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SLAROM-UF : Ultra Fine Group Cell Calculation Code for Fast Reactor - Version 20090113 -

(Translated Document)

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SLAROM-UF: Ultra Fine Group Cell Calculation Code for Fast Reactor

− Version 20090113 −

(Translated Document)

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SLAROM-UF is a cell calculation code for fast reactors to produce effective cross sections with high accuracy in practical computing time, taking full advantage of fine and ultra-fine group calculation schemes.

The fine group calculation scheme covers the whole energy range in a maximum of 900-group structure. Its group structure is finer above 52.5keV with a minimum lethargy width of 0.008. Effective cross sections are evaluated based on the Bondarenko method (background cross section method). The background cross section in a heterogeneous cell is approximately evaluated by the Tone method. The ultra-fine group calculation scheme covers the energy range below about 52.5keV. Its group structure is so fine (∼100,000 groups) as to treat resonance peaks as they are. Effective cross sections are calculated by solving an integral slowing down equation effectively, focusing only on elastic scattering and absorption reactions. Temperature can be specified freely by a user in the input data. The effective cross sections thus obtained are combined to calculate cell averaged cross sections.

SLAROM-UF is a successor of the SLAROM code and all of the original functionalities are incorporated. It works independently but works best with the fast reactor neutronics analysis code system JOINT-FR.

Keywords: SLAROM-UF, Fast Reactor, Cell Calculation, Ultra-Fine Group

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SLAROM-UF: 高速炉超微細群格子計算コード

－ Version 20090113 －
（翻訳資料）

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SLAROM-UF は高速炉用格子計算コードであり、詳細群計算と超微細群計算を組み合わせることにより実用的な計算時間で高精度な計算を実現する。

詳細群計算は全エネルギー範囲に対して自己遮へいテーブルを用いて実効断面積を評価する。非均質体系では東稔の方法が適用できる。ライブラリには 70 群、175 群、900 群のものが標準装備されている。900 群ライブラリは 52.5keV 以上でレサジー幅を 0.008 程度に細分したエネルギー群構造を有する。

超微細群計算は 52.5keV 以下で共鳴構造をほぼ再現できる詳細群構造（約 10 万群）を有し、弾性散乱と吸収反応に特化した積分型減速方程式を解くことにより効率的に厳密な中性子スペクトルを求め、実効断面積を得る。温度はユーザーにより任意に設定できる。

超微細群計算で得られた実効断面積は詳細群計算に反映され、詳細群構造の計算により格子平均断面積が求められる。900 群の詳細計算と超微細群計算を合わせて使用すれば全エネルギー範囲で連続エネルギーモンテカルロ法と同等の精度で実効断面積を得ることができる。

SLAROM-UF は格子計算コード SLAROM の後継であり、その機能をすべて兼ね備えるとともに高速炉解析システム JOINT-FR で利用するためのインターフェースも装備されている。

本報告書は 2004 年 3 月に発行された報告書（JNC TN9520 2004-001）の翻訳であり、翻訳は OECD/NEA の支援を受けて行われたものである。

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Contents

目 次

List of Tables

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1. Introduction

This document is a user's manual for SLAROM-UF: ultra fine group cell calculation code for fast reactors, Version 20081105.

SLAROM-UF is a cell calculation code for fast reactors to produce effective cross sections with high accuracy in practical computing time, taking full advantage of fine and ultra-fine (UF) group calculation schemes.

The fine group calculation scheme covers the whole energy range in a maximum of 900-group structure. The structure is finer above 52.5keV with a minimum lethargy width of 0.008. Effective cross sections are evaluated based on the Bondarenko method (background cross sec ton method). The background cross section in a heterogeneous cell is approximately evaluated by the Tone method.

The ultra-fine group calculation scheme covers the energy range below about 50keV. Its group structure is so fine (~100,000 groups) as to treat resonance peaks as they are. Effective cross sections are calculated by solving an integral slowing down equation effectively focusing only on elastic scattering and absorption. Temperature can be defined freely in the calculation.

The effective cross sections thus obtained are combined and used in the flux calculation.

SLAROM-UF has been developed from the SLAROM[1)] code and all of the original functionalities are incorporated. It works independently but works best with the fast reactor neutronics analysis code system JOINT-FR[2)].

Major features included in SLAROM-UF are:

1 heterogeneous cell treatment by Tone method[3)]

2 an ultra-fine group calculation option[4)]

3 reaction rate (or rate ratio) preservation method[5)]

4 current defined by TIBERE method[6)]

5 fine group (175, and 900) calculation capability

6 incident energy dependent fission spectrum

7 higher PL order scattering cross sections.

Some of the above features are described in the next Section.

2. Major Features

2.1 Tone Method

The Tone method is employed to evaluate the background cross section in a heterogeneous cell.
Starting from the integral neutron balance equation

$$\Sigma_{i,t}(u)\Phi_i(u)V_i = \sum_j \left[P_{j\to i}\left(u\right)V_j S_j(u)\right], \tag{2.1.1}$$

we introduce an approximation

$$\frac{P_{j\to i}\left(u\right)}{\Sigma_{i,t}(u)} \approx f_i(u)\frac{P^g_{j\to i}}{\Sigma^g_{i,t}}, \tag{2.1.2}$$

where u is the lethargy, Φ is the flux, V is the volume, Σ_x is the macroscopic cross section for reaction x, $P_{j\to i}$ is the probability for a neutron born in region j to have its first collision in region i, and τ is the neutron source term. The subscript "i" and "j" denote that the values are on the corresponding regions.

Equation (2.1.2) is based on the assumption that the ratio varies slowly with lethargy considering $P_{j\to i}(u)$ is a function of $\Sigma_{i,t}(u)$, thus does not depend on the region j.

Using the reciprocity relation

$$P_{i\to j}\left(u\right)\Sigma_{i,t}(u)V_i = P_{j\to i}\left(u\right)\Sigma_{j,t}(u)V_j, \tag{2.1.3}$$

Equation (2.1.2) becomes

$$P^g_{j\to i}V_j\Sigma_{j,t}(u)f_i(u) \quad = \quad P_{i\to j}\left(u\right)\Sigma^g_{i,t}V_i. \tag{2.1.4}$$

Taking summation over region j and using the normalization condition, $\sum_j P_{i\to j}\left(u\right) = 1$, we obtain

$$f_i(u) \quad = \quad \frac{V_i\Sigma^g_{i,t}}{\sum_j \left[P^g_{j\to i}V_j\Sigma_{j,t}(u)\right]}. \tag{2.1.5}$$

Substituting Eq. (2.1.2) to Eq. (2.1.1), and assuming the source term $S_j(u)$ is constant within a group, we obtain

$$\Phi_i(u) \quad = \quad f_i(u)\sum_j \left[\frac{V_j P^g_{j\to i}}{V_i\Sigma^g_{i,t}}\tau^g_j\right]. \tag{2.1.6}$$

In this expression, the lethargy dependence of the flux is determined by f_i:

$$\Phi_i(u) \quad \propto \quad \frac{1}{\sum_j \left[P^g_{j\to i}V_j\Sigma_{j,t}(u)\right]}. \tag{2.1.7}$$

Expressing $\Sigma_{j,t}$ by a resonance term and the moderator term

$$\Sigma_{j,t}(u) = N_{0,j}\sigma_{0,t}(u) + \Sigma^g_{m,j,t}, \tag{2.1.8}$$

we obtain the relation

$$\Phi_i(u) \quad \propto \quad \frac{1}{\sigma_{0,t}(u) + \sigma^g_{Tone,b,i}}, \tag{2.1.9}$$

where

$$\sigma^g_{Tone,b,i} \quad = \quad \frac{\sum_j \left[P^g_{j\to i}V_j\Sigma^g_{m,j,t}\right]}{\sum_j \left[P^g_{j\to i}V_j N_{0,j}\right]}. \tag{2.1.10}$$

Equation (2.1.9) has the same form as the NR approximation

$$\Phi\left(u\right) \propto \frac{1}{\sigma_{0,t}\left(u\right) + \sigma_b} \tag{2.1.11}$$

and the equivalent background cross section is evaluated by Eq. (2.1.10).

Then the effective cross sections are obtained by interpolating $\sigma^g_{b,i}$ in the background cross sections.

2.2 UF Calculation

The ultra-fine (UF) calculation option solves the integral slowing down equation in an ultra fine group structure using the recurrence formula developed by Kier[7]. The slowing down property is considered only by the elastic scattering. The calculation is applied over the energy range below about 50keV.

When only the elastic scattering is considered, the source term in Eq. (2.1.1) is written as

$$S_j(u) = \sum_k \int_{u-\varepsilon_k}^{u} \Sigma_{k,s}(u') \frac{exp(u'-u)}{1-\alpha_k} \Phi_j(u') du', \tag{2.2.1}$$

where k is the nuclide, $\alpha = \left(\frac{A-1}{A+1}\right)^2$ (A: the atomic mass), and ε is the maximum lethargy gain ($\varepsilon = -\ln\alpha$).

Substituting Eq.(2.2.1) into Eq. (2.1.1), and letting $\varphi_i(u) = \Phi_i(u) V_i exp(u)$, we obtain

$$\Sigma_{t,i}(u)\varphi_i(u) = \sum_j P_{j\to i}(u) \sum_k \frac{1}{1-\alpha_k} \int_{u-\varepsilon_k}^{u} \Sigma_{k,s}(u')\varphi_j(u')\, du'. \tag{2.2.2}$$

Integrating over an energy group g ($u_{g+} \sim u_{g-}$; u_{g+} and u_{g-} are the lethargy boundaries of group g and $u_{g-} > u_{g+}$), and assuming $\Sigma_{t,i}$, φ_i, and $P_{j\to i}$ are constant within the group, we get

$$\Sigma_{t,i,g}\varphi_{i,g} = \sum_j P_{j\to i,g} \sum_k S_{k,j,g}. \tag{2.2.3}$$

$S_{k,j,g}$ is expressed as

$$S_{k,j,g} = \frac{1}{1-\alpha_k} \int_{u_{g+}}^{u_{g-}} \int_{u-\varepsilon_k}^{u} \Sigma_{k,s}(u')\varphi_j(u')\, du' du \tag{2.2.4}$$

$$= \frac{1}{1-\alpha_k} \int_{u_{g+}}^{u_{g-}} \left(\int_{u-\varepsilon_k}^{u_{g-}-\varepsilon_k} \Sigma_{k,s}(u')\varphi_j(u')\, du' + \int_{u_{g-}-\varepsilon_k}^{u_{g+}} \Sigma_{k,s}(u')\varphi_j(u')\, du' + \int_{u_{g-}-\varepsilon_k}^{u_{g+}} \Sigma_{k,s}(u')\varphi_j(u')\, du' \right) du. \tag{2.2.5}$$

Since the group structure is so fine that the 1st and the 3rd terms in the right hand side are negligible, thus

$$S_{k,j,g} \approx \frac{1}{1-\alpha_k} \int_{u_{g+}}^{u_{g-}} \int_{u_{g-}-\varepsilon_k}^{u_{g+}} \Sigma_{k,s}(u')\varphi_j(u')\, du' du \tag{2.2.6}$$

$$= \frac{\Delta u_g}{1-\alpha_k} \int_{u_{g-}-\varepsilon_k}^{u_{g+}} \Sigma_{k,s}(u')\varphi_j(u')\, du' \tag{2.2.7}$$

Then

$$\frac{S_{k,j,g}}{\Delta u_g} - \frac{S_{k,j,g-1}}{\Delta u_{g-1}} = \frac{1}{1-\alpha_k} \left(\int_{u_{(g-1)+}}^{u_{g+}} \Sigma_{k,s}(u')\varphi_j(u')\, du' + \int_{u_{(g-1)-}-\varepsilon_k}^{u_{g-}-\varepsilon_k} \Sigma_{k,s}(u')\varphi_j(u')\, du' \right) \tag{2.2.8}$$

$$= \frac{1}{1-\alpha_k} \left(\int_{u_{(g-1)+}}^{u_{(g-1)-}} \Sigma_{k,s}(u')\varphi_j(u')\, du' - \int_{u_{(g-1)+}-\varepsilon_k}^{u_{(g-1)-}-\varepsilon_k} \Sigma_{k,s}(u')\varphi_j(u')\, du' \right) \tag{2.2.9}$$

$$\approx \frac{1}{1-\alpha_k} \left(\Sigma_{k,s,g-1}\varphi_{j,g-1} - \Sigma_{k,s,g-1-\mathrm{L}_k}\varphi_{j,g-1-\mathrm{L}_k} \right), \tag{2.2.10}$$

where L_k is the number of groups which corresponds to the maximum lethargy gain.

$$\frac{S_{k,j,g}}{\Delta u_g} - \frac{S_{k,j,g-1}}{\Delta u_{g-1}} = \frac{1}{1-\alpha_k} \left(\Sigma_{k,s.,g-1}\varphi_{j,g-1} - \Sigma_{k,s.,g-1-\mathrm{I}}\varphi_{j,g-1-\mathrm{I}} \right) \tag{2.2.11}$$

SLAROM-UF solves Eq. (2.2.3) in an ultra-fine group structure (about 100,000 group) below about 50keV. The scatteing rate in Eq.(2.2.11) is approximated by the intermediate group scattering rate (about 10,000 groups).

SLAROM-UF uses the PENDF data library (about 250,000 points) named "PMCROSS", from which the 100,000 group cross section data (named "User MCROSS" (UMCROSS)) are generated in SLAROM-UF for a user-specified temperature.

The group structure of UMCROSS library is listed in Table 2.2.1.

Table 2.2.1 Energy structure of UF calculation

Energy region number	Upper boundary (eV)	Number of energy groups[a)]	Lethagy width($\times 10^{-5}$)
1	5.24752×10^4	56000	3.125
2	9.11882×10^3	12000	6.250
3	4.30743×10^3	12000	12.500
4	9.61117×10^2	8000	25.000
5	1.30073×10^2	12000 (14000)	50.000
Total		100,000(10,2000)	

a) The lowerst energy boundary depends on the energy structure of the fine group libraries. The values are on the 70 group library with the lowerst energy boundary 3.22419×10^{-1}eV and those in parentheses are on the 175 or 900 group library with 1.18611×10^{-1}eV.

Thus calculated neutron flux in the ultra-fine group structure is used to obtain effective cross sections in the group structure specified in the fine group calculation step. Cross sections replaced are on capture, fission, elastic scattering, and elastic removal reactions.

2.3 RRRP Method

In the RRRP module, the RRRP method (Reaction Rate Ratio Preservation method) and the RRP method (Reaction Rate Preservation method) are available.

2.3.1 RRRP method

The RRRP method adjusts a homogenized cross section in regions R_1, $\Sigma_{R_1}^{hom}$, to preserve the ratio of the reaction rate in a region R_2 (surrounding the regions R_1) to that in the regions R_1, before and after the homogenization, that is,

$$\underbrace{\frac{\int_{R_2}\Sigma_{R_2}(r)\,\Phi^{hom}(r)\,dr}{\int_{R_1}\Sigma_{R_1}^{hom}\Phi^{hom}(r)\,dr}}_{After\ homogenization}=\underbrace{\frac{\int_{R_2}\Sigma_{R_2}(r)\,\Phi^{het}(r)\,dr}{\int_{R_1}\Sigma_{R_1}(r)\,\Phi^{het}(r)\,dr}}_{Before\ homogenization}, \tag{2.3.1}$$

where the superscripts *het* and *hom* mean that the values are thoes before and after the homogenization, respectively.

Then the homogenized cross section $\Sigma_{R_1}^{hom}$ is obtained by

$$\Sigma_{R_1}^{hom}=\frac{\int_{\mathrm{R}_2}\Sigma_{R_2}(r)\,\Phi^{hom}(r)\,dr}{\int_{\mathrm{R}_1}\Phi^{hom}(r)\,dr}\cdot\frac{\int_{R_1}\Sigma_{R_1}(r)\,\Phi^{het}(r)\,dr}{\int_{R_2}\Sigma_{R_2}(r)\,\Phi^{het}(r)\,dr} \tag{2.3.2}$$

The flux after the homogenization, Φ^{hom}, is unknown and need to solve the Pij equation which uses $\Sigma_{R_1}^{hom}$. Then an iteration procedure is employed.

$$\Sigma_{R_1}^{hom(n+1)}=\frac{\int_{\mathrm{R}_2}\Sigma_{R_2}(r)\,\Phi^{hom(n)}(r)\,dr}{\int_{\mathrm{R}_1}\Phi^{hom(n)}(r)\,dr}\cdot\frac{\int_{R_1}\Sigma_{R_1}(r)\,\Phi^{het}(r)\,dr}{\int_{R_2}\Sigma_{R_2}(r)\,\Phi^{het}(r)\,dr} \tag{2.3.3}$$

At the beginning (n=1) of the iteration, $\Sigma_{R_1}^{hom(1)}$is obtained from the normal averaging procedure and $\Phi^{hom(1)}$ is calculated. Then $\Sigma_{R_1}^{hom(2)}$ is obtained and $\Phi^{hom(2)}$ is calculated.

The iteration continues until the change in $\Sigma_{R_1}^{hom(n)}$ becomes smaller than the specified error criterion.

2.3.2 RRP method

The RRP method is similar to the RRRP method but preserve the absolute reaction rate RR in the homogenized regions.

$$\int_{R_1}\Sigma_{R_1}^{hom}\Phi^{hom}(r)\,dr=\int_{R_1}\Sigma_{R_1}(r)\,\Phi^{het}(r)\,dr \tag{2.3.4}$$

Then the homogenized cross section $\Sigma_{R_1}^{hom}$ is obtained by

$$\Sigma_{R_1}^{hom}=\frac{\int_{R_1}\Sigma_{R_1}(r)\,\Phi^{het}(r)\,dr}{\int_{\mathrm{R}_1}\Phi^{hom}(r)\,dr} \tag{2.3.5}$$

The Eq.(2.3.5) is solved iteratively, while the source term of the Pij equation is normalized.

Differences in the resulting cross sections by the RRRP method and by the RRP method are negligible. The RRRP method is better in calculation stability, but the number of surrounding regions must be one. The RRP method can be applied when homogenizing an entire cell.

2.4 Options for Transport Cross Section

The exact definition of the group-wise microscopic transport cross section is

$$\sigma_{tr,g} = \sigma^1_{t,g} - \sigma^1_{s,1,g} = \sigma^1_{t,g} - \overline{\mu}\sigma^0_{s,0,g}, \tag{2.4.1}$$

where the superscript denotes the angular flux moment of the weighting function (0/flux, 1/current). The subscript number indicates the Legendre order of scattering cross section, and the subscripts "tr", "t", and "s" denote transport, total, and scatteing cross sections, respectively.

SLAROM-UF uses the following three formulas for the transport cross section.

$$\sigma_{tr,g} = \sigma^0_{t,g} - \sigma^1_{s,1,g} \qquad \text{(flux weighted)} \tag{2.4.2}$$

$$\sigma_{tr,g} = \sigma^1_{t,g} - \sigma^1_{s,1,g} \qquad \text{(current weighted)} \tag{2.4.3}$$

$$\sigma_{tr,g} = \sigma^1_{t,g} - \overline{\mu}\left(\sigma^0_{el,0,g} + \left(\sigma^1_{t,g} - \sigma^0_{t,g}\right)\right) \qquad \text{(EXPANDA)} \tag{2.4.4}$$

The variable ICASE in PREP module determines which is used in the calculations of the collision probability and diffusion coefficient. Equation (2.4.4) is a definition used in the EXPANDA code (JAERI 1239).

2.5 Treatment of Cross Sections for the Higher Legendre Moment

2.5.1 Group-wise cross section

An group-wise cross section for the n-th Legendre moment is defined by

$$\sigma^n_g = \frac{\int_{u\in g} \Phi^n(u)\,\sigma^n(u)\,du}{\int_{u\in g} \Phi^n(u)\,du}, \tag{2.5.1}$$

where Φ is the weighting flux.

The Bondarenko method (i.e. the narrow resonance approximation with the B_N equation)

$$\Phi^n(u) \propto \frac{C(u)}{(\sigma_{0,t}(u) + \sigma_b)^n} \tag{2.5.2}$$

is often employed to represent Φ.

SLAROM-UF employs Eq.(2.5.2), but the cross section library data for the Legendre moment higher than 0 is provided only on the total cross section.

For the other cross sections of the higher Legendre order, SLAROM-UF applies the following correction factor to results obtained for the 0th moment.

$$\text{Conversion factor} = \frac{\sigma^1_{t,g}}{\sigma^0_{t,g}}$$

This factor is applied to results by UF calculation as well where only the cross sections for the 0th moment are evaluated.

2.5.2 Definition of current for average and condense

The weighting flux used in averaging cross sections in space and energy group, should also reflect the Legendre moment of the cross section.

In SLAROM-UF, the current defined by

$$J^g_i = \frac{B\sum_j P^g_{j\to i}\phi^g_j V_j}{3V_i\left(\Sigma^g_{tr,i} + DB^2\right)} \tag{2.5.3}$$

is applied to cross sections for the Legendre moment higher than 0. B is the buckling and D is the diffusion coefficient calculated in the homogenized cell (atomic number density averaged).

Equation (2.5.2) is derived based on TIBERE method with the B_1 equation. The transport cross section averaged with the current, $\overline{\Sigma^g_{tr}}$, and the Benoist's cell averaged diffusion coefficient, $\overline{D^g}$, satisfy the relation $\overline{D^g} = \frac{1}{3\overline{\Sigma^g_{tr}}}$.

3. Cross Section Library

This section describes the cross section libraries used in the fine group and the ultra fine group calculations.

SLAROM-UF has been developed only for fast reactor neutronics calculations and cannnot treat photon data. The code also does not deal with either upper scattering or the thermal scattering data.

The group constant library consists of the following two constants:

- Fine group constants (70-group, 175-group, and 900-group)
- Ultra fine group constants for ultra fine group calculation ($\leqq$50keV)

In the current version, the libraries are provided for JENDL-3.2[8], JENDL-3.3[9], ENDF/B-VII[10], and JEFF-3.1[11]. Nuclides available are listed in the Index file (Section 3.3.1).

3.1 Fine Group Cross Section Library

3.1.1 Specifications of group constants

Specifications of the fine group constants are as follows. The 70-group constants include all of the JFS-3 (JENDL-3 version of JFS (JAERI Fast Set))[12] properties. The features of JFS-3 are noted in the brackets.

(Data contained)

- One dimensional reaction group constants (total, fission, capture, etc.)
- Scattering matrices up to P5 component (elastic scattering, inelastic scattering, (n,2n), (n,3n), (n,4n) reactions)

  [the JFS includes only P0 and does not include (n,3n), (n,4n) reactions]
- Fission spectra (incident energy group dependent vector)

  [No dependency in JFS-3]
- Self-shielding factor tables are provided for total, fission, capture, elastic, and elastic removal cross section. Only the total cross section has a current-weighted self-shielding factor in addition to the flux weighted. The scattering matrix for the higher order PL components is substituted with that of P0.

The following features are on the 175 and 900 group constants. The 70 group constants have the same properties as the JFS.

- Upper energy 20MeV. [JFS-3 : 10MeV]
- Thermal Maxwellian + 1/E + fission spectrum is used as a weighting function in generating data. [JFS-3 uses collision density of Monju innner core]
- Parameter data points of the self-shielding factor table are increased. The data points are listed as in Table 3.1.1. A point at 35 barn was added to the background cross section (σ_0), because σ_0 of ^{238}U locates from 30 to 50 barn. Temperature parameters at 270 K and 1300 K were added because critical experiments are usually carried out at room temperature (around 20 degree C = 293 K) and the temperature of a power reactor is around 1300 K.
- TIMS code[13] is not used [TIMS is used for major heavy nuclides in JFS-3]

  Group constants were all created with the NR approximaion in NJOY[14]. Those created with TIMS are more accurate but not provided in the 175 and 900 group constants. This assumes use of the UF calculation option in the 175 or 900 group calculation. Without the UF calculation option, calculated effective cross sections would be less acurate than thoes calculated with the 70 group constant set.

Table 3.1.1 Parameter points in self-shielding factor table

No.	σ_0 (barn)	Temperature (K)
1	0.1	270
2	1	300
3	10	800
4	35	1300
5	100	2100
6	1000	4500
7	10000	
8	100000	
9	1000000	

3.1.2 Group structure

The group structures of the fine group constants of the three types are listed in Appendix A.

The group structure of the 70-group constants is the same as that of JFS-3.

The energy structure of the 175-group constants was created based on the VITAMIN-J-175-group library (VITAMIN-E-174-group library[15] plus 1 group (energy boundary at 12.84MeV)). The group structure of the 175-group constants differs from that of the VITAMIN-J-175 in the following aspects: the original divisions of Group-1 to Group-5 (from 20.00MeV to 14.92MeV) are now two groups; the original Group-62 (from 1.11MeV to 1.00MeV) is now two groups; the original divisions of Group-174 and Group-175 (from 0.414eV to 1E-5eV) are now three groups. The last group reflects energy boundaries of 70-group constants. Finally, the original divisions of Group-111 to Group-114 (from 67.4keV to 40.9keV) are now six groups, and the original divisions from group-115 to group-124 (from 40.9keV to 19.3keV) are now nine groups. These modifications refine the energy range higher than the upper limit (approx. 50keV) of the ultra fine group calculation, or reflect energy boundaries of 900-group constants.

In 900-group constants, lethargy is defined as width 0.008 over 50keV considering an increase of average lethargy (1/120) by elastic scattering of a heavy nuclide (U-238), and as widths 0.050 to 0.125 under 50keV where the ultra-fine group calculation is performed ($\Delta u \approx$ 0.0005). As an exception, Group-1 is defined by its lower energy boundary at 16.1607MeV considering (d, t) reaction at 14.1MeV and the fact that contribution of production reaction rates from 16.1607 to 20.0MeV is less than 0.00003 in the GODIVA reactor where the neutron spectrum is extremely hard. In addition, coarser lethargy widths are defined over the thermal energy range under 0.1523eV. The lethargy widths are also partly adjusted for consistency with energy boundaries of 175-group constants.

3.1.3 Creation of group constants

Group constants were created by processing PENDF with NJOY version 99.161. The PENDF had been created by LINEAR[16], RECENT[17], and SIGMA1[18] codes in PREPRO2004. For major heavy nuclides, the 70-group constants were created by TIMS, where resonances were treated by an ultra fine group calculation with pseudo resonance ladders for unresolved resonances.

3.2 Ultra Fine Group Cross Section

The group constants used in the ultra fine group calculation are created in SLAROM-UF from the PMCROSS library at a user-specified temperature.

3.2.1 PMCROSS library

This section explains the PMCROSS library.
(Specification)

- Reaction: Capture, elastic scattering (P0), and fission.
- PENDF data (binary).
- Energy range: 10^{-5} eV to 55.1656keV.
- Temperature: 270K
- TIMS is used to create PENDF for unresolved resonance.
- Nuclides: All nuclides included in 175-group and 900-group fine group constants (Some exceptions exist due to creation constraints).
- Additional explanations below:
- Capturing the cross section considers reactions including (n,α) and (n,p).
- Number of data points: approx. 300 thousands.
- The upper energy limit is greater than that in the calculation (52.4752keV) to consider Doppler broadening.
- Converting to a lower temperature is not possible.
- Data are provided for nuclides without resonances, with an expectation of an improvement in accuracy, especially in the elastic removal cross section.

3.2.2 Creation of PMCROSS library

PENDF data were created by the TIMS code for unsolved resonances and by the LINEAR, RECENT, and SIGMA1 codes for the others. TIMS is used to create a fictitious ladder of cross sections for unresolved resonances. An example of key parameter settings in the TIMS code are shown in Table 3.2.1.

There are some restrictions in creating the PMCROSS library. For example, in the library of JENDL-3.2, average values of infinitely diluted cross sections are used for the unsolved resonance range in Zr-nat. and Mo-nat. because discrepancies of unsolved resonance energy ranges between the isotopes preclude the use of TIMS. Therefore, the self-shielding effect on these nuclides cannot be considered in this range. In the case of Zr-nat., Zr-91, whose natural abundance is 11%, has unresolved resonances in the range over 30keV. In the case of Mo-nat., all Mo isotopes (for example Mo-95, natural abundance 16%) have unresolved resonances in the range over 2keV. When the self-shielding effect by these unsolved resonances is important, take the PMCROSS library off the Index file. Then the self-shielding effect is evaluated only by the fine group calculation.

Table 3.2.1 Resonance parameter error assumed in TIMS (e.g. JENDL-3.2)

Nuclide	MAT No.	Tape No.	Cross section tolerance (%)	Resonance width tolerance (%)	ICFT (=1:fertile) (=2:fissile)
Th-232	9040	313	4	8	1
U-233	9222	313	4	8	2
U-234	9225	313	3	6	1
U-235	9228	313	5	10	2
U-236	9231	313	3	6	1
U-238	9237	313	3	6	1
Np-237	9346	313	4	8	2
Pu-239	9437	314	4	8	2
Pu-240	9440	314	3	6	1
Pu-241	9443	314	4	10	2
Pu-242	9446	314	4	8	1
Am-241	9543	314	4	8	2
Am-242-m	9547	314	5	10	2
Am-243	9549	314	4	8	2
Cm-244	9637	314	3	6	1
Cm-245	9640	314	5	14	2

3.3 Library Format

The library consists of the following four types of files:

1 "Index file" to define cross section data file names, PMCROSS data, and number of energy groups (text file).

2 "N-ENERGY file" to define parameters including energy structure of the fine group constants (binary file).

3 Cross section data files of the fine group constants (binary file).

4 PMCROSS library

The Index file is used in both fine group and ultra-fine group calculations.
The following section explains each file.

3.3.1 Index file

The Index file is a text file that contains basic data, such as nuclide names and number of energy groups. This file can be located in any directory and be modified by users. A sample is shown in Table 3.3.1. The format is explained as follows:
(File format)

#1 IMAX, MXR1D, MXR2D, MXPL1, MXREAC, MXSIG0, MXTMP, MXNR, IMAXG (int*9)

IMAX : Number of neutron energy groups

MXR1D : Maximum number of reactions for a one-dimensional reaction cross section

MXR2D : Maximum number of reactions for a two-dimensional reaction cross section

MXPL1 : Maximum Legendre order + 1

MXREAC : Maximum number of reactions for the f-table

MXSIG0 : Maximum number of σ_0 parameters in the f-table

MXTMP : Maximum number of temperature parameters in the f-table

MXNR : Maximum number of R-parameter density ratio points in the f-table

At least, one of the constants listed in #3 must have MXNR R-parameters. Otherwise an error occurs in TONE method. Put 0 to kill R-parameter calculation.

IMAXG : Number of energy group of gamma rays (for future expansion of the code)

#2 LNMAX (int)

LNMAX : Number of nuclides

#3 NUCNAM, MXSNAM, NCODE, IZMASS (character, character, int*2). Repeated LNMAX times)

NUCNAM : Name of nuclides (within 15 characters) designating the fine group constants.

MXSNAM : Name of nuclides ("X" + within 15 characters) designating the PMCROSS library. The first character "X" can be any. It will be replaced by a character determined in the code.

NCODE : Nuclide code number. This number is used in the input card to specify nuclides. The users can re-assign)

IZMASS : Number defined with atomic number (IZ), mass number (IA), and state (ISTATE) by the following formula:

IZMASS = 10000 × IZ + 10× IA + ISTATE,

where

ISTATE=0 : Ground state

ISTATE=1 : Meta state

IZ $\geqq$ 200 is assigned to a user-defined nuclide as lumped fission product.

Table 3.3.1 Index file

```
*****************************************************************
*    index file of new-jfs3 pds type library
*    this index file is read by setting setenv 'INDEX'
*    all data is read using free-format !!!
*****************************************************************
*    this index file is stored :
*         /data/JFS900G/J32/NewJFS3-Index.dat.g900
*****************************************************************
*  a card with first column '*' is regarded as a comment card
*****************************************************************
* #1  IMAX MXR1D MXR2D MXPL1 MXREAC MXISIG0 MXTMP MXNR IMAXG
*****************************************************************
     175   20      3    6     6       9       6    1    0
*****************************************************************
* #2  LNMAX : no of nuclide in this library
*****************************************************************
       60
*****************************************************************
********  repeat #3 LNMAX times ******************************
* #3  NUCNAM  MXSNAM   NCODE   IZMASS
*...+....1....+....2....+....3....+....4....+....5....+....6..
*****************************************************************
      H01J32               1    10010
      HE3J32             203    20030
      HE4J32             204    20040
      BE9J32  XBE9         4    40090
      B10J32  XB10       105    50100
                      .
                      .
                      .
      U05J32  XU05       925   922350
      U06J32  XU36       926   922360
*      U08J32  XU08       928   922380  /noTIMS
      U08J32T XU08       928   922380
      NP7J32  XNP7       937   932370
      NP9J32  XNP9       939   932390
      PU8J32  XPU8       948   942380
      PU9J32  XPU9       949   942390
      PU0J32  XPU0       940   942400
      PU1J32  XPU1       941   942410
      PU2J32  XPU2       942   942420
      AM1J32  XAM1       951   952410
      AM2J32  XAM2       952   952420
      AM3J32  XAM3       953   952430
      AMMJ32  XAMM       950   952421
      CM2J32  XCM2       962   962420
      CM3J32  XCM3       963   962430
      CM4J32  XCM4       964   962440
                      .
                      .
                      .
*****************************************************************
*     end of INDEX file definision                              *
*****************************************************************
```

3.3.2 N-ENERGY file

"N-ENERGY" file is a binary file that contains general information of the fine group constant. The format is explained as follows:
(File format) (Data type is based on FORTRAN default)

LENG, IMAX, (ENBND(I) I=1, IMAX+1), (DU(I), I=1, IMAX), (VEL(I), I=1, IMAX), (WTFLUX(I), I=1, IMAX), (CHILIB(I), I=1, IMAX)

LENG : Length of this member (in words)

IMAX : Number of energy groups

ENBND : Energy boundary (eV)

DU : Lethargy width

VEL : Velocity (cm/sec)

WTFLUX : Weighing flux used in creation of the constant

CHILIB : Fission spectrum (data is always on ^{239}Pu.)

3.3.3 Cross section data file

Group-wise cross section data files are binary files provide for each nuclide. The files consist of six kinds of files. Each file is named by prefix ("C", "R", "T", "M", "F", or "V") + "NUCNAM" defined in the Index file. The format of each is explained as follows:
(File format) (Data type is based on FORTRAN default)

(1) 'C' + NUCNAM file (Control data)

LENG, LENG, NCODE, AWT, IFISS, ICHVEC, IUPSC, IBURN, IDELAY, IGAMMA, IMAX, NGG, NOMT1D, NOMT2D, NOMTFT, NSIG0, MAXTMP, MAXNR, IDUM1, IDUM2, IDUM3, (MTXPL1(I), I=1, NOMT2D), (MTXLA(I), I=1, NOMT2D), (KTEMP(I), I=1, NOMTFT), (NTEMP(I), I=1, NOMTFT), (NR(I), I=1, NOMTFT), (ISTFT(I), I=1, NOMTFT), (IENDFT(I), I=1, NOMTFT), (MTFTAB(I), I=1, NOMTFT), (SIG0(I), I=1, NSIG0), (TEMP(I), I=1, MAXTMP), ((RPARA(J, I), J=1, NSIG0), I=1, MAXNR)

LENG : Length of this member (in words).

NCODE : Nuclide code number.

AWT : Atomic weight in a.m.u..

IFISS : 0/1=No fission data / Fission data exists.

ICHVEC : 0/1/n=No fission spec/Averaged fission spectrum/Vector.

IUPSC : 0/1=No up-scattering/Up-scattering exists (for future use).

IBURN : 0/1=No burn up data/ Efiss, Ecap and so on (for future use).

IDELAY : 0/n=No delayed data/n is the number of family (for future use).

IGAMMA : 0/1=No gamma data/Gamma data exist (for future use).

IMAX : No. of energy groups.

NGG : No. of gamma energy groups (for future use).

NOMT1D : No. of 1d reaction data.

NOMT2D : No. of matrix data (=3).

NOMTFT : No. of the f-table reaction.

NSIG0 : No. of sigma-0.

MAXTMP : No. of temperature points in the f-table.

MAXNR : No. of R-parameter density ratio points in the f-table.

IDUM1 : Integer data for future use.

IDUM2 : Integer data for future use.

IDUM3 : Integer data for future use.

MTXPL1 (NOMT2D) : Maximum number of PL order in each reaction.

MTXLA (NOMT2D) : Lowest energy group No. with non-zero data.

KTEMP (NOMTFT) : No. of temperatures parameter in each reaction.

NTEMP (NOMTFT) : Energy group No. where temperature dependency starts.

NR (NOMTFT) : No. of R-parameter in each reaction.

ISTFT (NOMTFT) : Highest energy group No. where the f-table data exist.

IENDFT (NOMTFT) : Lowest energy group No. where the f-table data exist.

MTFTAB (NOMTFT) : MT number of each reaction (MT=18, 100, 2, 1, etc.).

SIG0 (NSIG0) : Sigma-0 values.

TEMP (MAXTMP) : Temperature in kelvin.

RPARA (NSIG0, MAXNR) : R-parameter values.

(2) 'R'+ NUCNAM (1-D reaction data)

LENG, LENG, NOMT1D, (MT1D(MT), MT=1, NOMT1D), (LEN1D(MT), MT=1, NOMT1D), ((SIG1DT(I, MT), I=1, LEN1D(MT), MT=1, NOMT1D)

LENG : Length of this member (words)

NOMT1D : No. of 1D reaction data

MT1D (MT) : MT number of MT-th reaction

LEN1D (MT) : No. of data for MT-th reaction

SIG1DT (I, MT) : I-th group constant of MT-th reaction,

where MT number is listed in Table 3.3.2.

Table 3.3.2 MT number for reactions

MT	Reaction
18	Fission
452	Nu-value (neutrons per fission)
100	Capture (sum of MT=102 116)
4	Total inelastic
2	Elastic
251	The average cosine of the scattering angle for elastic laboratory system
998	Elastic removal
-16	Total (n,2n)
17	Total (n,3n)
37	(n,4n)
455	Delayed nu-value (neutrons per fission)
16	(n,2n)
102	(n,γ)
103	(n,p)
104	(n,d)
105	(n,t)
106	(n,He)
197	(n,α)
-18	Fission spectrum

(3) 'T'+NUCNAM (total cross section)

LENG, (SIGT(I), I=1, IMAX)

LENG : Length of this member (words)

SIGT (I) : I-th group total cross section

(4) 'M'+ NUCNAM (matrix data if MTXLA(MT)>0 & MTXPL1(MT)>-1)

LENG, LENG, NOMT2D, (((((MTXLEN(I, IPL, MT), (STR(ID, I, IPL, MT), ID=1, MTXLEN(I, IPL, MT)), I=1, MTXLA(MT)), IPL=1, MTXPL1(MT)+1)), MT=1, NOMT2D)

LENG : Length of this member (in words)

NOMT2D : Number of 2D reactions

MTXLEN (I, IPL, MT) : Length of data for I-th source group, IPL-1 Legendre order and MT-th reaction

STR (ID, I, IPL, MT) : Scattering matrix data of ID+I-1 sink group from I-th source group for IPL-1 Legendre order and MT-th reaction

, where,

MT=1 : Elastic

MT=2 : Total inelastic

MT=3 : (n,2n) + (n,3n) + (n,4n)

(5) 'F'+ NUCNAM (the f-table data if NOMTFT>0)

LENG, LENG, NOMTFT, (((((XFX(J, K, N, I, MT), J=1, NSIG0), K=1, KTEMP(MT)), N=1, NR(MT), I=ISTFT(MT), IENDFT(MT)), MT=1, NOMTFT)

LENG : Length of this member (in words)

XFX (J, K, N, I, MT) : The f-table data of J-th Sigma0, K-th temperature, N-th R-parameter, I-th group, MT-th reaction

(6) 'V'+ NUCNAM (energy dependent fission spectrum if ICHVEC>1)

LENG, LENG, IMAX, ICHVEC, MXDWNX, (ICHNG(I), I=1, IMAX), ((CHIV(J, K), J=1, MXDWNX), K=1, ICHVEC)

LENG : Length of this member (words)

IMAX : No. of energy groups

ICHVEV : Lowest energy group No. at which dependency on incident energy exists

MXDWNX : Lowest energy group No. at which fission spectrum data is not zero

ICHNG (I) : Specify the position in CHIV data for I-th energy group fission spectrum

CHIV (J, K) : J-th group fission spectrum data by K-th source

3.3.4 PMCROSS library

The PMCROSS library consists of the following two types of files:

(1) CONT0000 to contain general information (binary file).

(2) Cross section data files to contain the group constant of each nuclide (binary file).

The cross section data files are provided for each nuclide. The files are on three reactions (elastic, capture, and fission) and named using "MXSNAM" defined in the Index file. Cross section data are divided by the size defined by "IMXREC" in CONT0000 file (set to 30,000 in the constant creation process) and stored in a series of files starting from "001".

The format is explained as follows:
(File format) (Data type is based on FORTRAN default)

(1) CONT0000 : General information (energy range, number of data, and temperature)

LENG, TITLE, ELOW, EHI, TEMP, NPMAX, IMXREC

LENG : Length of this member (in words)

TITLE : Title (character*40)

ELOW : Lower energy limit

EHI : Upper energy limit

TEMP : Temperature (K)

NPMAX : Maximum energy points in all nuclides

IMXREC : Maximum number of energy points stored in a file

(2) 'C'+ MXSNAM(2:4) + '0000': Information of nuclide

LENG, ITAPE, MATNO, NPOUT1, NPOUT2, NPOUT3, IZA, ISWUNR, AM, ELOW, EHI, TEMP, QVAL1, QVAL2, QVAL3, EULOW, EUHIGH, CDATE1, CDATE2

LENG : Length of this member (in words)

ITAPE : Tape number (not used)

MATNO : Material number

NPOUT1 : Number of data points for elastic

NPOUT2 : Number of data points for fission

NPOUT3 : Number of data points for capture

IZA : ID number (as 239Pu = 94239)
ISWUNR : Flag if unresolved resonance presents (0/1 = No/Yes)
AM : Atomic weight in a.m.u.
ELOW : Lower energy limit
EHI : Upper energy limit
TEMP : Temperature (K)
QVAL1 : Q-value for elastic
QVAL2 : Q-value for fission
QVAL3 : Q-value for capture
EULOW : Lower energy limit of unresolved resonance range
EUHIGH : Upper energy limit of unresolved resonance range
CDATE1 : Date of creation (character*4)
CDATE2 : Date of creation (character*4) (CDATE1 + CDATE2 = "MM/DD/YY")

(3) 'F'+ MXSNAM(2:4) + 'C' + serial # : Capture cross section
'F'+ MXSNAM(2:4) + 'E' + serial # : Elastic scattering cross section
'F'+ MXSNAM(2:4) + 'F' + serial # : fission cross section (if any)
Above three files follow the common format:
LENG, (ENERGY(I), I=1,LENG/2), (CROSS(I), I=1, LENG/2)

LENG : Length of this member (in words)
ENERGY : Energy point (eV) of I-th data
CROSS : Cross section (b) for I-th data

4. Input File Description

4.1 Basic Input Data

The input format of SLAROM-UF is based on SLAROM[1]. Items for geometry configuration are the same as those of SRAC95 (the reference of the version is in Japanese and the recent version SRAC2006[19] is shown in the reference). Thus, this section describes only the minimum input parameters, and the user should refer to the documents mentioned above for further details.

The input format is a free format, similar to SLAROM unless specified. The following expressions are also available.

Repeat : 2(1.0,1,5), 3(0.) expands into 1.0, 1.5, 1.0, 1.5, 0., 0., 0.

Addition : 12, 4*2, 25 expands into 12, 14, 16, 18, 20, 25.

Comment : Writing "/" at the end of the input allows the addition of comments after "/".

Section 1 PREP

#1 **INDEX** (8H)

= 'PREP' : Homogeneous or heterogeneous cell with DANCOF method

= 'PREPTONE' : Derive s0 using Tone's formula for a heterogeneous cell. PATH must be run in advance.

#2 **TITLE** (18A4) : Comment

#3

1. **NREG** : Number of regions.
2. **NSCR** : Cell structure.
   = 0 Symmetric.
   = 1 Cyclic.
3. **ICASE** : Designates cross section used in calculation of collision probability and diffusion coefficient.
   = 0 Flux weighted transport cross section
   = ±1 Current weighted transport cross section
   = 2 Flux weighted total cross section.
   = 3 EXPANDA type transport cross section.
4. **IBSW** : Type of calculation, and buckling search.
   =-1 Derive effective cross section in homogeneous calculation (redefine **ICASE** = 1 automatically).
   =0 Derive effective cross section in homogeneous calculation only.
   =1 Derive effective cross section in specified cell model.
   =2 Buckling search.
5. **IGEOM** : Geometric configuration in effective cross section calculation.
   =0 Slab cell.
   =1 Cylindrical cell.
6. **IPR** : Print format for homogeneous cross section.
   =0 No
   =1 Macro cross section.
   =2 +Micro cross section.
   =3 +Macro cross section (scattering matrix).
   =4 +Micro cross section (scattering matrix).
   =5 +Micro cross section (scattering matrix per reaction).

7. **ITPE** : Iteration of background cross section.
   =0 No
   ≠1 Yes
8. **MICOUT** : PDS output for micro cross section.
   =0/1 Output all except matrix.
   <0 Output all. (essential when collapsing micro scattering matrix.)
9. **IPL** : PL Order (the value is used in print out and calculation. If **IPL**=0, IPL for calculation is reset to 1.)
10. **LNMAX** : Energy group of the cross section library. Not used (determined by the Index file).
11. **NRMAC** : Number of regions to output effective cross section into PDS file.
12. **IXCODE** : Code number of nuclide of which fission spectrum is saved. Not used (average fission spectrum is always calculated).
13. **IMAX** : Energy group. Not used (determined by the Index file). However, defining a negative value here activates the composition data modification option. (Enter #10'-1 and #10'-2.)

#4

1. **TE** : Temperature (K). (When a dummy value larger than 10^4 is input, input #9 if **NREG**=1 (nuclide-wise) and input #5 if **NREG**>1 (region-wise). If **TE** > 10^4 and **NREG**>1, **TE** is set to mod(**TE**, 10000) in the preliminary homogeneous calculation carried out before the heterogeneous calculation.
2. **AINP** : Bell factor. (Recommendation: 1.20-1.25 for slab cell, 1.30 for pin cell.)
3. **BSQ** : Buckling. (The value is not used when **IBSW**=2 (buckling search). The value or searched value is used only in flux calculation not in self-shielding calculation.)

#5 **TEG** (**REG**) : Temperature of each region (K). (Enter only when **TE** > 10^4 and **NREG**>1.)

#6 **NOELM** (**REG**) : Number of nuclides in each region.

#7 **RMAX** (**REG**) : Width of each region (cm). If **INDEX**='PREPTONE", the value is not used (determined in PATH module).

#8 **NCODE**, **DEN** (**REG**) : Nuclide code and atom number density (10^{24} atom/cm^3).
Input as many nuclides as used.The line can be changed in any data but must be changed at the end of each region.

#9 **TEHM** (**NOELM**(1)) : Temperature of each nuclide (K). (Enter only when **TE** > 10^4 and **NREG**=1.)

Add the following when **IMAX**<0 (to change the cell average atom number density without changing the effective microscopic cross section)

#10'-1 **JJBMOD** (free format) : Number of nuclides to provide cell average atom number density

#10'-2 ((**NCDMOD**(j), **DENMOD**(j), j=1, **JJBMOD**):
NCDMOD(j) : Code of nuclide j
DENMOD(j) : Cell average atom number density of nuclide j

#11 **ANAME** (6H) : Name of the PDS file of the homogeneous calculation. (Put a blank line if the cross section PDS output is not necessary.)

Enter cards from #12 to #14 only when **NRMAC** > 0 (repeat **NRMAC** times).
#12 **IREG** : Region number.
#13 **TITLE** (18A4) : Comment.
#14 **ANAME** (6H) : Name of effective cross section.

Section 2 PATH

#1 **Index** (4H): "PATH"

#2 **TITLE** (18A4) : Comment

#3

1. **NG** : Energy group. Not used (determined by the Index file).
2. **NM** : Number of materials.
3. **IDRECT** : Anisotropic collision probability calculation.
   = 1 No
   = 2 Yes
4. **IFORM** : Output format of Pij (this does not affect the calculation).
   =0 Pij
   =1 Pij/(Σ_{tr}+DB2)
5. **IBSW** : Buckling search setting. If already defined in other modules as PREP, the value is re-defiend.
   $\leqq$ 1 No
   $>$ 1 Yes
6. **IPREP** : Effective cross section.
   = 0 Use the effective cross section created in PREP.
   = 1 Read PDS file (designate in cards from #13 to #15).
7. **IPL** : PL Order (the value is read but not used).

#4

1. **IGT** : Geometry of cell. (Same as SRAC95)
   = 1 Spherical.
   = 2 One-dimension slab.
   = 3 One-dimension cylinder.
   = 4 Cubic lattice by concentric partitioning.
   = 5 Cubic lattice by two-dimension partitioning.
   = 6 Hexagonal lattice by concentric partitioning.
   = 7 Hexagonal lattice by two-dimension partitioning.
   = 8 Equilateral rectangular sub-assembly symmetric to 45 degree X-Y partitioning
   = 9 Equilateral rectangular sub-assembly symmetric to 45 degree X-Y partitioning where pin rods are installed in a circular pattern.
   = 10 Circular sub-assembly where pin rods are installed in a circular pattern.
   = 11 Circular sub-assembly where pin rods are asymmetrically installed.
   = 12 Hexagonal sub-assembly where pin rods are asymmetrically installed.
   = 13 Rectangular sub-assembly where pin rods are installed on the nodes of X-Y grids.
   = 14 Hexagonal sub-assembly where pin rods are installed in a hexagonal lattice.
   = 15 Hexagonal sub-assembly where pin rods are installed on the nodes of triangle mesh grids.
   = 16 Quarter symmetric rectangular sub-assembly where pin rods are installed on the nodes of X-Y grids.
2. **NZ** : Number of regions.
3. **NR** : Number of regions (to calculate collision probability). (**NR**$\leqq$**NZ**)
4. **IBOUND** : Boundary conditions.
   = 0 Isotropic (white).
   = 1 Periodic.
   = 2 Isolated (black).
   = -1 60 degree rotational (only for **IGT** = 12).

5. **NX** : Number of partitions
   In X-direction (**IGT** = 2, 8, 9, 13, 15, or 16).
   In radial direction (**IGT** = 1, 3, 4, 5, 6, 7, 10, 11, 12, or 14).
6. **NY** : Number of partitions
   In Y-direction (**IGT** = 13, 16).
   In angular direction (**IGT** = 11, 12).
   For outer region of a hexagonal sub-assembly (**IGT** = 15).
7. **NTPIN** : Number of pin rods (effective for **IGT** = 10 to 16, calculated internally for **IGT** = 9).
8. **NAPIN** :
   Number of pin rods in an X-direction (**IGT** = 9).
   Number of concentric circles where pin rods are installed (**IGT** = 10).
   Number of concentric hexagons where pin rods are installed (**IGT** = 14).
   Number of triangle meshes that border on a X-axis (**IGT** = 15).
9. **NCELL** : Number of lattices to trace a neutron path. (For **IBOUND** = 1. Not used when selecting circular geometries.)
   Recommendation: > 5.
10. **IEDPIJ** : Print options for collision probability.
    = 0 No output.
    = 1 Output.
11. **NGR** : Order of Gaussian integration on radial numerical integration (not used when **IGT** = 2).
    Recommendation: 6 to 10. Calculation time of Pij integration is proportional to this variable.
    In case **IGT** = 8, 9, 13, 15, or 16, trapezoid integration works instead of Gaussian integration and **NGR** defines the number of partitions for trapezoid integration in a radial direction.
12. **NDA** : Number of partitions of an angular region (**IBETM**) for numerical integration of an angular direction.
    Valid when **IGT** = 4 to 16. Sufficient accuracy is obtained when defining **NDA** as equal to half of **IBETM**. Number of **NX*****NGR*****NDA** neutron paths are traced on two-dimension integration. The ratio of the numerically integrated volume to the accurate region volume are printed out in the *.FT06 file. If the discrepancy from unity is larger than 2%, adjust the **NGR** and **NDA**.
13. **NDPIN** : Number of partitions of pin rods in a radial direction(for **IGT** = 9 to 16).
14. **IDIVP** :
    i. Selection of partitioning functions for **RPP** (#10) (for **IGT** = 9,10,11,12, or 14).
    =1 **RPP** depicts radial position of pin rod. **RPP** also makes coolant region partitioning in X or radial direction similar to **RX**.
    =2 **RPP** additionally divides the pin rod region into inner and outer regions.
    ii. Selection of partitioning function by **RX** and **TY** (for **IGT** = 13 or 16).
    =0 Deactivates the moderator region partitioning when **NTPIN**$\neq$ 0, and treats regions other than the pin region as one region.
    =1 Activates partitioning of **RX** and **TY**. Usually, **IDIVP**=1.
15. **IBETM** : Angular region (degree) of angular integration (for **IGT** = 4 to 16).
    Set **IBETM**=45 for a symmetric square lattice and **IBETM**=30 for a symmetric hexagonal lattice. Set double of these degrees when **IBOUND**=1 (periodic boundary).
    Set 360 when right-left symmetry.
16. **IPLOT** : Not used. Enter 0.

#5 **NREG**(I) (I = 1, **NZ**). (No need when **NR** = **NZ**.) :
NR region number corresponding to I-th **NZ** region.

#6 **MAR**(I) (I = 1, **NR**) :

Material number corresponding to **NR** region.

#7 **NPIN**(I) (I = 1, **NAPIN**) :

Number of pin rods on each of the **NAPIN** concentric circles or hexagons (Need if **IGT** = 10 or 14).

#8 **RX**(I) (I = 1, **NX**+1) :

Partitioning position in X direction: The distance to the border (cm). **RX**(1) = 0.

#9 **TY**(I) (I = 1, **NY**) :

Angular direction position in θ degree. (Need if **IGT** = 11 or 12, and **NY** >1)

#10 **RPP**(I) : Need under the conditions below.

1. When **IGT**=9, 10, or 14, and **NAPIN**≠0. (I = 1, **NAPIN**)
   Enter pin rod position in an X-axis direction when **IGT** = 9.
   Enter radius (cm) of the ring to install pin rods when **IGT** = 10.
   Enter distance (cm) from the center to the side plane of each hexagonal when **IGT** = 14.
2. When **IGT**=11 or 12, and **NTPIN**≠0. (I = 1, **NTPIN**)
   Radial direction position of each pin rod (distance between pin rod center and sub-assembly center (cm)).

#11 **THETA**(I) (I = 1, **NTPIN**) : Angular direction position of each pin rod in θ (deg). Need if **IGT** = 10, 11, or 12, and **NTPIN**≠0.

#12 **RDP**(I) : Need under the conditions below.

1. When **IGT** = 10 or 14 and **NAPIN**≠0. (I = 1, **NDPIN**+1)
   Enter pin rod inner partitioning radius (common in all pin rods). **RDP**(1)=0.0.
2. When **IGT** = 9, 11, 12, 13, 15, or 16, and **NTPIN**≠0. (I = 1, (**NDPIN**+1)*__NTPIN__)
   Enter inner partitioning radius of each pin rod, **RDP**(I=1, **NTPIN**)=0.0.
   Enter radii corresponding to pin rods of 1/8 system including diagonal axes, when **IGT** = 9 and **NTPIN** = **NAPIN***(**NAPIN**+1)/2, .
   Enter radii corresponding to 1/6 sub-assembly and with the remainder acting as dummy (0.0), when **IGT** = 15.

Enter cards from #13 to #15 when **IPREP**>0.
#13 **BSQ** : Buckling (not used).
#14 **KAI** (6H) : PDS file name of fission spectra.
#15 **ANAME**(I) (6H) (I = 1, **NM**) : PDS file name of the effective cross section read.

Section 3 PIJF

#1 "PIJF"(4H)

#2

1. **NGK** : Not used.
2. **IFFG** : Flux guess.
   =0 Flat.
   =1 weight flux in the Library
   =2 Read from card #4
3. **IOFLX** : Neutron flux output option. **IOFLX** = **ITF**+**IPRF**.

- **ITF**
  = 4 Write into the logical unit 4.
  = 0 No.
  (**ITF** $\geqq$ 4 when using EDIT module)
- **IPRF**
  = 0 No print out.
  = 1 Print out. Region integration and energy integration.
  = 2 + Each region average spectrum
  = 3 + Others

4. **ICONV** : Always = 3.
5. **IPTXEC** : Control of cross section output for each region.
   = 0 No.
   = 1 Print out.
6. **IPT** : Print option of volume information.
   = 0 No.
   = 1 Print out.
7. **IPTPIJ** : Print option of collision probability.
   = 0 No.
   = 1 Print out.
8. **IPTFG** : Print option of neutron flux initial value.
   = 0 No.
   = 1 Print out.

#3 Enter 0 for default values in the input below

1. **ITMIN** : Limit of inner iteration (default = 2).
2. **ITMOUT** : Limit of outer iteration (default = 100).
3. **EPSI** : Conversion criterion of inner iteration calculation (default = 1.0×10^{-4}).
4. **EPSO** : Conversion criterion of outer iteration calculation (default = 1.0×10^{-5}).
5. **EPSG** : Extrapolation criterion (default = 0.01).
6. **RELG** : Acceleration factor initial value (default = 1.4).

#4 **PHI** (**NR*NG**) : Neutron flux initial value. (Enter when **IFFG** = 2).

#5 **IRXEC** : Option of reading activated cross section data.
= 0 No.
> 0 Number of cross section data to read from card #6.

#6 **XEC** (**NG**) : Activated cross section data. (Enter **IRXEC** times when **IRXEC**>0)

Section 4 EDIT

#1 **INDEX** (4H) : "EDIT"

#2

1. **IRPHI** : Input neutron flux. (Not used. Always 2.)
   = 1 Read from card.
   = 2 Read from the logical unit 4 (written in PIJF or PIJB module).
2. **IRP** : Calculation option of anisotropic diffusion coefficient. (Not used. Determined by **IDRECT** in PATH)
   = 0 Isotropic collision probability read from unit 21 (written in PATH module) .
   = 2 Anisotropic collision probability read from unit 22 (written in PATH module).

3. **JPRINT** : Print output of cell average cross section.
   =0 No.
   =1 Macro cross section
   =2 + micro cross section
   =3 + macro cross section (scattering matrix)
   =4 + micro cross section (scattering matrix)
   =5 + micro cross section (scattering matrix for each reaction)
4. **INR** : Designation of cell average region.
   = 0 Entire cell.
   = 1 Averaging partially (define anisotropic diffusion coefficient by Benoist method).
   = 2 Averaging partially (define anisotropic diffusion coefficient by Takeda method). (Recommended)
5. **IWT** : Weight to homogenize higher order PL cross section (including transport cross section).
   = 0 Current.
   = 1 Neutron flux.

#3 **NR1**, **NR2**, **LM1**, **LM2** : Designation of partial region. Enter when **INR**≠0.

NR1 : Lower limit of **NZ** region number for averaging.

NR2 : Upper limit of **NZ** region number for averaging.

LM1 : Lower limit of **NR** region number for averaging. (Not used)

LM2 : Upper limit of **NR** region number for averaging. (Not used)

#4 **PHI** (**NR***NG) : Neutron flux distribution. (Enter when **IRPHI** = 1).

#5 **ANAME** (6H) : PDS file name of effective cross section to save. Leave a blank line not to save. Microscopic cross section is saved only when **MICOUT**≠0 in PREP module.

4.2 Ultra Fine Group Calculation Option (PEACO Module)

#1 **INDEX** (A8) : 'PEACO' or 'PEACOHOM'

'PEACO' : Heterogeneous cell calculation. (Run PATH in advance).
'PEACOHOM' : Homogeneous cell calculation.

Parameters **NM** (number of material) and **NR** (number of region) subsequently referred are values input in PATH.

#2 **TITLE** (A72)

TITLE : Comment

#3 **IC8**, **IPRT**, **IPLOT**, **MPLOT**

IC8 : User MCROSS library energy structure
= 4 or -4 Standard UFLIB structure.
= 5 ERANOS 1968 group based structure.

The initial neutron flux distribution of the first group is read from #8 when IC8=-4.

IPRT : Print output options
= 0 No detailed output.
= 1 Detailed output of PEACO module.
=-1 Macro cross section (same format as PREP and EDIT, valid only for PEACOHOM).
=-2 + micro cross section
=-3 + macro cross section (scattering matrix)
=-4 + micro cross section (scattering matrix)
=-5 + micro cross section (scattering matrix for each reaction)

IPLOT : Plot option of calculated neutron spectrum (0/1: No/Yes)
MPLOT : Plot option of MCROSS library (0/1: No/Yes).

#4 (**TEMP**(M), M=1, **NM**)

TEMP : Temperature of M-th material (K)

#5 (**BL**(M), M=1, **NM**)

BL : Average chord length of M-th material (cm) (=4V/S)
Used to interpolate Pij, when the number of resonant materials is two or less.

#6 (**NCOR**(M), M=1, **NM**)

NCOR : Input material number M when M-th material is resonant. Input zero when M-th material is not resonant.
If the number of resonant materials is two or less, Pij is interpolated which reduces the burden on the CPU.

#7 (**NAMOUT**(M), M=1, **NM**) (9A8→**NM**/9 lines)

NAMOUT : Member name of PDS cross section file output.
Blank lines are necessary, when output is not needed.

#8 (**FLXINI**(I), I=1, **NR**) (Necessary when **IC8**<0)

FLXINI : Neutron flux of a group at the beginning of the solution of I-th R-region (volume integrated value).

#9 **TITOUT** (A72) : Comment for the output cross section
Necessary for the number of **NAMOUT** data. Not necessary if **NAMOUT** is all blank.
Putting "skip" or "SKIP" in the first 4 letters skips TITOUT input after the line.

4.3 Collapse Option (COND Module)

The higher PL order scattering matrix and transport cross section are collapsed by the current. The other cross sections and diffusion coefficient are collapsed by the flux.

#1 **INDEX** (A4) : 'COND'

#2 **TITLE** (18A4) : Comment

#3 **IMAXB** : Number of groups after collapse (input negative value for re-collapse)

#4 **NAMEIN** (A8) : Name of material. (Enter when the input of #3 is negative.)

#5 (**LAPSE**(I), I=1, **IMAXB**) : Group number before collapse (last group number in the I-th group). This input is not needed for a special case that the number of groups is the same before and after collapse).

The following section is necessary for the number of materials.

#6 **NAMEIN**, **NAMOUT**, **IFLXOP**, **MICOUT**, **IPRINT** (2A8,*)

NAMEIN : Material name of the cross section file before collapse (6 characters).

Quit COND module by setting **NAMEIN**='END' and put dummy values for the rest of inputs.

NAMOUT : Material name of the cross section file after collapse (6 characters).

IFLXOP : Designates neutron spectrum.

=0 Use neutron spectrum calculated by the B1 equation and stored in **NAMEIN**.
(In case of homogeneous or homogenized cell).
>0 Refer to #7.
Use flux data calculated by PIJF or PIJB module.
(To collapse cross sections in each region. Available for homogenized cross section as well.)

MICOUT : Output option for effective micro cross section.

=0/1 Output all except matrix
=-1 Output all.

IPRINT : Print output option

=0 No
=1 Macro cross section.
=2 + micro cross section
=3 + macro cross section (scattering matrix)
=4 + micro cross section (scattering matrix)
=5 + micro cross section (matrix for each reaction)

Enter #7 when **IFLXOP**>0.

#7 (**IFXPOS**(I), I=1, **IFLXOP**) :

NR region number of neutron spectrum data. Sum of spectra is used in collapsing.

#8 **COMOUT** (18A4) : Comment on collapsed cross section.

4.4 Multi Step Calculation Option (PIJB Module)

PIJB has the same functionalities as PIJF. Unlike PIJF, PIJB works without any other module except PATH, and can specify the buckling value and cross section files.

#1 **INDEX** (A4) : 'PIJB'

#2 **TITLE** (18A4)

TITLE : Comment.

#3 **ICASE**, **IBSW**, **IPL**, **IMIC**, **BSQ**

ICASE : Definition of cross section for collision probability calculation (same as **ICASE** in PREP).

IBSW : Critical buckling search option. If already defined in other modules as PREP, the value is re-defiend.

=0 or 1/ >1 : No search / Search.

IPL : PL Order (the value is used in print out and calculation. If **IPL**=0, the value is used in print out and that in calculation is determined in the previous calculation module.

IMIC : Micro cross section matrix process.

(Automatically defines **IMIC**= **-**1 when COND module is used in advance with **MICOUT**=**-**1.)

=0/1 No.

=**-**1 Yes.

BSQ : Buckling (replaced with closest value if **BSQ**=0). If already defined in other modules as PREP, the value is re-defiend.

#4 (**MATNAM**(M), M=1, **NM**) (A8):

Name of M-th material (to read cross section in PDS file). **NM** is input in PATH.

#5 **NGK**, **IFFG**, **IOFLX**, **ICONV**, **IPTXEC**, **IPT**, **IPTPIJ**, **IPTFG**

Follow #2 in PIJF module.

#6 **ITMIN**, **ITMOUT**, **EPSI**, **EPSO**, **EPSG**, **RELG**

Follow #3 in PIJF module.

#7 ((**PHI**(I, J), J=1, **NR**), I=1, **IMAX**)

Follow #4 in PIJF module. (Input when **IFFG**=2.)

#8 **IRXEC**

Follow #5 in PIJF module. (Quits PIJB module when setting **IRXEC**=0.)

#9 (**XSEC**(I), I=1, **IMAX**)

Follow #6 in PIJF module. (Repeats **IRXEC** times only when **IRXEC**>1.)

4.5 Cell Homogenizing Option By Reaction Rate Ratio Preservation Method (RRRP module)

As described in Section 2.3, the two methods are available.

The module uses the neutron flux saved in the logical unit 4 calculated in either PIJF or PIJB module in advance. The RRRP module does not have buckling search functionalities but if a buckling value is used in the previous PIJF (or PIJB) module, the buckling value is applied.

The RRRP module makes an iteration calculation on the reaction rate. At the end of the iteration process, the module writes a resulting adjustment ratio, common in all cross sections into logical unit 87. Then the adjustment ratio is applied to all the cross sections (including the diffusion coefficients) in EDIT module. Note that an inverse of the adjustment ratio is applied to higher order PL cross sections including the transport cross section to preserve the relation between the diffusion coefficient and transport cross section. When defining IMHD = 4 or 5, the ratio is applied to the higher order PL cross sections and the inverse is to the diffusion coefficients.

To collapse cross sections adjusted in RRRP module, copy the RRRP flux stored in the logical unit 23 to 32 into 4. Then the logical unit 4 is read in the COND module. (The RRRP flux is first stored in the unit 23. The next unit number is allocated when the RRRP module is called next time in single execution. The module can be called ten times maximum.)

(Input format)

PIJF module (see Section 4.1) or PIJB module (see Section 4.4) is necessary to obtain neutron flux distribution in advance. The module can be anywhere before RRRP module.

#1 **INDEX** (A4) : 'RRRP'

#2 **NM1**, **NM2**, **ITMAX**, **IMHD**

NM1,NM2 : Region numbers to be homogenized (**NM1** to **NM2**).

ITMAX : Maximum number of the iteration calculation.

IMHD : Method

- =**1** RRRP method
- =**2** RRP method
- =**3** No application
- =**4** RRRP method (product of transport cross section and flux is preserved)
- =**5** RRP method (product of transport cross section and flux is preserved)

Defining a negative value indicates the flux weighted transport cross section is used in the collision probability calculation during the iteration process.

#3 **EPSRP** : Conversion criterion of cross section.

#4 EDIT module (see Section 4.1)

To obtain cell averaged cross sections reflecting the adjustment ratio.

4.6 Isotope Mix Processing (ISOMIX module)

When a natural element is used (e.g. ID=26 for Fe) and its nuclide ID is not found in the library, SLAROM-UF automatically divides the element into isotopes based on natural abundance data.

The ISOMIX module reconstructs cross sections of the natural element from those of the divided isotopes and rewrites the PDS file.

The following 19 elements are available: Mg, Si, Cl, C, K, Ca, Ti, Cr, Fe, Ni, Cu, Ga, Zr, Nb, Mo, Ag, Nd, Hf, W, and Pb.

To add an element, define its natural abundance data in the subroutine BLOCD (maximum of 20 nuclides).

(Input format)

#1 **INDEX** (6H) : "ISOMIX"

#2 **NAME** (6H) : Name of material that contains isotopes.

(Note 1) Repeat the input as many times as necessary and input 'END' to terminate this module. The PDS file of the designated material is renewed.

(Note 2) ISOMIX module can run without any other module.

5. Cross Section Output Files

This chapter describes output formats of the cross section files. The file is generally called Partitioned Data Set (PDS) file.

5.1 File Type

Table 5.1.1 summarizes cross section files output by SLAROM-UF. The file name is 8 characters where the 7th and 8th characters are fixed.

Table 5.1.1 Cross section output files in SLAROM-UF

Content	7th and 8th characters
(1) Control information (including number of groups and composition data)	SC
(2) Character control information (including titles)	ST
(3) Effective macro cross section	S0
(4) Anisotropic effective macro cross section	Sn ('n' is PL order)
(5) Self-shielding factor of nuclide contained in designated material	SS
(6) Effective micro cross section of nuclide contained in designated material.	SB
(7) Effective micro scattering matrix of nuclide contained in designated material.	SM
(8) Incident energy dependent fission spectrum	SX

5.2 File Format

(File format) (Data type is based on FORTRAN default if not specified)

(1) 'xxxxxxSC' member (control information)

LENG, IMAX, JJB, IPL, MXREAC, NOMICR, ITOT, IDIFF, ISWXI, LENP0X, LENPLX, IHOMO, LENCOM, NGLIB, IB1P1, RTEMP, VOLREG, ICOND, MICOUT, DUM1, (NEL(I), I=1, JJB), (DEN(I), I=1, JJB), (AW(I), I=1, JJB), (MTMICR(I), I=1, NOMICR), (ENBND(I), I=1, IMAX+1), (VEL(I), I=1, IMAX), (LAPSE(I), I=1, IMAX),

IF (IB1P1.GT.0) THEN

AKEFF, AKINF, BSQ, (FLUX(I), I=1, IMAX), (CURENT(I), I=1, IMAX)

ENDIF

IF (IHOMO.EQ.3) THEN

(FLUX(I), I=1, IMAX)

(CURENT(I), I=1, IMAX)

ENDIF

, where

LENG : Data length of designated member (word length).

IMAX : Number of energy groups.

JJB : Number of nuclides included in the material.

IPL : Legendre order of anisotropic scattering data.

MXREAC : Number of reactions in calculated self-shielding factor in 'xxxxxxSS' member. When IHOMO=2 or 3, the member is not output.

NOMICR : Number of reactions in a one-dimensional effective microscopic cross section in 'xxxxxxSB' member

ITOT : Definition of transport cross section.

=0 Flux weighted transport cross section

=1 Current weighted transport cross section

=2 Total cross section

=3 EXPANDA transport cross section.

IDIFF : Definition of diffusion coefficient.

=0 D=$1/3\Sigma_{tr}$ (Σ_{tr} is the flux weighted transport cross section).

=1 D=$1/3\Sigma_{tr}$ (Σ_{tr} is the current weighted transport cross section).

=3 Benoist's averaged diffusion coefficient (defined in EDIT module).

=4 Benoist's perpendicular diffusion coefficient (defined in EDIT module).

ISWXI : Incident energy group dependent fission spectrum member ('xxxxxxSX').

=0/1 : No output / Output

LENP0X : Number of one-dimension reactions (=16 or 18) at zeroth order effective macro cross section in 'xxxxxxS0' member.

LENPLX : Number of one-dimension reactions (=2) at higher order effective macro cross section in 'xxxxxxSn' member.

IHOMO :

=0 Cross sections processed by heterogeneous calculation in PREP or PREPTONE module.

=1 Cross sections processed by homogeneous calculation in PREP module.

=2 Cross sections processed by EDIT module.

=3 Cross sections processed by COND module.

LENCOM : Data length (in words) of 'xxxxxxST' member.

NGLIB : Number of groups used in the fine group calculation.

IB1P1 : 0/1/2: Neither P1 nor B1 formula / P1 formula / B1 formula (The P1 formula option is no longer available even though it is shown).

RTEMP : Temperature (K).

VOLREG : Volume (cm^3).

ICOND : 0/1= Fine group / Collapsed group.

MICOUT : 0/1/-1= output of effective micro scattering matrix (No/No/Yes)

DUM1 : Not used.

NEL : Nuclide code number of nuclides included in the material.

DEN : Atom number density of nuclide included in the material.

AW : Mass of nuclide included in the material.

MTMICR : Reaction ID in one-dimensional effective micro cross section in 'xxxxxxSB' member.

ENBND : Energy boundary (eV).

VEL : Neutron velocity (cm/sec)

LAPSE : Collapse group structure

AKEFF : One point approximated effective neutron multiplication factor derived by B1 formula.

AKINF : One point approximated infinite neutron multiplication factor derived by B1 formula.

BSQ : Buckling used in B1 formula.

FLUX : One point approximated flux derived by B1 formula or flux used in COND module.

CURRENT : One point approximated current spectrum derived by B1 formula or current used in COND module.

(2) 'xxxxxxST' member (character control information)

(TITLE(I), I=1, 18), (CDNAME(I), I=1, 2), (NUCNAM(I, J), I=1, 2), J=1, JJB), (DATE(I), I=1, 2), (MATID(I), I=1, 2), (CODMAT(I), I=1, 2), (FLXID(I), I=1, 2), (CODFLX(I), I=1, 2)

, where

TITLE : Comment of this material (18A4)

CDNAME : Process code name (2A4: CDNAME(1)='SLAR', CDNAME(2)='OM ').

NUCNAM(I,J) : Nuclide name of J-th nuclide (2A4: NUCNAM(1, J) + NUCNAM(2, J)).

DATE : Date (2A4)

MATID : Original material name if IMAX < NGLIB (2A4 : MATID(1) + MATID(2)). Blank If IMAX = NGLIB.

CODMAT : Process code name of MATID (2A4 : CODMAT(1) + CODMAT(2)).

FLXID : Flux member name used to produce this material data (2A4 : FLXID(1) + FLXID(2)).

CODFLX : Process code name of flux member (2A4 : CODFLX(1) + CODFLX(2)).

(3) 'xxxxxxS0' member (macroscopic cross section)

LENG, LENG, IMAX, LEN1D, (LSS(I), LGV(I), (SIG1D(I, MT), MT=1, LEN1D), (SIGS(J, I), J=I+1- LSS(I), I+LGV(I)-LSS(I)), I=1, IMAX)

, where

LENG : Length of this member (in words).

IMAX : No. of energy groups.

LEN1D : No. of 1D reaction.

LSS(I) : Position of self-scattering of I-th group.

LGV(I) : Length of scattering data of I-th group.

SIG1D(I,MT) : I-th group cross section of MT-th reaction.

SIGS(J,I) : Scattering matrix (J=sink group, I=source group) = elastic + inela + 2*n2n + 3*n3n

Table 5.2.1 MT number in S0 member

MT	Reaction	MT	Reaction
1	Production	2	Fission
3	Capture	4	Elastic
5	Inelastic	6	(n,2n)
7	(n,3n)	8	(n,4n)
9	Total	10	Total (Current-weighted)
11	P1 component of total scattering (current-weighted)		
12	P1 component of elastic scattering (current-weighted)		
13	Average diffusion coefficient		
14	Perpendicular diffusion coefficient		
15	Parallel diffusion coefficient		
16	Fission spectrum		
17	Diffusion coefficient (1/(3*transport))		
18	Transport (EXPANDA)		

(4) 'xxxxxxSn' member (anisotropic macroscopic cross section)

LENG, IMAX, LEN1D, (LSS(I), LGV(I), (SIG1D(I, MT), MT=1, LEN1D), (SIGS(J, I), J=I+1-LSS(I), I+LGV(I)-LSS(I)), I=1, IMAX)

, where

LENG : Length of this member (in words).

IMAX : No. of energy groups.

LEN1D : No. of 1D reaction.

LSS(I) : Position of self-scattering of i-th group.

LGV(I) : Length of scattering data of i-th group.

SIG1D(I,MT) : I-th group cross section of MT-th reaction.
MT=1 PL component of elastic cross section,
MT=2 PL component of total scattering.

SIGS(J,I) : PL component of scattering matrix (J=sink group, I=source group) = elastic + inela + 2*n2n + 3*n3n
All data is multiplied by 2n+1 factor.

(5) 'xxxxxxSS' member (self-shielding factor)

LENG, IMAX, MXREAC, JJB, ((LENSF(MT, K), (SSF(I, MT, K), I=1, LENSF(MT, K)), MT=1, MXREAC), K=1, JJB)

,where

LENG : Length of this member (in words).

IMAX : No. of energy groups.

MXREAC : No. of reactions.

JJB : No. of nuclide.

LENSF(MT,K) : Length of self-shielding factors of MT-th reaction for K-th nuclide.
From LENSF(MT,K)+1 to IMAX group, there is no data.

SSF(I,MT,K) : I-th group self-shielding factor of MT-th reaction for K-th nuclide.

MT=1 fission, MT=2 capture, MT=3 elastic, MT=4 total (current weighted), MT=5 elastic removal, MT=6 inelastic

(6) 'xxxxxxSB' member (microscopic cross section)

LENG, IMAX, MXREAC, JJB, ((LENMC(MT, K), (BMIC(I, MT, K), I=1, LENMC(MT, K)), MT=1, MXREAC), K=1, JJB)

, where

LENG : Length of this member (in words).

IMAX : No. of energy groups.

MXREAC : No. of reactions.

JJB : No. of nuclide.

LENMC(MT,K) : Length of effective microscopic cross section of MT-th reaction for K-th nuclide.
From LENMC(MT, K)+1 to IMAX group, cross section is all zero!!!

BMIC(I,MT,K) : I-th group effective micro.
Cross section of MT-th reaction for K-th nuclide reaction type of MT-th data is defined by MTMICR in 'xxxxxxSC' member.

Table 5.2.2 MT number in SB member

MT	Reaction	MT	Reaction
1	Production	2	Fission
3	Capture	4	Elastic
5	Inelastic	6	(n,2n)
7	(n,3n)	8	(n,4n)
9	Total	10	Total (current-weighted)
11	P1 component of total scattering (current-weighted)		
12	P1 component of elastic scattering (current-weighted)		
13	Elastic removal		
14	N/A		
15	N/A		
16	Fission spectrum from library ("R member")		
17	Diffusion coefficient (1/(3*transport))		
18	Transport (EXPANDA)		

(7) 'xxxxxxSM' member (microscopic scattering matrix)

LENG, IMAX, JJB, IPL, (((LNZG(ITYPE, IP, MT), (LGVM(I, ITYPE, IP, MT), (SIGS(KK, IP, MT), KK=1, LGVM(I, ITYPE, IP, MT)), I=1, LNZG(ITYPE, IP, MT)), ITYPE=1, MXR2D), IP=1, IPL), MT=1, JJB)

, where

LENG : Length of this member (in words).

IMAX : No. of energy groups.

JJB : No. of nuclides.

IPL : PL order.

LNZG(ITYPE,IP,MT) : Maximum energy group number with non-zero data (ITYPE=reaction type, IP=PL order + 1, MT=nuclide)

LGVM(I,ITYPE,IP,MT) : Length of scattering data of I-th group

SIGS(KK,IP,MT) : Scattering matrix (KK=sequential data number for ITYPE, LNZG, and LGVM, IP=PL order + 1, MT=nuclide)

(8) 'xxxxxxSX' member (incident energy dependent fission spectrum). Output when ISWXI in 'xxxxxxSC'=1.

LENG, IMAX, ICHVEC, MXDWNX, (ICHNG(I), I=1, IMAX), ((CHIV(J, K), J=1, MXDWNX), K=1, ICHVEC)

, where

LENG : Length of this member (in words).

IMAX : No. of energy groups.

ICHVEV : Lowest energy group number at which dependency on incident energy exists.

MXDWNX : Lowest energy group number at which fission spectrum data is not zero.

ICHNG(I) : Specify the position in CHIV data for I-th group fission spectrum.

CHIV(J,K) : J-th group fission spectrum data by K-th source.

6. How to Install

6.1 System Requirement

- SLAROM-UF is written in FORTRAN 77 and works on LINUX operating system. It may work on other UNIX operating systems, but has not been tested.
- Use GNU FORTRAN (g77) to compile SLAROM-UF. Other FORTRAN compiler may work, but has not been tested.
- Disk space about 1GByte is necessary for a library set. The library data is independent each other among nuclides and group constants, and the user can save required disk space by removing unused data.
- In execution, additional disk space is necessary to store cross section files. In case of 900 group calculation with microscopic scattering matrix output, disk space about 1MByte per nuclide is required.
- Memory space required depends on calculation cases. In case of the 900 group calculation in 25 regions, about 300MByte is needed.

6.2 Installation

1 The user needs to have archived files:

1. slarom-uf-xxxxxx.tgz : SLAROM-UF code ("xxxxxx " is a version number)
2. uflib_xxx-xxxxxx.tgz : Cross section library ("xxx" is an identifier of evaluated nuclear data files.
   Ex. "j32" for JENDL-3.2, "j33" for JENDL-3.3, "e7" for ENDF/B-VII-0, "jf31" for JEFF-3.1)

2 Extract files from the above files with the tar command.

Ex. tar xvfo slarom-uf-xxxxxx.tgz

1. Extracting from slarom-uf-xxxxxx.tgz, the user will find at least following directory structure.

   slarom-uf
   - /**pij** — part of source files
   - /**plot**— part of source files
   - /**sample** — sample input
     - /**out.org** — sample output
   - /**src** — main source files

2. Extracting from uflib_xxx-xxxxxx.tgz, the user will find at least following directory structure. See Section 2 for details about the library contents.

   UFLIB.XXX ("XXX" is in capitals of the library identifier "xxx")
   - /**LIB.g70** — 70 group constants
   - /**LIB.g175** — 175 group constants
   - /**LIB.g900** — 900 group constants
   - /**Pmcross** — PMCROSS library

Some additional directories will be created depending on distributed packages.

6.3 Compile

Go to the slarom-uf directory and type "make". Then slarom-uf.lm, the load module of SLAROM-UF, will be created.

The maximum values of parameters used in the code, such as number of nuclides and number of energy groups, are defined in the include file (see Table C.1). If the users needs larger or smaller values, modify the include file and compile all.

6.4 Execution

1 SLAROM-UF uses environment variables in Table 6.4.1. The user must define the variables before execution.

Table 6.4.1 Environment variables used in SLAROM-UF

Environment variable	Usage
INDEX	Path of the Index file
JFSLIB	Directory path of the fine group constants
MCROSS	Directory path of PMCROSS library
PDSIN	Directory path of PDS file for effective cross section to input
PDSOUT	Directory path of PDS file for effective cross section to output
WORKPDS	Work directory path of PDS file
UMCROSS	Directory path of User MCROSS library

The path name must be within 70 characters. The relative path can be used with the path length less than 130 characters.

2 The user can execute SLAROM-UF with the command:

slarom-uf.lm < input file > output file

Above two procedures are usually carried out with a shell script file. A sample of the shell script is described in Appendix B.

When the execution ends normally, the user-designated cross sections are output. For example, when outputting a cross section named "ICVHOM", each member (depicted in italic letters) is written in the directory designated by the environment variable PDSOUT together with the following messages at the end of the printout file (the logical utnit 6).

```
** NAMOUT IS RESETTING : ICVHOM
MEMBER ICVHOMSC OF LENGTH 443 IS STORED IN PDSOUT FILE
MEMBER ICVHOMST OF LENGTH 68 IS STORED IN PDSOUT FILE
MEMBER ICVHOMS0 OF LENGTH 3720 IS STORED IN PDSOUT FILE
MEMBER ICVHOMS1 OF LENGTH 2659 IS STORED IN PDSOUT FILE
MEMBER ICVHOMSS OF LENGTH 5306 IS STORED IN PDSOUT FILE
MEMBER ICVHOMSB OF LENGTH 8169 IS STORED IN PDSOUT FILE
MEMBER ICVHOMSX OF LENGTH 3014 IS STORED IN PDSOUT FILE
```

The status of each module can be confirmed in the printout file by the comment telling the normal end of each module. Ex. ***** PATH ROUTINE DONE ****** in case of PATH module.

A message in the debug information file (unit 99) would be a help to identify an error when an abnormality occured.

6.5 I/O Units Information

SLAROM-UF uses logical units in Table 6.5.1.

Table 6.5.1 Logical units used in SLAROM-UF

Logical Unit	Type	Content	Remark
5	Text	Input file	
6	Text	Printout file	
99	Text	Debug output	
95	Text	Work file	Used in REAM, REAI
96	Text	Work file	Used in NUCCHG
4	Binary	Neutron flux	Used in EDIT, PIJB
20	Binary	Collision probability calc. work file	St stored
21	Binary	Collision probability calc. work file	Pij stored
22	Binary	Collision probability calc. work file	Anisotropic Pij stored
23-32	Binary	Neutron flux for RRRP module	
81-84	Binary	Collision probability calc. work file	Path table
86-87	Binary	Effective cross section calc. work file.	
88	Text	Punch-out data	
89	Text	Post script file	Graphic output

Logical unit # 1,2,3,33,90,91 are also used.

6.6 Typical Running Time

Running time depends on the number of regions and the energy group structure. Typical running time is listed in Table 6.6.1. For a two-dimensional structure, it is not practical to apply the PEACO option.

Table 6.6.1 Typical running time

System	Fine group constant and UF option	CPU (second)
Homogeneous	70-group	2
	70-group+PEACO	49
	175-group+PEACO	51
	900-group +PEACO	86
Heterogeneous (18 regions)	70-group	5
	70-group +PEACO	190
	175-group +PEACO	206
	900-group +PEACO	694

Computer environment : Pentium4 2.8GHz LINUX-OSProblem: typical fuel cell (SCF cell, 1-D slab cell) of ZPPR-9 critical experiment.Number of nuclides : 19 (UF calculation considers 18 nuclides excluding hydrogen)

6.7 Restriction

SLAROM-UF is dedicated to fast reactor neutronics calculations and cannot treat photon data. The code also does not deal with either upper scattering or the thermal scattering data.

The UF calculation option is practically not available due to too large runnning time. The reflective boundary condition is not available in the slab geometry. The adjoint calculation is not available.

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Appendix A Energy Structure of the Fine Group Constants

Energy group structure of the 70 and 175 group constants are listed in Table A.1 and that of the 900 group constant in Table A.2. The lowest energy is common among the three constants and always 10^{-5}eV.

Table A.1 70 and 175 group structures

Group		Upper energy (eV)	lethargy	Δu	Group		Upper energy (eV)	lethargy	Δu
70G	175G				70G	175G			
	1	2.00000E+7	-0.69315	0.21315	8	50	1.73774E+6	1.75000	0.05000
	2	1.61607E+7	0.29315	0.08000		51	1.65299E+6	1.80000	0.05000
	3	1.49182E+7	-0.40000	0.02500		52	1.57237E+6	1.85000	0.05000
	4	1.45499E+7	-0.37500	0.02500		53	1.49569E+6	1.90000	0.05000
	5	1.41907E+7	-0.35000	0.02500		54	1.42274E+6	1.95000	0.05000
	6	1.38403E+7	-0.32500	0.02500	9	55	1.35335E+6	2.00000	0.05000
	7	1.34986E+7	-0.30000	0.05000		56	1.28735E+6	2.05000	0.05000
	8	1.28403E+7	-0.25000	0.02501		57	1.22456E+6	2.10000	0.05000
	9	1.25232E+7	-0.22500	0.02500		58	1.16484E+6	2.15000	0.05000
	10	1.22140E+7	-0.20000	0.05000		59	1.10803E+6	2.20000	0.05000
	11	1.16183E+7	-0.15000	0.05000	10	60	1.05399E+6	2.25000	0.05000
	12	1.10517E+7	-0.10000	0.05000		61	1.00259E+6	2.30000	0.04170
	13	1.05127E+7	-0.05000	0.05000		62	9.61640E+5	2.34170	0.05830
1	14	1.00000E+7	0.00000	0.05000		63	9.07180E+5	2.40000	0.05000
	15	9.51229E+6	0.05000	0.05000		64	8.62936E+5	2.45000	0.05000
	16	9.04837E+6	0.10000	0.05000	11	65	8.20850E+5	2.50000	0.05000
	17	8.60708E+6	0.15000	0.05000		66	7.80817E+5	2.55000	0.05000
	18	8.18731E+6	0.20000	0.05000		67	7.42736E+5	2.60000	0.05000
2	19	7.78801E+6	0.25000	0.05000		68	7.06512E+5	2.65000	0.05000
	20	7.40818E+6	0.30000	0.05000		69	6.72055E+5	2.70000	0.05000
	21	7.04688E+6	0.35000	0.05000	12	70	6.39279E+5	2.75000	0.05000
	22	6.70320E+6	0.40000	0.01667		71	6.08101E+5	2.80000	0.05000
	23	6.59241E+6	0.41667	0.03333		72	5.78443E+5	2.85000	0.05000
	24	6.37628E+6	0.45000	0.05000		73	5.50232E+5	2.90000	0.05000
3	25	6.06531E+6	0.50000	0.05000		74	5.23397E+5	2.95000	0.05000
	26	5.76950E+6	0.55000	0.05000	13	75	4.97871E+5	3.00000	0.10000
	27	5.48812E+6	0.60000	0.05000		76	4.50492E+5	3.10000	0.10000
	28	5.22046E+6	0.65000	0.05000		77	4.07622E+5	3.20000	0.05000
	29	4.96585E+6	0.70000	0.05000	14	78	3.87742E+5	3.25000	0.05000
4	30	4.72367E+6	0.75000	0.05000		79	3.68832E+5	3.30000	0.10000
	31	4.49329E+6	0.80000	0.10000		80	3.33733E+5	3.40000	0.10000
	32	4.06570E+6	0.90000	0.10000	15	81	3.01974E+5	3.50000	0.01160
5	33	3.67879E+6	1.00000	0.10000		82	2.98491E+5	3.51160	0.00430
	34	3.32871E+6	1.10000	0.05000		83	2.97210E+5	3.51590	0.00910
	35	3.16637E+6	1.15000	0.05000		84	2.94518E+5	3.52500	0.02500
	36	3.01194E+6	1.20000	0.05000		85	2.87246E+5	3.55000	0.05000
6	37	2.86505E+6	1.25000	0.05000		86	2.73237E+5	3.60000	0.10000
	38	2.72532E+6	1.30000	0.05000		87	2.47235E+5	3.70000	0.05000
	39	2.59240E+6	1.35000	0.05000	16	88	2.35177E+5	3.75000	0.05000
	40	2.46597E+6	1.40000	0.03333		89	2.23708E+5	3.80000	0.05000
	41	2.38513E+6	1.43333	0.00834		90	2.12797E+5	3.85000	0.05000
	42	2.36533E+6	1.44167	0.00833		91	2.02419E+5	3.90000	0.05000
	43	2.34570E+6	1.45000	0.01667		92	1.92547E+5	3.95000	0.05000
	44	2.30693E+6	1.46667	0.03333	17	93	1.83156E+5	4.00000	0.05000
7	45	2.23130E+6	1.50000	0.05000		94	1.74224E+5	4.05000	0.05000
	46	2.12248E+6	1.55000	0.05000		95	1.65727E+5	4.10000	0.05000
	47	2.01897E+6	1.60000	0.05000		96	1.57644E+5	4.15000	0.05000
	48	1.92050E+6	1.65000	0.05000		97	1.49956E+5	4.20000	0.05000
	49	1.82684E+6	1.70000	0.05000					

Continued Table of 70g and 175 group structures (2/2)

Group		Upper energy (eV)	lethargy	Δu	Group		Upper energy (eV)	lethargy	Δu
70G	175G				70G	175G			
18	98	1.42642E+5	4.25000	0.04999	38	142	9.61117E+2	9.25000	0.25000
	99	1.35686E+5	4.30000	0.05000	39	143	7.48518E+2	9.50000	0.25000
	100	1.29068E+5	4.35000	0.05000	40	144	5.82947E+2	9.75000	0.25000
	101	1.22773E+5	4.40000	0.04999	41	145	4.53999E+2	10.00000	0.25000
	102	1.16786E+5	4.45000	0.05000	42	146	3.53575E+2	10.25000	0.25000
19	103	1.11090E+5	4.50000	0.12500	43	147	2.75364E+2	10.50000	0.25000
	104	9.80366E+4	4.62500	0.12500	44	148	2.14454E+2	10.75000	0.25000
20	105	8.65170E+4	4.75000	0.04760	45	149	1.67017E+2	11.00000	0.25000
	106	8.24952E+4	4.79760	0.03690	46	150	1.30073E+2	11.25000	0.25000
	107	7.95066E+4	4.83450	0.09910	47	151	1.01301E+2	11.50000	0.25000
	108	7.20053E+4	4.93360	0.06640	48	152	7.88932E+1	11.75000	0.25000
21	109	6.73795E+4	5.00000	0.10000	49	153	6.14421E+1	12.00000	0.25000
	110	6.09675E+4	5.10000	0.07500	50	154	4.78512E+1	12.25000	0.25000
	111	5.65622E+4	5.17500	0.07500	51	155	3.72665E+1	12.50000	0.25000
22	112	5.24752E+4	5.25000	0.04600	52	156	2.90232E+1	12.75000	0.25000
	113	5.01160E+4	5.29600	0.10400	53	157	2.26033E+1	13.00000	0.25000
	114	4.51658E+4	5.40000	0.10000	54	158	1.76035E+1	13.25000	0.25000
23	115	4.08677E+4	5.50000	0.15000	55	159	1.37096E+1	13.50000	0.25000
	116	3.51752E+4	5.65000	0.10000	56	160	1.06770E+1	13.75000	0.25000
24	117	3.18278E+4	5.75000	0.10000	57	161	8.31529E+0	14.00000	0.25000
	118	2.87990E+4	5.85000	0.05000	58	162	6.47595E+0	14.25000	0.25000
	119	2.73944E+4	5.90000	0.05000	59	163	5.04348E+0	14.50000	0.25000
	120	2.60584E+4	5.95000	0.05000	60	164	3.92786E+0	14.75000	0.25000
25	121	2.47875E+4	6.00000	0.05000	61	165	3.05902E+0	15.00000	0.25000
	122	2.35786E+4	6.05000	0.10000	62	166	2.38237E+0	15.25000	0.25000
	123	2.13348E+4	6.15000	0.10000	63	167	1.85539E+0	15.50000	0.25000
26	124	1.93045E+4	6.25000	0.25000	64	168	1.44498E+0	15.75000	0.25000
27	125	1.50344E+4	6.50000	0.25000	65	169	1.12535E+0	16.00000	0.25000
28	126	1.17088E+4	6.75000	0.10000	66	170	8.76425E-1	16.25000	0.25000
	127	1.05946E+4	6.85000	0.15000	67	171	6.82560E-1	16.50000	0.25000
29	128	9.11882E+3	7.00000	0.25000	68	172	5.31579E-1	16.75000	0.25000
30	129	7.10174E+3	7.25000	0.25000	69	173	4.13994E-1	17.00000	0.25000
31	130	5.53084E+3	7.50000	0.25000	70	174	3.22419E-1	17.25000	1.00000
32	131	4.30743E+3	7.75000	0.15000		175	1.18611E-1	18.25000	9.38102
	132	3.70744E+3	7.90000	0.10000					
33	133	3.35463E+3	8.00000	0.10000					
	134	3.03539E+3	8.10000	0.10000					
	135	2.74654E+3	8.20000	0.05000					
34	136	2.61259E+3	8.25000	0.05000					
	137	2.48517E+3	8.30000	0.10000					
	138	2.24867E+3	8.40000	0.10000					
35	139	2.03468E+3	8.50000	0.25000					
36	140	1.58461E+3	8.75000	0.25000					
37	141	1.23410E+3	9.00000	0.25000					

Table A.2 900g group structure

Group	Upper energy (eV)	lethargy	Δu	Group	Upper energy (eV)	lethargy	Δu
1	2.00000E+7	-0.69315	0.21315	51	1.09199E+7	-0.08800	0.00800
2	1.61607E+7	-0.48000	0.00800	52	1.08329E+7	-0.08000	0.00800
3	1.60320E+7	-0.47200	0.00800	53	1.07466E+7	-0.07200	0.00800
4	1.59042E+7	-0.46400	0.00800	54	1.06609E+7	-0.06400	0.00800
5	1.57775E+7	-0.45600	0.00800	55	1.05760E+7	-0.05600	0.00600
6	1.56518E+7	-0.44800	0.00800	56	1.05127E+7	-0.05000	0.01000
7	1.55271E+7	-0.44000	0.00800	57	1.04081E+7	-0.04000	0.00800
8	1.54034E+7	-0.43200	0.00800	58	1.03252E+7	-0.03200	0.00800
9	1.52806E+7	-0.42400	0.00800	59	1.02429E+7	-0.02400	0.00800
10	1.51589E+7	-0.41600	0.00800	60	1.01613E+7	-0.01600	0.00800
11	1.50381E+7	-0.40800	0.00800	61	1.00803E+7	-0.00800	0.00800
12	1.49182E+7	-0.40000	0.00800	62	1.00000E+7	0.00000	0.00800
13	1.47994E+7	-0.39200	0.00800	63	9.92032E+6	0.00800	0.00800
14	1.46815E+7	-0.38400	0.00900	64	9.84127E+6	0.01600	0.00800
15	1.45499E+7	-0.37500	0.00700	65	9.76286E+6	0.02400	0.00800
16	1.44484E+7	-0.36800	0.00800	66	9.68507E+6	0.03200	0.00800
17	1.43333E+7	-0.36000	0.01000	67	9.60789E+6	0.04000	0.01000
18	1.41907E+7	-0.35000	0.00600	68	9.51229E+6	0.05000	0.00600
19	1.41058E+7	-0.34400	0.00800	69	9.45539E+6	0.05600	0.00800
20	1.39934E+7	-0.33600	0.01100	70	9.38005E+6	0.06400	0.00800
21	1.38403E+7	-0.32500	0.00500	71	9.30531E+6	0.07200	0.00800
22	1.37713E+7	-0.32000	0.00800	72	9.23116E+6	0.08000	0.00800
23	1.36615E+7	-0.31200	0.01200	73	9.15761E+6	0.08800	0.00800
24	1.34986E+7	-0.30000	0.00400	74	9.08464E+6	0.09600	0.00400
25	1.34447E+7	-0.29600	0.00800	75	9.04837E+6	0.10000	0.01200
26	1.33376E+7	-0.28800	0.00800	76	8.94044E+6	0.11200	0.00800
27	1.32313E+7	-0.28000	0.00800	77	8.86920E+6	0.12000	0.00800
28	1.31259E+7	-0.27200	0.00800	78	8.79853E+6	0.12800	0.00800
29	1.30213E+7	-0.26400	0.00800	79	8.72843E+6	0.13600	0.00800
30	1.29175E+7	-0.25600	0.00600	80	8.65888E+6	0.14400	0.00600
31	1.28403E+7	-0.25000	0.01000	81	8.60708E+6	0.15000	0.01000
32	1.27125E+7	-0.24000	0.00800	82	8.52144E+6	0.16000	0.00800
33	1.26112E+7	-0.23200	0.00700	83	8.45354E+6	0.16800	0.00800
34	1.25232E+7	-0.22500	0.00900	84	8.38618E+6	0.17600	0.00800
35	1.24110E+7	-0.21600	0.00800	85	8.31936E+6	0.18400	0.00800
36	1.23121E+7	-0.20800	0.00800	86	8.25307E+6	0.19200	0.00800
37	1.22140E+7	-0.20000	0.00800	87	8.18731E+6	0.20000	0.00800
38	1.21167E+7	-0.19200	0.00800	88	8.12207E+6	0.20800	0.00800
39	1.20202E+7	-0.18400	0.00800	89	8.05735E+6	0.21600	0.00800
40	1.19244E+7	-0.17600	0.00800	90	7.99315E+6	0.22400	0.00800
41	1.18294E+7	-0.16800	0.00800	91	7.92946E+6	0.23200	0.00800
42	1.17351E+7	-0.16000	0.01000	92	7.86628E+6	0.24000	0.01000
43	1.16183E+7	-0.15000	0.00600	93	7.78801E+6	0.25000	0.00600
44	1.15488E+7	-0.14400	0.00800	94	7.74142E+6	0.25600	0.00800
45	1.14568E+7	-0.13600	0.00800	95	7.67974E+6	0.26400	0.00800
46	1.13655E+7	-0.12800	0.00800	96	7.61854E+6	0.27200	0.00800
47	1.12750E+7	-0.12000	0.00800	97	7.55784E+6	0.28000	0.00800
48	1.11851E+7	-0.11200	0.00800	98	7.49762E+6	0.28800	0.00800
49	1.10960E+7	-0.10400	0.00400	99	7.43787E+6	0.29600	0.00400
50	1.10517E+7	-0.10000	0.01200	100	7.40818E+6	0.30000	0.01200

Continued Table of 900 group structure (2/9)

Group	Upper energy (eV)	lethargy	Δu	Group	Upper energy (eV)	lethargy	Δu
101	7.31982E+6	0.31200	0.00800	151	4.90662E+6	0.71200	0.00800
102	7.26149E+6	0.32000	0.00800	152	4.86752E+6	0.72000	0.00800
103	7.20363E+6	0.32800	0.00800	153	4.82874E+6	0.72800	0.00800
104	7.14623E+6	0.33600	0.00800	154	4.79026E+6	0.73600	0.00800
105	7.08929E+6	0.34400	0.00600	155	4.75209E+6	0.74400	0.00600
106	7.04688E+6	0.35000	0.01000	156	4.72367E+6	0.75000	0.01000
107	6.97676E+6	0.36000	0.00800	157	4.67666E+6	0.76000	0.00800
108	6.92117E+6	0.36800	0.00800	158	4.63940E+6	0.76800	0.00800
109	6.86602E+6	0.37600	0.00800	159	4.60243E+6	0.77600	0.00800
110	6.81131E+6	0.38400	0.00800	160	4.56576E+6	0.78400	0.00800
111	6.75704E+6	0.39200	0.00800	161	4.52938E+6	0.79200	0.00800
112	6.70320E+6	0.40000	0.00800	162	4.49329E+6	0.80000	0.00800
113	6.64979E+6	0.40800	0.00867	163	4.45749E+6	0.80800	0.00800
114	6.59241E+6	0.41667	0.00733	164	4.42197E+6	0.81600	0.00800
115	6.54424E+6	0.42400	0.00800	165	4.38673E+6	0.82400	0.00800
116	6.49209E+6	0.43200	0.00800	166	4.35178E+6	0.83200	0.00800
117	6.44036E+6	0.44000	0.01000	167	4.31711E+6	0.84000	0.00800
118	6.37628E+6	0.45000	0.00600	168	4.28271E+6	0.84800	0.00800
119	6.33814E+6	0.45600	0.00800	169	4.24858E+6	0.85600	0.00800
120	6.28764E+6	0.46400	0.00800	170	4.21473E+6	0.86400	0.00800
121	6.23754E+6	0.47200	0.00800	171	4.18114E+6	0.87200	0.00800
122	6.18783E+6	0.48000	0.00800	172	4.14783E+6	0.88000	0.00800
123	6.13853E+6	0.48800	0.01200	173	4.11478E+6	0.88800	0.01200
124	6.06531E+6	0.50000	0.00400	174	4.06570E+6	0.90000	0.00400
125	6.04109E+6	0.50400	0.00800	175	4.04947E+6	0.90400	0.00800
126	5.99296E+6	0.51200	0.00800	176	4.01720E+6	0.91200	0.00800
127	5.94521E+6	0.52000	0.00800	177	3.98519E+6	0.92000	0.00800
128	5.89783E+6	0.52800	0.00800	178	3.95344E+6	0.92800	0.00800
129	5.85084E+6	0.53600	0.00800	179	3.92193E+6	0.93600	0.00800
130	5.80422E+6	0.54400	0.00600	180	3.89068E+6	0.94400	0.00800
131	5.76950E+6	0.55000	0.01000	181	3.85968E+6	0.95200	0.00800
132	5.71209E+6	0.56000	0.00800	182	3.82893E+6	0.96000	0.00800
133	5.66658E+6	0.56800	0.00800	183	3.79842E+6	0.96800	0.00800
134	5.62142E+6	0.57600	0.00800	184	3.76815E+6	0.97600	0.00800
135	5.57663E+6	0.58400	0.00800	185	3.73813E+6	0.98400	0.00800
136	5.53220E+6	0.59200	0.00800	186	3.70834E+6	0.99200	0.00800
137	5.48812E+6	0.60000	0.00800	187	3.67879E+6	1.00000	0.00800
138	5.44439E+6	0.60800	0.00800	188	3.64948E+6	1.00800	0.00800
139	5.40101E+6	0.61600	0.00800	189	3.62040E+6	1.01600	0.00800
140	5.35797E+6	0.62400	0.00800	190	3.59155E+6	1.02400	0.00800
141	5.31528E+6	0.63200	0.00800	191	3.56294E+6	1.03200	0.00800
142	5.27292E+6	0.64000	0.01000	192	3.53455E+6	1.04000	0.00800
143	5.22046E+6	0.65000	0.00600	193	3.50638E+6	1.04800	0.00800
144	5.18923E+6	0.65600	0.00800	194	3.47844E+6	1.05600	0.00800
145	5.14788E+6	0.66400	0.00800	195	3.45073E+6	1.06400	0.00800
146	5.10686E+6	0.67200	0.00800	196	3.42323E+6	1.07200	0.00800
147	5.06617E+6	0.68000	0.00800	197	3.39596E+6	1.08000	0.00800
148	5.02580E+6	0.68800	0.01200	198	3.36890E+6	1.08800	0.01200
149	4.96585E+6	0.70000	0.00400	199	3.32871E+6	1.10000	0.00400
150	4.94603E+6	0.70400	0.00800	200	3.31542E+6	1.10400	0.00800

Continued Table of 900 group structure (3/9)

Group	Upper energy (eV)	lethargy	Δu	Group	Upper energy (eV)	lethargy	Δu
201	3.28901E+6	1.11200	0.00800	251	2.20469E+6	1.51200	0.00800
202	3.26280E+6	1.12000	0.00800	252	2.18712E+6	1.52000	0.00800
203	3.23680E+6	1.12800	0.00800	253	2.16969E+6	1.52800	0.00800
204	3.21101E+6	1.13600	0.00800	254	2.15240E+6	1.53600	0.00800
205	3.18542E+6	1.14400	0.00600	255	2.13525E+6	1.54400	0.00600
206	3.16637E+6	1.15000	0.01000	256	2.12248E+6	1.55000	0.01000
207	3.13486E+6	1.16000	0.00800	257	2.10136E+6	1.56000	0.00800
208	3.10988E+6	1.16800	0.00800	258	2.08462E+6	1.56800	0.00800
209	3.08510E+6	1.17600	0.00800	259	2.06801E+6	1.57600	0.00800
210	3.06052E+6	1.18400	0.00800	260	2.05153E+6	1.58400	0.00800
211	3.03613E+6	1.19200	0.00800	261	2.03518E+6	1.59200	0.00800
212	3.01194E+6	1.20000	0.00800	262	2.01897E+6	1.60000	0.00800
213	2.98794E+6	1.20800	0.00800	263	2.00288E+6	1.60800	0.00800
214	2.96413E+6	1.21600	0.00800	264	1.98692E+6	1.61600	0.00800
215	2.94052E+6	1.22400	0.00800	265	1.97109E+6	1.62400	0.00800
216	2.91709E+6	1.23200	0.00800	266	1.95538E+6	1.63200	0.00800
217	2.89384E+6	1.24000	0.01000	267	1.93980E+6	1.64000	0.01000
218	2.86505E+6	1.25000	0.00600	268	1.92050E+6	1.65000	0.00600
219	2.84791E+6	1.25600	0.00800	269	1.90901E+6	1.65600	0.00800
220	2.82522E+6	1.26400	0.00800	270	1.89380E+6	1.66400	0.00800
221	2.80271E+6	1.27200	0.00800	271	1.87871E+6	1.67200	0.00800
222	2.78037E+6	1.28000	0.00800	272	1.86374E+6	1.68000	0.00800
223	2.75822E+6	1.28800	0.01200	273	1.84889E+6	1.68800	0.00800
224	2.72532E+6	1.30000	0.00400	274	1.83416E+6	1.69600	0.00400
225	2.71444E+6	1.30400	0.00800	275	1.82684E+6	1.70000	0.01200
226	2.69281E+6	1.31200	0.00800	276	1.80504E+6	1.71200	0.00800
227	2.67135E+6	1.32000	0.00800	277	1.79066E+6	1.72000	0.00800
228	2.65007E+6	1.32800	0.00800	278	1.77639E+6	1.72800	0.00800
229	2.62895E+6	1.33600	0.00800	279	1.76224E+6	1.73600	0.00800
230	2.60800E+6	1.34400	0.00600	280	1.74820E+6	1.74400	0.00600
231	2.59240E+6	1.35000	0.01000	281	1.73774E+6	1.75000	0.01000
232	2.56661E+6	1.36000	0.00800	282	1.72045E+6	1.76000	0.00800
233	2.54616E+6	1.36800	0.00800	283	1.70674E+6	1.76800	0.00800
234	2.52587E+6	1.37600	0.00800	284	1.69314E+6	1.77600	0.00800
235	2.50574E+6	1.38400	0.00800	285	1.67965E+6	1.78400	0.00800
236	2.48578E+6	1.39200	0.00800	286	1.66627E+6	1.79200	0.00800
237	2.46597E+6	1.40000	0.00800	287	1.65299E+6	1.80000	0.00800
238	2.44632E+6	1.40800	0.00800	288	1.63982E+6	1.80800	0.00800
239	2.42683E+6	1.41600	0.00800	289	1.62675E+6	1.81600	0.00800
240	2.40749E+6	1.42400	0.00933	290	1.61379E+6	1.82400	0.00800
241	2.38513E+6	1.43333	0.00833	291	1.60093E+6	1.83200	0.00800
242	2.36533E+6	1.44167	0.00833	292	1.58817E+6	1.84000	0.01000
243	2.34570E+6	1.45000	0.00600	293	1.57237E+6	1.85000	0.00600
244	2.33167E+6	1.45600	0.01067	294	1.56297E+6	1.85600	0.00800
245	2.30693E+6	1.46667	0.00533	295	1.55051E+6	1.86400	0.00800
246	2.29466E+6	1.47200	0.00800	296	1.53816E+6	1.87200	0.00800
247	2.27638E+6	1.48000	0.00800	297	1.52590E+6	1.88000	0.00800
248	2.25824E+6	1.48800	0.01200	298	1.51374E+6	1.88800	0.01200
249	2.23130E+6	1.50000	0.00400	299	1.49569E+6	1.90000	0.00400
250	2.22239E+6	1.50400	0.00800	300	1.48972E+6	1.90400	0.00800

Continued Table of 900 group structure (4/9)

Group	Upper energy (eV)	lethargy	Δu	Group	Upper energy (eV)	lethargy	Δu
301	1.47785E+6	1.91200	0.00800	351	9.90629E+5	2.31200	0.00800
302	1.46607E+6	1.92000	0.00800	352	9.82736E+5	2.32000	0.00800
303	1.45439E+6	1.92800	0.00800	353	9.74905E+5	2.32800	0.00800
304	1.44280E+6	1.93600	0.00800	354	9.67137E+5	2.33600	0.00570
305	1.43130E+6	1.94400	0.00600	355	9.61640E+5	2.34170	0.01030
306	1.42274E+6	1.95000	0.01000	356	9.51786E+5	2.35200	0.00800
307	1.40858E+6	1.96000	0.00800	357	9.44202E+5	2.36000	0.00800
308	1.39736E+6	1.96800	0.00800	358	9.36679E+5	2.36800	0.00800
309	1.38623E+6	1.97600	0.00800	359	9.29215E+5	2.37600	0.00800
310	1.37518E+6	1.98400	0.00800	360	9.21811E+5	2.38400	0.00800
311	1.36422E+6	1.99200	0.00800	361	9.14466E+5	2.39200	0.00800
312	1.35335E+6	2.00000	0.00800	362	9.07180E+5	2.40000	0.00800
313	1.34257E+6	2.00800	0.00800	363	8.99951E+5	2.40800	0.00800
314	1.33187E+6	2.01600	0.00800	364	8.92780E+5	2.41600	0.00800
315	1.32126E+6	2.02400	0.00800	365	8.85666E+5	2.42400	0.00800
316	1.31073E+6	2.03200	0.00800	366	8.78609E+5	2.43200	0.00800
317	1.30029E+6	2.04000	0.01000	367	8.71609E+5	2.44000	0.01000
318	1.28735E+6	2.05000	0.00600	368	8.62936E+5	2.45000	0.00600
319	1.27965E+6	2.05600	0.00800	369	8.57774E+5	2.45600	0.00800
320	1.26945E+6	2.06400	0.00800	370	8.50939E+5	2.46400	0.00800
321	1.25934E+6	2.07200	0.00800	371	8.44159E+5	2.47200	0.00800
322	1.24930E+6	2.08000	0.00800	372	8.37432E+5	2.48000	0.00800
323	1.23935E+6	2.08800	0.01200	373	8.30760E+5	2.48800	0.01200
324	1.22456E+6	2.10000	0.00400	374	8.20850E+5	2.50000	0.00400
325	1.21968E+6	2.10400	0.00800	375	8.17573E+5	2.50400	0.00800
326	1.20996E+6	2.11200	0.00800	376	8.11059E+5	2.51200	0.00800
327	1.20032E+6	2.12000	0.00800	377	8.04596E+5	2.52000	0.00800
328	1.19075E+6	2.12800	0.00800	378	7.98185E+5	2.52800	0.00800
329	1.18126E+6	2.13600	0.00800	379	7.91825E+5	2.53600	0.00800
330	1.17185E+6	2.14400	0.00600	380	7.85516E+5	2.54400	0.00600
331	1.16484E+6	2.15000	0.01000	381	7.80817E+5	2.55000	0.01000
332	1.15325E+6	2.16000	0.00800	382	7.73047E+5	2.56000	0.00800
333	1.14406E+6	2.16800	0.00800	383	7.66888E+5	2.56800	0.00800
334	1.13495E+6	2.17600	0.00800	384	7.60777E+5	2.57600	0.00800
335	1.12590E+6	2.18400	0.00800	385	7.54715E+5	2.58400	0.00800
336	1.11693E+6	2.19200	0.00800	386	7.48702E+5	2.59200	0.00800
337	1.10803E+6	2.20000	0.00800	387	7.42736E+5	2.60000	0.00800
338	1.09920E+6	2.20800	0.00800	388	7.36818E+5	2.60800	0.00800
339	1.09044E+6	2.21600	0.00800	389	7.30947E+5	2.61600	0.00800
340	1.08176E+6	2.22400	0.00800	390	7.25122E+5	2.62400	0.00800
341	1.07314E+6	2.23200	0.00800	391	7.19344E+5	2.63200	0.00800
342	1.06459E+6	2.24000	0.01000	392	7.13613E+5	2.64000	0.01000
343	1.05399E+6	2.25000	0.00600	393	7.06512E+5	2.65000	0.00600
344	1.04769E+6	2.25600	0.00800	394	7.02286E+5	2.65600	0.00800
345	1.03934E+6	2.26400	0.00800	395	6.96690E+5	2.66400	0.00800
346	1.03106E+6	2.27200	0.00800	396	6.91139E+5	2.67200	0.00800
347	1.02284E+6	2.28000	0.00800	397	6.85632E+5	2.68000	0.00800
348	1.01469E+6	2.28800	0.01200	398	6.80168E+5	2.68800	0.01200
349	1.00259E+6	2.30000	0.00400	399	6.72055E+5	2.70000	0.00400
350	9.98586E+5	2.30400	0.00800	400	6.69372E+5	2.70400	0.00800

Continued Table of 900 group structure (5/9)

Group	Upper energy (eV)	lethargy	Δu	Group	Upper energy (eV)	lethargy	Δu
401	6.64039E+5	2.71200	0.00800	451	4.45118E+5	3.11200	0.00800
402	6.58748E+5	2.72000	0.00800	452	4.41572E+5	3.12000	0.00800
403	6.53499E+5	2.72800	0.00800	453	4.38053E+5	3.12800	0.00800
404	6.48291E+5	2.73600	0.00800	454	4.34563E+5	3.13600	0.00800
405	6.43126E+5	2.74400	0.00600	455	4.31100E+5	3.14400	0.00800
406	6.39279E+5	2.75000	0.01000	456	4.27665E+5	3.15200	0.00800
407	6.32918E+5	2.76000	0.00800	457	4.24257E+5	3.16000	0.00800
408	6.27875E+5	2.76800	0.00800	458	4.20877E+5	3.16800	0.00800
409	6.22872E+5	2.77600	0.00800	459	4.17523E+5	3.17600	0.00800
410	6.17908E+5	2.78400	0.00800	460	4.14196E+5	3.18400	0.00800
411	6.12985E+5	2.79200	0.00800	461	4.10896E+5	3.19200	0.00800
412	6.08101E+5	2.80000	0.00800	462	4.07622E+5	3.20000	0.00800
413	6.03255E+5	2.80800	0.00800	463	4.04374E+5	3.20800	0.00800
414	5.98448E+5	2.81600	0.00800	464	4.01152E+5	3.21600	0.00800
415	5.93680E+5	2.82400	0.00800	465	3.97956E+5	3.22400	0.00800
416	5.88949E+5	2.83200	0.00800	466	3.94785E+5	3.23200	0.00800
417	5.84257E+5	2.84000	0.01000	467	3.91639E+5	3.24000	0.01000
418	5.78443E+5	2.85000	0.00600	468	3.87742E+5	3.25000	0.00600
419	5.74983E+5	2.85600	0.00800	469	3.85423E+5	3.25600	0.00800
420	5.70401E+5	2.86400	0.00800	470	3.82352E+5	3.26400	0.00800
421	5.65856E+5	2.87200	0.00800	471	3.79305E+5	3.27200	0.00800
422	5.61348E+5	2.88000	0.00800	472	3.76283E+5	3.28000	0.00800
423	5.56875E+5	2.88800	0.01200	473	3.73284E+5	3.28800	0.01200
424	5.50232E+5	2.90000	0.00400	474	3.68832E+5	3.30000	0.00400
425	5.48036E+5	2.90400	0.00800	475	3.67359E+5	3.30400	0.00800
426	5.43669E+5	2.91200	0.00800	476	3.64432E+5	3.31200	0.00800
427	5.39337E+5	2.92000	0.00800	477	3.61528E+5	3.32000	0.00800
428	5.35039E+5	2.92800	0.00800	478	3.58648E+5	3.32800	0.00800
429	5.30776E+5	2.93600	0.00800	479	3.55790E+5	3.33600	0.00800
430	5.26547E+5	2.94400	0.00600	480	3.52955E+5	3.34400	0.00800
431	5.23397E+5	2.95000	0.01000	481	3.50143E+5	3.35200	0.00800
432	5.18189E+5	2.96000	0.00800	482	3.47353E+5	3.36000	0.00800
433	5.14060E+5	2.96800	0.00800	483	3.44585E+5	3.36800	0.00800
434	5.09964E+5	2.97600	0.00800	484	3.41839E+5	3.37600	0.00800
435	5.05901E+5	2.98400	0.00800	485	3.39115E+5	3.38400	0.00800
436	5.01870E+5	2.99200	0.00800	486	3.36413E+5	3.39200	0.00800
437	4.97871E+5	3.00000	0.00800	487	3.33733E+5	3.40000	0.00800
438	4.93904E+5	3.00800	0.00800	488	3.31073E+5	3.40800	0.00800
439	4.89968E+5	3.01600	0.00800	489	3.28435E+5	3.41600	0.00800
440	4.86064E+5	3.02400	0.00800	490	3.25818E+5	3.42400	0.00800
441	4.82191E+5	3.03200	0.00800	491	3.23222E+5	3.43200	0.00800
442	4.78349E+5	3.04000	0.00800	492	3.20647E+5	3.44000	0.00800
443	4.74537E+5	3.04800	0.00800	493	3.18092E+5	3.44800	0.00800
444	4.70756E+5	3.05600	0.00800	494	3.15557E+5	3.45600	0.00800
445	4.67005E+5	3.06400	0.00800	495	3.13043E+5	3.46400	0.00800
446	4.63284E+5	3.07200	0.00800	496	3.10549E+5	3.47200	0.00800
447	4.59593E+5	3.08000	0.00800	497	3.08074E+5	3.48000	0.00800
448	4.55930E+5	3.08800	0.01200	498	3.05619E+5	3.48800	0.00800
449	4.50492E+5	3.10000	0.00400	499	3.03184E+5	3.49600	0.00400
450	4.48694E+5	3.10400	0.00800	500	3.01974E+5	3.50000	0.01160

Continued Table of 900 group structure (6/9)

Group	Upper energy (eV)	lethargy	Δu	Group	Upper energy (eV)	lethargy	Δu
501	2.98491E+5	3.51160	0.00430	551	2.00005E+5	3.91200	0.00800
502	2.97210E+5	3.51590	0.00910	552	1.98411E+5	3.92000	0.00800
503	2.94518E+5	3.52500	0.01100	553	1.96830E+5	3.92800	0.00800
504	2.91296E+5	3.53600	0.00800	554	1.95262E+5	3.93600	0.00800
505	2.88975E+5	3.54400	0.00600	555	1.93706E+5	3.94400	0.00600
506	2.87246E+5	3.55000	0.01000	556	1.92547E+5	3.95000	0.01000
507	2.84388E+5	3.56000	0.00800	557	1.90631E+5	3.96000	0.00800
508	2.82122E+5	3.56800	0.00800	558	1.89112E+5	3.96800	0.00800
509	2.79874E+5	3.57600	0.00800	559	1.87605E+5	3.97600	0.00800
510	2.77644E+5	3.58400	0.00800	560	1.86110E+5	3.98400	0.00800
511	2.75432E+5	3.59200	0.00800	561	1.84628E+5	3.99200	0.00800
512	2.73237E+5	3.60000	0.00800	562	1.83156E+5	4.00000	0.00800
513	2.71060E+5	3.60800	0.00800	563	1.81697E+5	4.00800	0.00800
514	2.68900E+5	3.61600	0.00800	564	1.80249E+5	4.01600	0.00800
515	2.66758E+5	3.62400	0.00800	565	1.78813E+5	4.02400	0.00800
516	2.64632E+5	3.63200	0.00800	566	1.77388E+5	4.03200	0.00800
517	2.62523E+5	3.64000	0.00800	567	1.75975E+5	4.04000	0.01000
518	2.60432E+5	3.64800	0.00800	568	1.74224E+5	4.05000	0.00600
519	2.58356E+5	3.65600	0.00800	569	1.73182E+5	4.05600	0.00800
520	2.56298E+5	3.66400	0.00800	570	1.71802E+5	4.06400	0.00800
521	2.54256E+5	3.67200	0.00800	571	1.70433E+5	4.07200	0.00800
522	2.52230E+5	3.68000	0.00800	572	1.69075E+5	4.08000	0.00800
523	2.50220E+5	3.68800	0.01200	573	1.67727E+5	4.08800	0.00800
524	2.47235E+5	3.70000	0.00400	574	1.66391E+5	4.09600	0.00400
525	2.46248E+5	3.70400	0.00800	575	1.65727E+5	4.10000	0.01200
526	2.44286E+5	3.71200	0.00800	576	1.63750E+5	4.11200	0.00800
527	2.42340E+5	3.72000	0.00800	577	1.62445E+5	4.12000	0.00800
528	2.40409E+5	3.72800	0.00800	578	1.61151E+5	4.12800	0.00800
529	2.38493E+5	3.73600	0.00800	579	1.59867E+5	4.13600	0.00800
530	2.36593E+5	3.74400	0.00600	580	1.58593E+5	4.14400	0.00600
531	2.35178E+5	3.75000	0.01000	581	1.57644E+5	4.15000	0.01000
532	2.32837E+5	3.76000	0.00800	582	1.56076E+5	4.16000	0.00800
533	2.30982E+5	3.76800	0.00800	583	1.54832E+5	4.16800	0.00800
534	2.29142E+5	3.77600	0.00800	584	1.53598E+5	4.17600	0.00800
535	2.27316E+5	3.78400	0.00800	585	1.52374E+5	4.18400	0.00800
536	2.25505E+5	3.79200	0.00800	586	1.51160E+5	4.19200	0.00800
537	2.23708E+5	3.80000	0.00800	587	1.49956E+5	4.20000	0.00800
538	2.21925E+5	3.80800	0.00800	588	1.48761E+5	4.20800	0.00800
539	2.20157E+5	3.81600	0.00800	589	1.47576E+5	4.21600	0.00800
540	2.18403E+5	3.82400	0.00800	590	1.46400E+5	4.22400	0.00800
541	2.16662E+5	3.83200	0.00800	591	1.45233E+5	4.23200	0.00800
542	2.14936E+5	3.84000	0.01000	592	1.44076E+5	4.24000	0.01000
543	2.12797E+5	3.85000	0.00600	593	1.42642E+5	4.25000	0.00600
544	2.11524E+5	3.85600	0.00800	594	1.41789E+5	4.25600	0.00800
545	2.09839E+5	3.86400	0.00800	595	1.40659E+5	4.26400	0.00800
546	2.08167E+5	3.87200	0.00800	596	1.39538E+5	4.27200	0.00800
547	2.06508E+5	3.88000	0.00800	597	1.38427E+5	4.28000	0.00800
548	2.04863E+5	3.88800	0.01200	598	1.37324E+5	4.28800	0.01200
549	2.02419E+5	3.90000	0.00400	599	1.35686E+5	4.30000	0.00400
550	2.01611E+5	3.90400	0.00800	600	1.35144E+5	4.30400	0.00800

Continued Table of 900 group structure (7/9)

Group	Upper energy (eV)	lethargy	Δu	Group	Upper energy (eV)	lethargy	Δu
601	1.34067E+5	4.31200	0.00800	651	8.98679E+4	4.71200	0.00800
602	1.32999E+5	4.32000	0.00800	652	8.91518E+4	4.72000	0.00800
603	1.31939E+5	4.32800	0.00800	653	8.84414E+4	4.72800	0.00800
604	1.30888E+5	4.33600	0.00800	654	8.77367E+4	4.73600	0.00800
605	1.29845E+5	4.34400	0.00600	655	8.70376E+4	4.74400	0.00600
606	1.29068E+5	4.35000	0.01000	656	8.65170E+4	4.75000	0.01000
607	1.27784E+5	4.36000	0.00800	657	8.56561E+4	4.76000	0.00800
608	1.26766E+5	4.36800	0.00800	658	8.49736E+4	4.76800	0.00800
609	1.25756E+5	4.37600	0.00800	659	8.42965E+4	4.77600	0.00800
610	1.24754E+5	4.38400	0.00800	660	8.36248E+4	4.78400	0.00800
611	1.23760E+5	4.39200	0.00800	661	8.29585E+4	4.79200	0.00560
612	1.22773E+5	4.40000	0.00800	662	8.24952E+4	4.79760	0.01040
613	1.21795E+5	4.40800	0.00800	663	8.16417E+4	4.80800	0.00800
614	1.20825E+5	4.41600	0.00800	664	8.09912E+4	4.81600	0.00800
615	1.19862E+5	4.42400	0.00800	665	8.03458E+4	4.82400	0.01050
616	1.18907E+5	4.43200	0.00800	666	7.95066E+4	4.83450	0.00550
617	1.17959E+5	4.44000	0.01000	667	7.90705E+4	4.84000	0.00800
618	1.16786E+5	4.45000	0.00600	668	7.84405E+4	4.84800	0.00800
619	1.16087E+5	4.45600	0.00800	669	7.78155E+4	4.85600	0.00800
620	1.15162E+5	4.46400	0.00800	670	7.71954E+4	4.86400	0.00800
621	1.14244E+5	4.47200	0.00800	671	7.65803E+4	4.87200	0.00800
622	1.13334E+5	4.48000	0.00800	672	7.59701E+4	4.88000	0.00800
623	1.12431E+5	4.48800	0.01200	673	7.53648E+4	4.88800	0.00800
624	1.11090E+5	4.50000	0.00400	674	7.47643E+4	4.89600	0.00800
625	1.10646E+5	4.50400	0.00800	675	7.41686E+4	4.90400	0.00800
626	1.09765E+5	4.51200	0.00800	676	7.35776E+4	4.91200	0.00800
627	1.08890E+5	4.52000	0.00800	677	7.29913E+4	4.92000	0.00800
628	1.08023E+5	4.52800	0.00800	678	7.24097E+4	4.92800	0.00560
629	1.07162E+5	4.53600	0.00800	679	7.20054E+4	4.93360	0.01040
630	1.06308E+5	4.54400	0.00800	680	7.12604E+4	4.94400	0.00800
631	1.05461E+5	4.55200	0.00800	681	7.06926E+4	4.95200	0.00800
632	1.04621E+5	4.56000	0.00800	682	7.01293E+4	4.96000	0.00800
633	1.03787E+5	4.56800	0.00800	683	6.95705E+4	4.96800	0.00800
634	1.02960E+5	4.57600	0.00800	684	6.90161E+4	4.97600	0.00800
635	1.02140E+5	4.58400	0.00800	685	6.84662E+4	4.98400	0.00800
636	1.01326E+5	4.59200	0.00800	686	6.79207E+4	4.99200	0.00800
637	1.00518E+5	4.60000	0.00800	687	6.73795E+4	5.00000	0.00800
638	9.97174E+4	4.60800	0.00800	688	6.68426E+4	5.00800	0.00800
639	9.89229E+4	4.61600	0.00900	689	6.63100E+4	5.01600	0.00800
640	9.80366E+4	4.62500	0.00700	690	6.57816E+4	5.02400	0.00800
641	9.73527E+4	4.63200	0.00800	691	6.52575E+4	5.03200	0.00800
642	9.65770E+4	4.64000	0.00800	692	6.47375E+4	5.04000	0.00800
643	9.58074E+4	4.64800	0.00800	693	6.42216E+4	5.04800	0.00800
644	9.50440E+4	4.65600	0.00800	694	6.37099E+4	5.05600	0.00800
645	9.42867E+4	4.66400	0.00800	695	6.32023E+4	5.06400	0.00800
646	9.35354E+4	4.67200	0.00800	696	6.26987E+4	5.07200	0.00800
647	9.27901E+4	4.68000	0.00800	697	6.21991E+4	5.08000	0.00800
648	9.20508E+4	4.68800	0.00800	698	6.17035E+4	5.08800	0.01200
649	9.13173E+4	4.69600	0.00800	699	6.09675E+4	5.10000	0.00400
650	9.05897E+4	4.70400	0.00800	700	6.07241E+4	5.10400	0.00800

Continued Table of 900 group structure (8/9)

Group	Upper energy (eV)	lethargy	Δu	Group	Upper energy (eV)	lethargy	Δu
701	6.02402E+4	5.11200	0.00800	751	1.29402E+4	6.65000	0.05000
702	5.97602E+4	5.12000	0.00800	752	1.23091E+4	6.70000	0.05000
703	5.92841E+4	5.12800	0.00800	753	1.17088E+4	6.75000	0.05000
704	5.88117E+4	5.13600	0.00800	754	1.11378E+4	6.80000	0.05000
705	5.83431E+4	5.14400	0.00800	755	1.05946E+4	6.85000	0.05000
706	5.78782E+4	5.15200	0.00800	756	1.00779E+4	6.90000	0.05000
707	5.74170E+4	5.16000	0.00800	757	9.58635E+3	6.95000	0.05000
708	5.69595E+4	5.16800	0.00700	758	9.11882E+3	7.00000	0.05000
709	5.65622E+4	5.17500	0.00900	759	8.67409E+3	7.05000	0.05000
710	5.60554E+4	5.18400	0.00800	760	8.25105E+3	7.10000	0.05000
711	5.56087E+4	5.19200	0.00800	761	7.84864E+3	7.15000	0.05000
712	5.51656E+4	5.20000	0.00800	762	7.46586E+3	7.20000	0.05000
713	5.47261E+4	5.20800	0.00800	763	7.10174E+3	7.25000	0.05000
714	5.42900E+4	5.21600	0.00800	764	6.75539E+3	7.30000	0.05000
715	5.38574E+4	5.22400	0.00800	765	6.42592E+3	7.35000	0.05000
716	5.34283E+4	5.23200	0.00800	766	6.11253E+3	7.40000	0.05000
717	5.30026E+4	5.24000	0.01000	767	5.81442E+3	7.45000	0.05000
718	5.24752E+4	5.25000	0.00600	768	5.53084E+3	7.50000	0.05000
719	5.21613E+4	5.25600	0.00800	769	5.26110E+3	7.55000	0.05000
720	5.17457E+4	5.26400	0.00800	770	5.00451E+3	7.60000	0.05000
721	5.13333E+4	5.27200	0.00800	771	4.76044E+3	7.65000	0.05000
722	5.09243E+4	5.28000	0.00800	772	4.52827E+3	7.70000	0.05000
723	5.05185E+4	5.28800	0.00800	773	4.30743E+3	7.75000	0.05000
724	5.01160E+4	5.29600	0.05400	774	4.09735E+3	7.80000	0.05000
725	4.74815E+4	5.35000	0.05000	775	3.89752E+3	7.85000	0.05000
726	4.51658E+4	5.40000	0.05000	776	3.70744E+3	7.90000	0.05000
727	4.29630E+4	5.45000	0.05000	777	3.52662E+3	7.95000	0.05000
728	4.08677E+4	5.50000	0.05000	778	3.35463E+3	8.00000	0.05000
729	3.88746E+4	5.55000	0.05000	779	3.19102E+3	8.05000	0.05000
730	3.69786E+4	5.60000	0.05000	780	3.03539E+3	8.10000	0.05000
731	3.51752E+4	5.65000	0.05000	781	2.88735E+3	8.15000	0.05000
732	3.34597E+4	5.70000	0.05000	782	2.74654E+3	8.20000	0.05000
733	3.18278E+4	5.75000	0.05000	783	2.61259E+3	8.25000	0.05000
734	3.02755E+4	5.80000	0.05000	784	2.48517E+3	8.30000	0.05000
735	2.87990E+4	5.85000	0.05000	785	2.36397E+3	8.35000	0.05000
736	2.73944E+4	5.90000	0.05000	786	2.24867E+3	8.40000	0.05000
737	2.60584E+4	5.95000	0.05000	787	2.13900E+3	8.45000	0.05000
738	2.47875E+4	6.00000	0.05000	788	2.03468E+3	8.50000	0.05000
739	2.35786E+4	6.05000	0.05000	789	1.93545E+3	8.55000	0.05000
740	2.24287E+4	6.10000	0.05000	790	1.84106E+3	8.60000	0.05000
741	2.13348E+4	6.15000	0.05000	791	1.75127E+3	8.65000	0.05000
742	2.02943E+4	6.20000	0.05000	792	1.66586E+3	8.70000	0.05000
743	1.93045E+4	6.25000	0.05000	793	1.58461E+3	8.75000	0.05000
744	1.83630E+4	6.30000	0.05000	794	1.50733E+3	8.80000	0.05000
745	1.74675E+4	6.35000	0.05000	795	1.43382E+3	8.85000	0.05000
746	1.66156E+4	6.40000	0.05000	796	1.36389E+3	8.90000	0.05000
747	1.58052E+4	6.45000	0.05000	797	1.29737E+3	8.95000	0.05000
748	1.50344E+4	6.50000	0.05000	798	1.23410E+3	9.00000	0.05000
749	1.43012E+4	6.55000	0.05000	799	1.17391E+3	9.05000	0.05000
750	1.36037E+4	6.60000	0.05000	800	1.11666E+3	9.10000	0.05000

Continued Table of 900 group structure (9/9)

Group	Upper energy (eV)	lethargy	Δu	Group	Upper energy (eV)	lethargy	Δu
801	1.06220E+3	9.15000	0.05000	851	4.78512E+1	12.25000	0.12500
802	1.01039E+3	9.20000	0.05000	852	4.22285E+1	12.37500	0.12500
803	9.61117E+2	9.25000	0.05000	853	3.72665E+1	12.50000	0.12500
804	9.14242E+2	9.30000	0.05000	854	3.28876E+1	12.62500	0.12500
805	8.69654E+2	9.35000	0.05000	855	2.90232E+1	12.75000	0.12500
806	8.27241E+2	9.40000	0.05000	856	2.56129E+1	12.87500	0.12500
807	7.86896E+2	9.45000	0.05000	857	2.26033E+1	13.00000	0.12500
808	7.48518E+2	9.50000	0.05000	858	1.99473E+1	13.12500	0.12500
809	7.12013E+2	9.55000	0.05000	859	1.76035E+1	13.25000	0.12500
810	6.77287E+2	9.60000	0.05000	860	1.55350E+1	13.37500	0.12500
811	6.44256E+2	9.65000	0.05000	861	1.37096E+1	13.50000	0.12500
812	6.12835E+2	9.70000	0.05000	862	1.20987E+1	13.62500	0.12500
813	5.82947E+2	9.75000	0.05000	863	1.06770E+1	13.75000	0.12500
814	5.54516E+2	9.80000	0.05000	864	9.42245E+0	13.87500	0.12500
815	5.27472E+2	9.85000	0.05000	865	8.31529E+0	14.00000	0.12500
816	5.01747E+2	9.90000	0.05000	866	7.33822E+0	14.12500	0.12500
817	4.77276E+2	9.95000	0.05000	867	6.47595E+0	14.25000	0.12500
818	4.53999E+2	10.00000	0.05000	868	5.71501E+0	14.37500	0.12500
819	4.31857E+2	10.05000	0.05000	869	5.04348E+0	14.50000	0.12500
820	4.10796E+2	10.10000	0.05000	870	4.45085E+0	14.62500	0.12500
821	3.90761E+2	10.15000	0.05000	871	3.92786E+0	14.75000	0.12500
822	3.71703E+2	10.20000	0.05000	872	3.46633E+0	14.87500	0.12500
823	3.53575E+2	10.25000	0.05000	873	3.05902E+0	15.00000	0.12500
824	3.36331E+2	10.30000	0.05000	874	2.69958E+0	15.12500	0.12500
825	3.19928E+2	10.35000	0.05000	875	2.38237E+0	15.25000	0.12500
826	3.04325E+2	10.40000	0.05000	876	2.10243E+0	15.37500	0.12500
827	2.89483E+2	10.45000	0.05000	877	1.85539E+0	15.50000	0.12500
828	2.75364E+2	10.50000	0.05000	878	1.63738E+0	15.62500	0.12500
829	2.61935E+2	10.55000	0.05000	879	1.44498E+0	15.75000	0.12500
830	2.49160E+2	10.60000	0.05000	880	1.27519E+0	15.87500	0.12500
831	2.37008E+2	10.65000	0.05000	881	1.12535E+0	16.00000	0.12500
832	2.25449E+2	10.70000	0.05000	882	9.93119E-1	16.12500	0.12500
833	2.14454E+2	10.75000	0.05000	883	8.76425E-1	16.25000	0.12500
834	2.03995E+2	10.80000	0.05000	884	7.73442E-1	16.37500	0.12500
835	1.94046E+2	10.85000	0.05000	885	6.82560E-1	16.50000	0.12500
836	1.84582E+2	10.90000	0.05000	886	6.02357E-1	16.62500	0.12500
837	1.75580E+2	10.95000	0.05000	887	5.31579E-1	16.75000	0.12500
838	1.67017E+2	11.00000	0.05000	888	4.69116E-1	16.87500	0.12500
839	1.58871E+2	11.05000	0.05000	889	4.13994E-1	17.00000	0.12500
840	1.51123E+2	11.10000	0.05000	890	3.65348E-1	17.12500	0.12500
841	1.43753E+2	11.15000	0.05000	891	3.22419E-1	17.25000	0.12500
842	1.36742E+2	11.20000	0.05000	892	2.84533E-1	17.37500	0.12500
843	1.30073E+2	11.25000	0.12500	893	2.51100E-1	17.50000	0.12500
844	1.14789E+2	11.37500	0.12500	894	2.21595E-1	17.62500	0.12500
845	1.01301E+2	11.50000	0.12500	895	1.95557E-1	17.75000	0.12500
846	8.93978E+1	11.62500	0.12500	896	1.72578E-1	17.87500	0.12500
847	7.88932E+1	11.75000	0.12500	897	1.52300E-1	18.00000	0.25000
848	6.96230E+1	11.87500	0.12500	898	1.18611E-1	18.25000	2.00000
849	6.14421E+1	12.00000	0.12500	899	1.60523E-2	20.25000	3.00000
850	5.42225E+1	12.12500	0.12500	900	7.99196E-4	23.25000	4.38102

Appendix B Sample of Shell Script and Input

B.1 Sample Shell Script

This is a sample of the shell script to execute SLAROM-UF. The sample shell script "slarom-uf.sh" can be used with the command:
./slarom-uf.sh [library name] [energy group] [input file name] [output file name]
(Ex. ./slarom-uf.sh J32 70 homo_T homo_T_70g)

```
#!/bin/sh
#
LIB=$1 #
IGM=$2 #
INP=$3 #
OUP=$4 #
# Absolute path or Relative path from WORK directory defined later.
LM=../../slarom-uf.lm                       # SLAROM-UF load module
INDEX=../../../UFLIB.$LIB/Index.g"$IGM"     # index file
JFSLIB=../../../UFLIB.$LIB/LIB.g"$IGM"      # library
MCROSS=../../../UFLIB.$LIB/Pmcross          # mcross library
#
DIR=`pwd`
PDS=PDS"$IGM"g
#
WORK=$DIR/WORK                           # WORK directory
#
#=============  Exec SLAROM-UF with following input data =============
date "+ %m-%d-%y (%a)  %T === slarom-uf start === input file= $INP"
cd $WORK
#
INPUT=$DIR/$INP.ft05                   # input data
OUTPUT=$DIR/$OUP                       # output file without extension
WKDR=./$INP.WORK                       # WORK
PDSWRK=./$INP.PDSW                     # WORK
UMCROSS=./$INP.UMX                     # WORK
#
mkdir $WKDR
mkdir $PDSWRK
mkdir $UMCROSS
if [ -d ./$PDS ];then #
        echo -n #
else #
        mkdir $PDS #
fi #
#
PDSIN=./$PDS
PDSOUT=./$PDS
MCROSS=$MCROSS
UMCROSS=$UMCROSS
WORKPDS=$PDSWRK
#
export INDEX JFSLIB PDSIN PDSOUT MCROSS UMCROSS WORKPDS
$LM < $INPUT > $OUTPUT.ft06
#
date "+ %m-%d-%y (%a)  %T === slarom-uf  end  ==="
```

```
#=============  Remove scratch files ================================
#
mv fort.99 $OUTPUT.ft99
rm fort.*
rm -r $WKDR
rm -r $PDSWRK
rm -r $UMCROSS
#
exit 0
```

B.2 Sample Input

Typical input data are explained. In each case, the group structure of the fine group constant library and resulting cross section is determined by the library specified in the Index file.

(1) Homogeneous cell with UF calculation

This is a case of a homogeneous cell calculation with the UF calculation option. The group structure of the fine group constant library and resulting cross section is determined by the library specified in the Index file.

```
PREP
  ZPPR09   INNER CORE 70G-PEACO
  1  1  0 -1  0  0  3 -1  0  0  0  0  70 /
300.0  1.25  0.0/
  19 /
 1.0 /
 942 2.45580E-06 949 8.86154E-04 940 1.17351E-04 941 1.11169E-05
 951 6.95786E-06 925 1.81513E-05 928 8.24098E-03  13 4.73968E-06
  42 2.39883E-04   8 1.45213E-02   6 1.04688E-03  11 8.74537E-03
  29 4.31003E-05  26 1.20560E-02  24 2.87632E-03  28 1.27056E-03
  25 2.43451E-04  14 1.66525E-04   1 9.25538E-06 /homo density
        /BLANK LINE
PEACOHOM
PEACO HOMO. TEST RUN
      4  -1   0  0   / IC8 IPRT IPLOT MPLOT
  300.0   / TEMP
    1.0   / BL
      1   / NCOR
HOMPEC  /PDS file

stop
```

(2) Heterogeneous slab cell with UF calculation

This is a case of a heterogeneous cell calculation by TONE method with the UF calculation option. The group structure of the fine group constant library and resulting cross section is determined by the library specified in the Index file.

```
PATH
  ZPPR-9 SINGLE COLUM FUEL (HETEROGENEOUS MODEL) with PEACO
  70 18 2 1 2 0 0
  2 18 18 1 18 0 0 0 6 0 1 1 0 0 2 0
  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 /
  0.00000  0.22225  0.85725  1.17475  1.21285  2.40665  2.44475  2.48285
  3.04165  3.07975  3.11785  3.67665  3.71475  3.75285  4.31165  4.34975
  4.66725  5.30225  5.52450 /
PREPTONE
  ZPPR-9 SINGLE COLUM FUEL (HETEROGENEOUS MODEL) with PEACO OPTION
```

```
  18   1  -1  2  0   0   1  -1   0   0   0   0  70
     300.       1.25         0.0
  9  3  2  9 11  9  9  8  9  9 11  9  9 12  9 10  3  9
  0.22225  0.63500  0.31750  0.03810  1.19380  0.03810  0.03810  0.55880
  0.03810  0.03810  0.55880  0.03810  0.03810  0.55880  0.03810  0.31750
  0.63500  0.22225
  13 1.17088E-06  42 9.06416E-05   6 2.14120E-04  26 5.00001E-02
  24 1.40091E-02  28 5.71215E-03  25 1.24539E-03  14 8.36576E-04
  29 2.25280E-04                                          /MATERIAL 1
 925 3.06071E-05 928 1.43603E-02   8 3.78400E-02          /MATERIAL 2
 925 9.43957E-05 928 4.19446E-02                          /MATERIAL 3
  13 7.76766E-05  42 1.85578E-05   6 1.50536E-04  26 5.87078E-02
  24 1.70137E-02  28 8.57806E-03  25 1.28878E-03  14 1.05267E-03
  29 1.79658E-04                                          /MATERIAL 4
  13 1.17088E-06  42 9.53405E-06   8 1.54998E-06   6 2.48426E-05
  11 2.13734E-02  29 3.09953E-05  26 5.83876E-03  24 1.64600E-03
  28 6.92797E-04  25 1.43379E-04  14 9.62370E-05          /MATERIAL 5
  13 7.76766E-05  42 1.85578E-05   6 1.50536E-04  26 5.87078E-02
  24 1.70137E-02  28 8.57806E-03  25 1.28878E-03  14 1.05267E-03
  29 1.79658E-04                                          /MATERIAL 6
  13 6.98629E-05  42 9.53405E-06   6 2.27862E-05  26 6.44423E-02
  24 1.88421E-02  28 9.30738E-03  25 1.60551E-03  14 9.37859E-04
  29 1.22733E-04                                          /MATERIAL 7
 942 2.42789E-05 949 8.76084E-03 940 1.16017E-03 941 1.09906E-04
 951 6.87879E-05 925 5.62549E-05 928 2.50042E-02  42 2.24172E-03 /MATERIAL 8
  13 6.98629E-05  42 9.53405E-06   6 2.27862E-05  26 6.44423E-02
  24 1.88421E-02  28 9.30738E-03  25 1.60551E-03  14 9.37859E-04
  29 1.22733E-04                                          /MATERIAL 9
  13 7.89990E-05  42 1.85051E-05   6 1.52106E-04  26 5.88087E-02
  24 1.70433E-02  28 8.59376E-03  25 1.29042E-03  14 1.05522E-03
  29 1.81036E-04                                          /MATERIAL 10
  13 1.17088E-06  42 9.53405E-06   8 1.47827E-06   6 2.47396E-05
  11 2.06712E-02  29 3.07990E-05  26 5.83876E-03  24 1.64600E-03
  28 6.92797E-04  25 1.43379E-04  14 9.62370E-05          /MATERIAL 11
  13 7.89990E-05  42 1.85051E-05   6 1.52106E-04  26 5.88087E-02
  24 1.70433E-02  28 8.59376E-03  25 1.29042E-03  14 1.05522E-03
  29 1.81036E-04                                          /MATERIAL 12
  13 6.98629E-05  42 4.80090E-05   6 2.27862E-05  26 5.85035E-02
  24 1.71273E-02  28 8.41402E-03  25 1.25414E-03  14 8.27120E-04
  29 1.12981E-04                                          /MATERIAL 13
  13 1.17088E-06  42 9.53405E-06   8 3.02159E-02   6 1.00413E-02
  11 2.01273E-02  29 5.41814E-05  26 5.83876E-03  24 1.64600E-03
  28 6.92797E-04  25 1.43379E-04  14 9.62370E-05   1 9.15021E-05 /MATERIAL 14
  13 6.98629E-05  42 4.80090E-05   6 2.27862E-05  26 5.85035E-02
  24 1.71273E-02  28 8.41402E-03  25 1.25414E-03  14 8.27120E-04
  29 1.12981E-04                                          /MATERIAL 15
  13 1.17088E-06  42 9.53405E-06   8 4.81222E-02   6 2.27862E-05
  26 3.95571E-02  24 1.64600E-03  28 6.92797E-04  25 1.43379E-04
  14 9.62370E-05  29 2.53078E-05                          /MATERIAL 16
 925 3.06071E-05 928 1.43603E-02   8 3.78400E-02          /MATERIAL 17
  13 1.17088E-06  42 9.06416E-05   6 2.14120E-04  26 5.00001E-02
  24 1.40091E-02  28 5.71215E-03  25 1.24539E-03  14 8.36576E-04
  29 2.25280E-04                                          /MATERIAL 18
       /BLANK LINE
PEACO
  ZPPR-9 SINGLE COLUM FUEL IN THE INNER CORE
   4  0 0 0 / IC8 IPRT IPLOT MPLOT
```

```
  18(300.0) / TEMP
  18(1.0)   / BL
  1  17*1    / NCOR


PIJF
  37   0   4   3   0   0   0   0
   0   0       0.0       0.0       0.0       0.0
   0
EDIT
   2   2   1   0  0  /IRPHI IRP IEDXEC INR IWT
HETPEC
STOP
```

Appendix C Subroutine Information

This appendix summarizes information of major subroutines used in SLAROM-UF.

The subroutines are classified into most closely related modules and their names and functions are summarized in Tables C.1-C.9.

Table C.1 Include file

No.	File name	Function
1	MAINSINC	Total memory size
2	MATDTINC	Max. number of nuclides, energy groups, and regions
3	PCOINC	Max. number of energy groups in PEACO module
4	PIJPMINC	Memory size in PIJ module
5	READPINC	Memory size in cross section file process
6	VERSINC	Version information

Table C.2 PATH module

No.	File name	Function
1	E	1st to 5th order Ei function
2	KINTAB	BICKLEY function
3	PCOL	Control I/O process in PATH module
4	PIJ1	Geometry data process in PATH module
5	PIJ2	Pij calculation process
6	PIJIN	Control I/O process and memory in PIJ module

Table C.3 PREP and PREPTONE modules

No.	File name	Function
1	CYLNDF	Calculate DANCOF coef. for cylindrical model
2	ESLMJ	Control I/O process for PREP/PREPTONE module
3	INSPL	Spline interpolation of the f-table
4	IXTERP	R-parameter interpolation
5	MACRO	Calculate effective cross section from self-shielding factor
6	SETSG0	Calculate σ_0
7	SLABDF	Calculate DANCOF coef. for slab model
8	SPLINE	Calculate self-shielding factor
9	SSFCAH	Calculate self-shielding factor for heterogeneous cell
10	SSFCAL	Calculate self-shielding factor for homogeneous cell
11	XECCAL	Control calculation by DANCOF coef. method
12	TONCAL	Control calculation by TONE method
13	TONE	Control calculation by TONE method
14	RSRCH	R-parameter interpolation

Table C.4 PEACO module

No.	File name	Function
1	PCOAVF	UF calculation with direct Pij
2	PCOAVG	UF calculation with interpolated Pij
3	PCOCON	Retrieve library data
4	PCOEDT	Calculate self-shielding factor from PEACO results
5	PCOEIJ	Prepare PIJ used in PEACO module
6	PCOFIN	Read cross section from User MCROSS library
7	PCOIN0	Input control in PEACO module
8	PCOIN1	Preprocess in PEACO module
9	PCOIN2	Preprocess in PEACO module
10	PCOINT	Interpolate Pij
11	PCOMCR	Create temperature dependent cross section data as User MCROSS library
12	PCOOUT	Control temporary result and call PCOXEC sub-routine.
13	PCOPIJ	Calculation of PIJ for PIJ interpolation
14	PCOPLT	Plot neutron spectrum
15	PCOPRT	Print out results
16	PCOXEC	Update effective cross section based on PEACO result
17	PEACO	Control PEACO module
18	THINIT	Thinning neutron spectrum data for PCOPLT.
19	UMCBRH	Doppler broadening for higher energy range
20	UMCBRL	Doppler broadening for lower energy range
21	UMCBRN	Control Doppler broadening
22	UMCCRS	Prepare User MCROSS library
23	UMCENG	Define energy structure for User MCROSS library
24	UMCFIL	Control Doppler broadening
25	UMCONT	Output control data of User MCROSS library
26	UMCPLT	Plot User MCROSS library
27	UMCRED	Process Public MCROSS library
28	UMCROS	Control User MCROSS library creation process
29	UMCSET	Read User MCROSS library

Table C.5 PIJF and PIJB modules

No.	File name	Function
1	INP1F	Read input data for PIJF and PIJB module
2	INP2F	Read cross sections from scratch file for PIJF and PIJB module
3	INP3F	Read cross sections from scratch file for PIJF and PIJB module
4	INPT	Read Pij and initialize neutron flux
5	ITER	Iteration routine for integral transport equation
6	PIJ3F	Control calculation of integral transport equation
7	PIJFB	Control PIJF and PIJB modules
8	SIGRD	Negative cross section check
9	MATINV	Calculate inverse matrix for integral transport equation
10	TEDIT	Print out results
11	PNCHS	Print out neutron flux

Table C.6 PDS module

No.	File name	Function
1	FSPVEL	Read velocity and fission spectrum data from PDS file
2	GETDLY	Read delayed neutron data from PDS file
3	GETMAC	Read macroscopic cross sections from PDS file
4	GETMIC	Read microscopic cross sections from PDS file
5	GETSSF	Read self-shielding factors from PDS file
6	GETXI	Read fission spectra from PDS file
7	INIRUN	Initialize PDS files and read general information
8	CLSPDS	Close a PDS file
9	DELETE	Delete a PDS file
10	FILSRC	Set environment variables
11	GETLEN	Get data length of a PDS files
12	INFOR	Check I/O status of a PDS file
13	LNMEMB	Check number of characters of a PDS file Name
14	LNPATH	Set path of a PDS file
15	OPNPDS	Open a PDS file
16	OVRWRT	Overwrite data on a PDS file
17	PDSCON	Optimize PDS file
18	PDSDEL	Delete a PDS file
19	PDSERR	Post-process in case of error in a PDS file
20	PDSLEN	Get data length of a PDS files
21	PDSRD	Read a PDS file
22	PDSREN	Rename a PDS file
23	PDSSRC	Check presence of a PDS file
24	PDSWRT	Write a PDS file
25	PDSZRO	Initialize a PDS file
26	READ	Read a PDS file
27	RENAME	Rename a PDS file
28	SEARCH	Get data length of a PDS files
29	WRITE	Write a PDS file
30	WRITEO	Overwrite data on a PDS file
31	PREPDS	Read macroscopic cross sections from PDS files and write into a scratch file
32	PRTMAC	Print out macroscopic cross sections
33	PRTMIC	Print out microscopic cross sections
34	PUTDLY	Write delayed neutron data on PDS files
35	PUTMAC	Write macroscopic cross sections on PDS files
36	PUTMIC	Write microscopic cross sections on PDS files
37	PUTSSF	Write self-shielding factors on PDS files
38	PUTXI	Write fission spectra on PDS files
39	RDCHIV	Read fission spectrum from library
40	RDCONT	Read control data from library
41	RDFTAB	Read self-shielding table from library
42	RDMTX	Read scattering matrix from library
43	RDXSEC	Read 1-D cross section data from library
44	SETMTM	Set MT numbers of 1-D cross sections

*Modules No.2-No.24 are in the file "pds.f".

Table C.7 EDIT module

No.	File name	Function
1	EDIT	Control EDIT module. Read input data and set addresses.
2	EDITS	Control calculation of cell averaged cross sections. Set addresses.
3	EDTDIF	Calculate cell averaged diffusion coefficients.
4	EDTMIX	Calculate cell averaged cross sections.
5	EDTOUT	Write cell averaged cross sections.
6	EDTPRE	Preprocess of cell averaging process.

Table C.8 COND module

No.	File name	Function
1	CND2XS	Condense cross sections.
2	CNDCHI	Condense fission spectra.
3	CNDENB	Set condensed energy group structure.
4	CNDFLX	Condense neutron spectra.
5	CNDPDS	Read cross sections from PDS files.
6	CNDXS1	Condense 1-D cross sections.
7	CNDXS2	Condense 2-D cross sections.
8	CNDXSD	Condense 1-D cross sections.
9	CNDXSI	Condense 1-D cross sections by inverse weighting.
10	COND	Control COND module. Read input data and set addresses.
11	CONDXS	Condense cross sections and write results on PDS files.

Table C.9 RRRP module

No.	File name	Function
1	RRRP	Control RRRP module. Read input data and set addresses.
2	RRRPOUT	Update cross sections on scratch files based on RRRP results.
3	RRRPPRE	Calculate reaction rate ratio before averaging.
4	RRRPS	Iteration routine of RRRP method.

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国際単位系（SI）

表１．SI 基本単位

基本量	SI 基本単位	
	名称	記号
長さ	メートル	m
質量	キログラム	kg
時間	秒	s
電流	アンペア	A
熱力学温度	ケルビン	K
物質量	モル	mol
光度	カンデラ	cd

表２．基本単位を用いて表されるSI組立単位の例

組立量	SI 基本単位	
	名称	記号
面積	平方メートル	m^2
体積	立法メートル	m^3
速さ，速度	メートル毎秒	m/s
加速度	メートル毎秒毎秒	m/s^2
波数	毎メートル	m^{-1}
密度，質量密度	キログラム毎立方メートル	kg/m^3
面積密度	キログラム毎平方メートル	kg/m^2
比体積	立方メートル毎キログラム	m^3/kg
電流密度	アンペア毎平方メートル	A/m^2
磁界の強さ	アンペア毎メートル	A/m
量濃度[(a)]，濃度	モル毎立方メートル	mol/m^3
質量濃度	キログラム毎立法メートル	kg/m^3
輝度	カンデラ毎平方メートル	cd/m^2
屈折率[(b)]	（数字の） 1	1
比透磁率[(b)]	（数字の） 1	1

(a) 量濃度（amount concentration）は臨床化学の分野では物質濃度（substance concentration）ともよばれる。
(b) これらは無次元量あるいは次元１をもつ量であるが、そのことを表す単位記号である数字の１は通常は表記しない。

表３．固有の名称と記号で表されるSI組立単位

組立量	SI 組立単位			
	名称	記号	他のSI単位による表し方	SI基本単位による表し方
平面角	ラジアン[(b)]	rad	1[(b)]	m/m
立体角	ステラジアン[(b)]	sr[(c)]	1[(b)]	m^2/m^2
周波数	ヘルツ[(d)]	Hz		s^{-1}
力	ニュートン	N		m kg s^{-2}
圧力，応力	パスカル	Pa	N/m^2	m^{-1} kg s^{-2}
エネルギー，仕事，熱量	ジュール	J	N m	m^2 kg s^{-2}
仕事率，工率，放射束	ワット	W	J/s	m^2 kg s^{-3}
電荷，電気量	クーロン	C		s A
電位差（電圧），起電力	ボルト	V	W/A	m^2 kg s^{-3} A^{-1}
静電容量	ファラド	F	C/V	m^{-2} kg^{-1} s^4 A^2
電気抵抗	オーム	Ω	V/A	m^2 kg s^{-3} A^{-2}
コンダクタンス	ジーメンス	S	A/V	m^{-2} kg^{-1} s^3 A^2
磁束	ウエーバ	Wb	Vs	m^2 kg s^{-2} A^{-1}
磁束密度	テスラ	T	Wb/m^2	kg s^{-2} A^{-1}
インダクタンス	ヘンリー	H	Wb/A	m^2 kg s^{-2} A^{-2}
セルシウス温度	セルシウス度[(e)]	℃		K
光束	ルーメン	lm	cd sr[(c)]	cd
照度	ルクス	lx	lm/m^2	m^{-2} cd
放射性核種の放射能[(f)]	ベクレル[(d)]	Bq		s^{-1}
吸収線量，比エネルギー分与，カーマ	グレイ	Gy	J/kg	m^2 s^{-2}
線量当量，周辺線量当量，方向性線量当量，個人線量当量	シーベルト[(g)]	Sv	J/kg	m^2 s^{-2}
酸素活性	カタール	kat		s^{-1} mol

(a)SI接頭語は固有の名称と記号を持つ組立単位と組み合わせても使用できる。しかし接頭語を付した単位はもはやコヒーレントではない。
(b)ラジアンとステラジアンは数字の１に対する単位の特別な名称で、量についての情報をつたえるために使われる。実際には、使用する時には記号rad及びsrが用いられるが、習慣として組立単位としての記号である数字の１は明示されない。
(c)測光学ではステラジアンという名称と記号srを単位の表し方の中に、そのまま維持している。
(d)ヘルツは周期現象についてのみ、ベクレルは放射性核種の統計的過程についてのみ使用される。
(e)セルシウス度はケルビンの特別な名称で、セルシウス温度を表すために使用される。セルシウス度とケルビンの単位の大きさは同一である。したがって、温度差や温度間隔を表す数値はどちらの単位で表しても同じである。
(f)放射性核種の放射能（activity referred to a radionuclide）は、しばしば誤った用語で"radioactivity"と記される。
(g)単位シーベルト（PV,2002,70,205）についてはCIPM勧告2（CI-2002）を参照。

表４．単位の中に固有の名称と記号を含むSI組立単位の例

組立量	SI 組立単位		
	名称	記号	SI 基本単位による表し方
粘度	パスカル秒	Pa s	m^{-1} kg s^{-1}
力のモーメント	ニュートンメートル	N m	m^2 kg s^{-2}
表面張力	ニュートン毎メートル	N/m	kg s^{-2}
角速度	ラジアン毎秒	rad/s	m m^{-1} s^{-1}=s^{-1}
角加速度	ラジアン毎秒毎秒	rad/s^2	m m^{-1} s^{-2}=s^{-2}
熱流密度，放射照度	ワット毎平方メートル	W/m^2	kg s^{-3}
熱容量，エントロピー	ジュール毎ケルビン	J/K	m^2 kg s^{-2} K^{-1}
比熱容量，比エントロピー	ジュール毎キログラム毎ケルビン	J/(kg K)	m^2 s^{-2} K^{-1}
比エネルギー	ジュール毎キログラム	J/kg	m^2 s^{-2}
熱伝導率	ワット毎メートル毎ケルビン	W/(m K)	m kg s^{-3} K^{-1}
体積エネルギー	ジュール毎立方メートル	J/m^3	m^{-1} kg s^{-2}
電界の強さ	ボルト毎メートル	V/m	m kg s^{-3} A^{-1}
電荷密度	クーロン毎立方メートル	C/m^3	m^{-3} sA
表面電荷	クーロン毎平方メートル	C/m^2	m^{-2} sA
電束密度，電気変位	クーロン毎平方メートル	C/m^2	m^{-2} sA
誘電率	ファラド毎メートル	F/m	m^{-3} kg^{-1} s^4 A^2
透磁率	ヘンリー毎メートル	H/m	m kg s^{-2} A^{-2}
モルエネルギー	ジュール毎モル	J/mol	m^2 kg s^{-2} mol^{-1}
モルエントロピー，モル熱容量	ジュール毎モル毎ケルビン	J/(mol K)	m^2 kg s^{-2} K^{-1} mol^{-1}
照射線量（X線及びγ線）	クーロン毎キログラム	C/kg	kg^{-1} sA
吸収線量率	グレイ毎秒	Gy/s	m^2 s^{-3}
放射強度	ワット毎ステラジアン	W/sr	m^4 m^{-2} kg s^{-3}=m^2 kg s^{-3}
放射輝度	ワット毎平方メートル毎ステラジアン	W/(m^2 sr)	m^2 m^{-2} kg s^{-3}=kg s^{-3}
酵素活性濃度	カタール毎立方メートル	kat/m^3	m^{-3} s^{-1} mol

表５．SI 接頭語

乗数	接頭語	記号	乗数	接頭語	記号
10^{24}	ヨタ	Y	10^{-1}	デシ	d
10^{21}	ゼタ	Z	10^{-2}	センチ	c
10^{18}	エクサ	E	10^{-3}	ミリ	m
10^{15}	ペタ	P	10^{-6}	マイクロ	μ
10^{12}	テラ	T	10^{-9}	ナノ	n
10^{9}	ギガ	G	10^{-12}	ピコ	p
10^{6}	メガ	M	10^{-15}	フェムト	f
10^{3}	キロ	k	10^{-18}	アト	a
10^{2}	ヘクト	h	10^{-21}	ゼプト	z
10^{1}	デカ	da	10^{-24}	ヨクト	y

表６．SIに属さないが、SIと併用される単位

名称	記号	SI 単位による値
分	min	1 min=60s
時	h	1h =60 min=3600 s
日	d	1 d=24 h=86 400 s
度	°	1°=(π/180) rad
分	’	1’=(1/60)°=(π/10800) rad
秒	”	1”=(1/60)’=(π/648000) rad
ヘクタール	ha	$1ha=1hm^2=10^4m^2$
リットル	L，l	$1L=11=1dm^3=10^3cm^3=10^{-3}m^3$
トン	t	$1t=10^3$ kg

表７．SIに属さないが、SIと併用される単位で、SI単位で表される数値が実験的に得られるもの

名称	記号	SI 単位で表される数値
電子ボルト	eV	$1eV=1.602\ 176\ 53(14)\times10^{-19}J$
ダルトン	Da	$1Da=1.660\ 538\ 86(28)\times10^{-27}kg$
統一原子質量単位	u	1u=1 Da
天文単位	ua	$1ua=1.495\ 978\ 706\ 91(6)\times10^{11}m$

表８．SIに属さないが、SIと併用されるその他の単位

名称	記号	SI 単位で表される数値
バール	bar	$1 bar=0.1MPa=100kPa=10^5Pa$
水銀柱ミリメートル	mmHg	1mmHg=133.322Pa
オングストローム	Å	$1 Å=0.1nm=100pm=10^{-10}m$
海里	M	1 M=1852m
バーン	b	$1 b=100fm^2=(10^{-12}cm)2=10^{-28}m^2$
ノット	kn	1 kn=(1852/3600)m/s
ネーパ	Np	SI単位との数値的な関係は、対数量の定義に依存。
ベル	B	
デジベル	dB	

表９．固有の名称をもつCGS組立単位

名称	記号	SI 単位で表される数値
エルグ	erg	$1 erg=10^{-7}$ J
ダイン	dyn	$1 dyn=10^{-5}$N
ポアズ	P	$1 P=1 dyn\ s\ cm^{-2}=0.1Pa\ s$
ストークス	St	$1 St=1cm^2\ s^{-1}=10^{-4}m^2\ s^{-1}$
スチルブ	sb	$1 sb=1cd\ cm^{-2}=10^4cd\ m^{-2}$
フォト	ph	$1 ph=1cd\ sr\ cm^{-2}\ 10^4lx$
ガル	Gal	$1 Gal=1cm\ s^{-2}=10^{-2}ms^{-2}$
マクスウェル	Mx	$1 Mx = 1G\ cm^2=10^{-8}Wb$
ガウス	G	$1 G=1Mx\ cm^{-2}=10^{-4}T$
エルステッド[(c)]	Oe	$1 Oe \triangleq (10^3/4\pi)A\ m^{-1}$

(c) ３元系のCGS単位系とSIでは直接比較できないため、等号「 ≙ 」は対応関係を示すものである。

表10．SIに属さないその他の単位の例

名称	記号	SI 単位で表される数値
キュリー	Ci	$1 Ci=3.7\times10^{10}Bq$
レントゲン	R	$1 R = 2.58\times10^{-4}C/kg$
ラド	rad	$1 rad=1cGy=10^{-2}Gy$
レム	rem	$1 rem=1 cSv=10^{-2}Sv$
ガンマ	γ	1γ=1 nT=10-9T
フェルミ		1フェルミ=1 fm=10-15m
メートル系カラット		1メートル系カラット = 200 mg = 2×10-4kg
トル	Torr	1 Torr = (101 325/760) Pa
標準大気圧	atm	1 atm = 101 325 Pa
カロリー	cal	1cal=4.1858J（「15℃」カロリー），4.1868J（「IT」カロリー）4.184J（「熱化学」カロリー）
ミクロン	μ	1 μ =1μm=10^{-6}m

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