Delta(\sigma^k_{0,c})$
`SIGS␣1␣␣␣␣␣`	R(G)	$F_0(\kappa_{22}) = 1$	b	The linearly anisotropic component ($l = 1$) of the multigroup total scattering cross section $\Delta\sigma^g_{1,s}$
`SIGS␣1␣␣␣LIN`	R(G)	$F_1(\kappa_{22}) = 1$	$d^{-1}b$	The first order perturbation in the linearly anisotropic component of the multigroup total scattering cross section $\Delta\sigma^g_{1,s}$
`IJJ␣␣1␣␣␣␣␣`	I(G)	$F_0(\kappa_{22}) = 1$		Highest energy group number for which the linearly anisotropic component of the scattering cross section to group g does not vanishes, h^g_1
`IJJ␣␣1␣␣␣LIN`	I(G)	$F_1(\kappa_{22}) = 1$		Highest energy group number for which the first order perturbation in the linearly anisotropic component of the scattering cross section to group g does not vanishes, $h^g_{1,1}$
`NJJ␣␣1␣␣␣␣␣`	I(G)	$F_0(\kappa_{22}) = 1$		Number of energy groups for which the linearly anisotropic component of the scattering cross section to group g does not vanishes, n^g_1

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Example of isotopic cross section records for $L = 1$ and $I = 1$ continued from last page

Name	Type	Condition	Units	Comment
`NJJ␣␣1␣␣␣LIN`	I(G)	$F_1(\kappa_{22}) = 1$		Number of energy groups for which the first order perturbation in the linearly anisotropic component of the scattering cross section to group g does not vanishes, $n^g_{1,1}$
`SCAT␣1␣␣␣␣␣␣`	R($\sum_{g=1}^{G} n^g_1$)	$F_0(\kappa_{22}) = 1$	b	Compressed linearly anisotropic component of the scattering matrix $\sigma^k_{1,c}$
`SCAT␣1␣␣␣LIN`	R($\sum_{g=1}^{G} n^g_{1,1}$)	$F_1(\kappa_{22}) = 1$	d^{-1}b	Compressed first order perturbation in the linearly anisotropic component of the scattering matrix $\Delta(\sigma^k_{1,c})$

Note that most of these cross sections are not required to perform a cell calculation in DRAGON. In fact, in the DRAGON transport calculation, only σ^g, σ^g_{tc}, $\nu\sigma^g_f$, χ^g and the isotropic and linearly anisotropic scattering matrix are used. For burnup calculations, depending on the depletion chain prescribed (either on the WIMS–AECL or WIMS–D4 format libraries or as an input to DRAGON) the following cross sections may be required: σ^g_f, σ^g_c, $\sigma^g_{(n,2n)}$, $\sigma^g_{(n,3n)}$, $\sigma^g_{(n,4n)}$, $\sigma^g_{(n,p)}$, $\sigma^g_{(n,\alpha)}$. Finally, when editing isotopic cross sections, all the cross sections types in the library will be processed.

A final note on the use of the transport correction and the homogenized and directional transport cross section. In DRAGON, the transport correction cross section is used to correct the total and isotropic scattering cross section using the relations

$$\begin{aligned} \sigma^g_c &= \sigma^g - \sigma^g_{tc} \\ \sigma^{g\to g}_{c,0} &= \sigma^{g\to g}_0 - \sigma^g_{tc} \end{aligned}$$

On the other hand the so-called homogeneous and directional transport cross section obtained using

$$\begin{aligned} \sigma^g_{tr} &= (3D^g_h)^{-1} \\ \sigma^g_{tr,x} &= (3D^g_x)^{-1} \\ \sigma^g_{tr,y} &= \left(3D^g_y\right)^{-1} \\ \sigma^g_{tr,z} &= (3D^g_z)^{-1} \end{aligned}$$

where the diffusion coefficients are computed in the editing module for the case where the homogeneous and/or directional diffusion coefficients are known (from an homogeneous or heterogeneous buckling calculation in the flux module of DRAGON). If a transport calculation without leakage was performed in DRAGON, an approximate diffusion coefficients given by

$$D^g_h = \left(\frac{1}{3(\sigma^g - \sigma^g_{1,s})}\right)$$

will be used to compute σ^g_{tr}.

14 CONTENTS OF A /ISOFBM/ DIRECTORY

(Release 3.03)

Most of the records found in an /isotope/ directory now becomes sub-directories in a FBMXSDB isotope directory.

Table 54: Isotopic vector reaction sub-directory

Name	Type	Condition	Units	Comment
TOTAL␣␣␣␣␣␣␣	Dir			The multigroup total cross section sub-directory
NUSIGF␣␣␣␣␣␣	Dir			The sub-directory where the product of σ_f^g, the multigroup fission cross section with ν^g, the averaged number of neutron produced per fission is stored
NFTOT␣␣␣␣␣␣␣	Dir			The multigroup fission cross section sub-directory
CHI␣␣␣␣␣␣␣␣	Dir			The multigroup energy spectrum of the neutron emitted by fission sub-directory
STRD␣␣␣␣␣␣␣	Dir			The multigroup transport cross section sub-directory
H-FACTORS␣␣␣	Dir			The sub-directory containing the product of the macroscopic and microscopic fission cross-section times the energy recovered by fission

The multigroup scattering cross section matrix are again stored in a format similar to that described in Section 13. The main difference here is that SCAT␣0␣␣␣␣␣ and SCAT␣1␣␣␣␣␣ now represent sub-directories rather than records. We will therefore have:

Table 55: Scattering records and sub-directories

Name	Type	Condition	Units	Comment
IJJ␣0␣␣␣␣␣␣	I(G)			Highest energy group number for which the isotropic component of the scattering cross section to group g does not vanish, h_0^g
NJJ␣0␣␣␣␣␣␣	I(G)			Number of energy groups for which the isotropic component of the scattering cross section to group g does not vanish, n_0^g
SCAT␣0␣␣␣␣␣	Dir			The sub-directory containing the compressed isotropic component of the scattering matrix

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Scattering records and sub-directories continued from last page

Name	Type	Condition	Units	Comment
`IJJ␣1␣␣␣␣␣␣␣`	I(G)	$\mathcal{P}_3 > 1$		Highest energy group number for which the isotropic component of the scattering cross section to group g does not vanish, h_1^g
`NJJ␣1␣␣␣␣␣␣␣`	I(G)	$\mathcal{P}_3 > 1$		Number of energy groups for which the isotropic component of the scattering cross section to group g does not vanish, n_1^g
`SCAT␣1␣␣␣␣␣␣`	Dir	$\mathcal{P}_3 > 1$		The sub-directory containing the compressed linearly anisotropic component of the scattering matrix

Finally each of the above cross section directory will contain the following information:

Table 56: Cross section sub-directories

Name	Type	Condition	Units	Comment
`REF␣␣␣␣␣␣␣␣␣`	R(N_x)			Reference cross section
`D1C␣␣␣␣␣␣␣␣␣`	R(N_x)			First order coolant density feedback coefficients
`D2C␣␣␣␣␣␣␣␣␣`	R(N_x)			Second order coolant density feedback coefficients
`D1M␣␣␣␣␣␣␣␣␣`	R(N_x)			First order moderator density feedback coefficients
`D2M␣␣␣␣␣␣␣␣␣`	R(N_x)			Second order moderator density feedback coefficients
`T1C␣␣␣␣␣␣␣␣␣`	R(N_x)			First order coolant temperature feedback coefficients
`T2C␣␣␣␣␣␣␣␣␣`	R(N_x)			Second order coolant temperature feedback coefficients
`T1M␣␣␣␣␣␣␣␣␣`	R(N_x)			First order moderator temperature feedback coefficients
`T2M␣␣␣␣␣␣␣␣␣`	R(N_x)			Second order moderator temperature feedback coefficients
`T1F␣␣␣␣␣␣␣␣␣`	R(N_x)			First order fuel temperature feedback coefficients
`T2F␣␣␣␣␣␣␣␣␣`	R(N_x)			Second order fuel temperature feedback coefficients
`BOR␣␣␣␣␣␣␣␣␣`	R(N_x)			Boron concentration feedback coefficient
`NP239␣␣␣␣␣␣␣␣`	R(N_x)			$^{239}\mathrm{Np}$ concentration feedback coefficient
`SM149␣␣␣␣␣␣␣␣`	R(N_x)			$^{149}\mathrm{Sm}$ concentration feedback coefficient
`XEN␣␣␣␣␣␣␣␣␣`	R(N_x)			$^{135}\mathrm{Xe}$ concentration feedback coefficient

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Cross section sub-directories continued from last page

Name	Type	Condition	Units	Comment
FPC1␣␣␣␣␣␣␣␣	R(N_x)			First order pseudo-fissile isotope concentration feedback coefficient
FPC2␣␣␣␣␣␣␣␣	R(N_x)			Second order pseudo-fissile isotope concentration feedback coefficient
MIXFD␣␣␣␣␣␣␣␣	R(N_x)			Mixed density/temperature feedback coefficient for coolant

Note that in the above $N_x = G$ when vector cross sections are considered while $N_x = \sum_{g=1}^{G} n_i^g$ for scattering cross sections.

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