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A processing code for group constants for a fast reactor

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PROF GROUCH-G

A processing code for group constants for a fast reactor

Abstract

The code PROF GROUCH-G has been developed for producing fast reactor group constants by processing directly the nuclear data given by ENDF/A formats. Types of group constants obtained by the code are similar to the Russian group-constants set, but the processing and calculation methods have been improved in comparison with those of the conventional group-constants sets published so far. The characteristic features of the code are as follows:

(1) All data of DCC 1, 2, 6, 9 and 10 formats can be treated.

(2) Calculations of different nuclides, reaction and data types can be continuously carried out, and the respective results are obtained.

(3) For the angular distribution data of elastic and inelastic scattering, the energy transfer probabilities are in detail calculated by using the conservation law of momentum and energy.

(4) Smooth spectra $\phi_s(E)$ used for averaging cross sections are fission spectrum and $1/E^{\alpha}$. Composition dependence of cross sections is taken into account by using a spectrum $\phi_s(E)(\sigma_t(E)+\sigma_0)^{-1}$.

UKNDL and ENDF/B data also can be processed, because codes converting them into ENDF/A formats have been developed.

The PROF GROUCH-G is written for IBM-360/75 and FACOM-230/60.

November 1969

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高速炉用群定数作成コード：PROF GROUCH-G

要　旨

PROF GROUCH-G は，ENDF/A の形式で与えられている核データを直接処理することによって，高速炉用群定数を作成する為に開発された計算コードである．このコードによってソ連の群定数セットと類似の群定数が得られるが，核データの処理および計算法に改良が施されている．このコードの特徴は次の点にある．

（1） DCC 1, 2, 6, 9 および 10 の形式で与えられている全てのデータを処理する．

（2） 核種，反応および形式の異ったデータを連続的に処理してそれぞれに対応した結果が得られる．

（3） 弾性および非弾性散乱が角度分布によって与えられている場合，そのエネルギ分布への変換は，運動量とエネルギの保存則を用いて詳細に計算される．

（4） 断面積の平均に用いるスペクトルは核分裂スペクトルと $1/E^{\alpha}$ を採用し，群定数の組成依存性はこれらのスペクトルに $(\sigma_t+\sigma_0)^{-1}$ の補正を行うことによって考慮している．

現在 UKNDL および ENDF/B の形式のデータを ENDF/A の形式に変換する計算コードが用意されているので，これらのデータも PROF GROUCH-G によって処理することが出来る．なおこのコードは IBM-360/75 と FACOM-230/60 用に作成されている．

1969 年 11 月

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1. Introduction

Several number of nuclear data files for use in calculations of reactor constants have been developed hitherto. The ENDF/A[1], ENDF/B[2] and UKNDL[3] are typical files for the storage and retrieval of nuclear data. In the files, a huge amount of data for different reaction types of very many nuclides is stored in accordance with their characteristic format. It is desirable that the format is designed to be flexible for the storage of new data and the retrieval of old data, and for general utilization. The ENDF/A format was decided so as to satisfy these requirements.

Two cases might be considered for producing reactor constants by utilizing a nuclear data file. One is the case where the selected data from the file is once converted to an another particular format for a data-library for a spectrum code to calculate reactor constants such as MC²[4], in which the library tape is produced from the ENDF/B data. The other is the case where the file is directly processed and reactor constants are produced by using an approximate weighting spectrum in a processing code. A set of the resultant reactor constants is similar to a usual group-constants set such as YOM[5] or the Russian set[6] and to the MUFT or GAM-type library.

In the latter case, the set obtained by producing independently group constants of individual materials may not quite exactly predict the nuclear characteristics of a real reactor system. However, such a set is very convenient for nuclear design calculations, preceding analyses of experiments and so on, if the accuracy of the set is tolerable or reasonable for those purposes. It is also easy to modify or improve worse data of the set by using new nuclear data of higher accuracy or a more exact weighting spectrum.

The code PROF GROUCH-G (the signature "G" means "GAM-type") attempts to produce easily group constants for a fast reactor directly from the ENDF/A file. The original form of PROF GROUCH-G is the PROF GROUCH-M[7] which produces MUFT-type group constants. But the code has been largely modified and improved. The PROF GROUCH-G can treat all data of DCC 1, DCC 2, DCC 6, DCC 9 and DCC 10 formats. The weighting spectrum used is similar to that of the Russian set which takes approximately composition dependence of group constants into account.

2. Description of the Processing Code

2. 1 Weighting Spectrum

The standard weighting spectrum is given by $\phi_s(E)=1/E^{\alpha}$ below the energy ESPEC and $\phi_s(E)=A_0e^{-E/A_1}\sinh\sqrt{A_2E}$ (fission spectrum) above ESPEC, where ESPEC, α, A_0, A_1 and A_2 are input data. The ϕ_s is reasonable as a weighting spectrum in an energy range where cross sections are constant or smooth. However, in a case where cross sections vary rapidly especially in resonance energy regions, the ϕ_s should bring errors in resultant group constants. In the

code, influence of variations of cross sections on a spectrum is taken into account by the function $(\sigma_t{}^m(E)+\sigma_0{}^m)^{-1}$ like the Russian set, where $\sigma_t{}^m(E)$ is a microscopic total cross section and $\sigma_0{}^m$ the sum of macroscopic total cross sections of other materials per element m.

An effective cross section of the i-th group extending from E_{il} to E_{iu} is given by

$$\sigma_{ix}{}^m(\sigma_0{}^m)=\frac{\int_{Eil}^{Eiu}\sigma_x{}^m(E)\dfrac{\phi_s(E)}{\sigma_t{}^m(E)+\sigma_0{}^m}dE}{\int_{Eil}^{Eiu}\dfrac{\phi_s(E)}{\sigma_t{}^m(E)+\sigma_0{}^m}dE} \tag{1}$$

where the subscript x represents all reactions except for total cross section. An effective total cross section, which is used for the calculation of the transport cross section for diffusion coefficient, is given by

$$\sigma_{it}{}^m(\sigma_0{}^m)=\frac{\int_{Eil}^{Eiu}\dfrac{\phi_s(E)}{\sigma_t{}^m(E)+\sigma_0{}^m}dE}{\int_{Eil}^{Eiu}\dfrac{\phi_s(E)}{(\sigma_t{}^m(E)+\sigma_0{}^m)^2}dE}-\sigma_0{}^m \tag{2}$$

Generally, the $\sigma_0{}^m$ is defined by

$$\sigma_0{}^m=\sum_{n\neq m}N^n\sigma_t{}^n/N^m \tag{3}$$

where N^n and N^m are atomic densities of materials n and m, and in the PROF GROUCH-G the $\sigma_0{}^m$ is given as a parameteric input.

When only the $\phi_s(E)$ is used as a weighting spectrum, effective cross sections for infinite dilution are obtained, i. e.,

$$\sigma_{ix\infty}{}^m=\frac{\int_{Eil}^{Eiu}\sigma_x{}^m(E)\phi_s(E)dE}{\int_{Eil}^{Eiu}\phi_s(E)dE} \tag{4}$$

where x represents all reactions together with total cross section and the $\sigma_{ix\infty}{}^m$ is the same as the $\sigma_{ix}{}^m(\infty)$.

The choise between $\phi_s(E)$ and $\phi_s(E)(\sigma_t+\sigma_0)^{-1}$ is made by an input option. The factor for representing the composition dependence of cross sections is defined by

$$f_{ix}{}^m(\sigma_0{}^m)=\frac{\sigma_{ix}{}^m(\sigma_0{}^m)}{\sigma_{ix\infty}{}^m}. \tag{5}$$

The factor f is sometimes called a self-shielding factor.

The equations (1), (2) and (4) are used in cases for processing one-dimensional data, but in cases for calculating transfer matrices also, the same weighting spectra can be chosen.

2. 2 Equations of Elastic and Inelastic Scattering Matrices

Elastic and inelastic scattering matrices are obtained by processing the set of cross section (DCC 1 data) and angular (DCC 2) or energy distribution data (DCC 9, DCC 10) or data on Legendre moments (DCC 6), which are read in immediately after DCC 1 data.

The process of the set of DCC 1 and DCC 9 or DCC 10 data and the numerical method are the same as that of PROF GROUCH-M. The scattering matrices are simply obtained from

$$\sigma^{i\to j}=\frac{\int_{\Delta Ej}dF_F\int_{\Delta Ei}dE_I\sigma(E_I)P(E_I\to E_F)\phi(E_I)}{\int_{\Delta Ei}\phi(E_I)dE_I}, \tag{6}$$

where $P(E_I\to E_F)$ is given according to DCC 9 or DCC 10 data formats, and ΔE_i and ΔE_j are

the energy intervals of the i-and j-th groups.

On the other hand, the numerical procedure for the set of DCC 1 and DCC 2 is rather complex, because the angular distribution $P(E_I, \mu_c)$ or $P(E_I, \mu_l)$ must be converted to the energy distribution, where μ_c is the cosine of scattering angle in the center of mass system and μ_l in the laboratory system. The conversion of $P(E_I, \mu_c)$ or $P(E_I, \mu_l)$ into $P(E_I \to E_F)$ is made by use of the conservation law of energy and momentum. Both elastic and inelastic scattering matrices can be generally treated by the same formula except for consideration of the Q-value (or excited level energy) in inelastic scattering.

The general relations between the incident energy E_I, the final energy E_F and the cosine of scattering angle μ_c or μ_l are as follows.

$$\frac{E_F}{E_I}=\frac{\left(\sqrt{A^2-1+\mu_l^2-A(A+1)\frac{w_n}{E_I}}+\mu_l\right)^2}{(A+1)^2} \tag{7}$$

$$\mu_l=\frac{W+\mu_c}{\sqrt{W^2+2W\mu_c+1}} \tag{8}$$

where

$$W^2=\frac{1}{A^2-A(A+1)\frac{w_n}{E_I}} \tag{9}$$

and

$$\mu_l=\frac{1}{2}(A+1)\sqrt{\frac{E_F}{E_I}}-\frac{1}{2}(A-1)\sqrt{\frac{E_I}{E_F}}+\frac{A}{2}\frac{w_n}{E_I}\sqrt{\frac{E_I}{E_F}} \tag{10}$$

where A is atomic mass, and w_n is the excited energy of the n-th level for inelastic scattering and is set equal to zero for elastic scattering.

The angular distribution of the elastic and inelastic scattering cross sections (σ_s and σ_{in}) can be represented as a series of Legendre functions: $P_0(\mu_l)=1$; $P_1(\mu_l)=\mu_l$; $P_2(\mu_l)=\frac{1}{2}(3\mu_l^2-1)\cdots$ $\cdots$, and we shall write

$$Y_{x_1}(E_I, \mu_{x_2})=\sum_{l=0} S_{x_1,l}(E_I\to E_F)P_l(\mu_l) \tag{11}$$

where the suffix x_1 represents "s" or "in" and the x_2 "l" or "c".

$Y_{x_1}(E_I, \mu_{x_2})$ is given by the product of σ_{x_1} from DCC 1 data and $P(E_I, \mu_{x_2})$ from DCC 2.

In case that the angular distribution is given in the laboratory system, $S_{x_1,l}$ is obtained by using Eqs. (7)~(10) and

$$\begin{aligned}S_{x_1,l}(E_I\to E_F)&=\frac{2l+1}{4\pi}\int_{-1}^{+1}Y_{x_1}(E_I, \mu_l)P_l(\mu_l)\\&\quad\times\delta\left(E_F-\frac{E_I}{(A+1)^2}\left[\sqrt{A^2-1+\mu_l^2-A(A+1)\frac{w_n}{E_I}}+\mu_l\right]^2\right)d\mu_l\\&=\frac{2l+1}{4\pi}Y_{x_1}(E_I, \mu_l(E_I, E_F))P_l(\mu_l(E_I, E_F))\\&\quad\times\frac{(A+1)\sqrt{\frac{E_F}{E_I}}+(A-1)\sqrt{\frac{E_I}{E_F}}-A\frac{w_n}{E_I}\sqrt{\frac{E_I}{E_F}}}{4E_F}\end{aligned} \tag{12}$$

In the center of mass system,

$$\begin{aligned}S_{x_1,l}(E_I\to E_F)&=\frac{2l+1}{4\pi}\int_{-1}^{+1}Y_{x_1}(E_I, \mu_c)P_l(\mu_l)\frac{d\mu_c}{d\mu_l}\\&\quad\times\delta\left(E_F-\frac{E_I}{(A+1)^2}\left[\sqrt{A^2-1+\mu_l^2-A(A+1)\frac{w_n}{E_I}}+\mu_l\right]^2\right)d\mu_l\\&=\frac{2l+1}{4\pi}Y_{x_1}(E_I, \mu_c(E_I, E_F))P_l(\mu_l(E_I, E_F))\frac{[\sqrt{1-W^2(1-\mu_l^2)}+W\mu_l]^2}{\sqrt{1-W^2(1-\mu_l^2)}}\end{aligned}$$

$$\times \frac{(A+1)\sqrt{\frac{E_F}{E_I}}+(A-1)\sqrt{\frac{E_I}{E_F}}-A\frac{w_n}{E_I}\sqrt{\frac{E_I}{E_F}}}{4E_F}. \tag{13}$$

Eq. (13) is reduced to a rather simple form in case of elastic scattering, i. e.,

$$S_{s,l}(E_I \to E_F) = \frac{2l+1}{4\pi} Y_s(E_I,\ \mu_c(E_I,\ E_F))\, P_l(\mu_l(E_I,\ E_F)) \frac{(A+1)^2}{2AE_I}. \tag{14}$$

By use of $S_{x_1,0}(E_I \to E_F)$ and $S_{x_1,1}(E_I \to E_F)$ are obtained $\sigma_{x_1}{}^{i\to j}$, $\mu_{x_1}{}^{i\to j}$ and $\mu_{x_1}{}^{i}$, i.e.,

$$\sigma_{x_1}^{i\to j} = 4\pi \int_{\Delta Ej} dE_F \int_{\Delta Ei} dE_I S_{x_1,0}(E_I \to E_F)\phi(E_I) \Big/ \int_{\Delta Ei} dE_I \phi(E_I) = 4\pi S_{x_1,0}(i \to j), \tag{15}$$

$$\mu_{x_1}{}^{i\to j} = \frac{\int_{\Delta Ej} dE_F \int_{\Delta Ei} dE_I \phi(E_I) \int_{-1}^{+1} d\mu_l \cdot \mu_l Y_{x_1}(E_I,\ \mu_{x_2})}{\int_{\Delta Ej} dE_F \int_{\Delta Ei} dE_I \phi(E_I) \int_{-1}^{+1} d\mu_l Y_{x_1}(E_I,\ \mu_{x_2})} = \frac{S_{x_1,1}(i \to j)}{3S_{x_1,0}(i \to j)} \tag{16}$$

and

$$\mu_{x_1}{}^{i} = \frac{\int_{E_F \le E_I} dE_F \int_{\Delta Ei} dE_I \phi(E_I) \int_{-1}^{+1} d\mu_l \cdot \mu_l Y_{x_1}(E_I,\ \mu_{x_2})}{\int_{E_F \le E_I} dE_F \int_{\Delta Ei} dE_I \phi(E_I) \int_{-1}^{+1} d\mu_l Y_{x_1}(E_I,\ \mu_{x_2})} = \frac{\sum_{j\ge i} S_{x_1,1}(i \to j)}{3\sum_{j\ge i} S_{x_1,0}(i \to j)}. \tag{17}$$

Eq. (17) is rewritten as

$$\mu_{x_1}{}^{i} = \frac{\sum_{j\ge i} \mu_{x_1}{}^{i\to j} \sigma_{x_1}{}^{i\to j}}{\sigma_{x_1}{}^{i}} \tag{18}$$

where

$$\sigma_{x_1}{}^{i} = \sum_{j\ge i} \sigma_{x_1}{}^{i\to j}. \tag{19}$$

The $\sigma_{x_1}{}^{i}$ should coincide with the σ_{ix} from Eq. (1), but because of an error introduced from numerical integrations, the normalization of above transfer matrices is carried out in the code, to make the sum of the matrices coincide with σ_{ix}.

For the angular distribution, Legendre coefficients of the probability distribution or coefficients of differential cross sections are sometimes given. In this case we must use DCC 6 type data. The $Y_{x_1}(E_I,\ \mu_{x_2})$ is produced by the Legendre coefficients and cross sections. Then Eq. (12)~(17) are applied to this $Y_{x_1}(E_I,\ \mu_{x_2})$. However DCC 6 is designed to use only for elastic scattering.

When angular distribution data are processed, another transfer matrices $\sigma_{x_1}{}'^{i\to j}$ also is obtained, where the diagonal component $\sigma_{x_1}{}'^{i\to i}$ is given by

$$\sigma_{x_1}{}'^{i\to i} = \sigma_{x_1}{}^{i\to i} - \sigma_{x_1}{}^{i}\mu_{x_1}{}^{i}. \tag{20}$$

Equation (20) is proposed in the code PIXSE[8]. The $\sigma_{x_1}{}'^{i\to j}$ is obtained only in card form.

2. 3 Method of Processing

The processing is performed according to specifications of data, i. e., by distinguishing varieties of nuclides, reaction types, data types (here all types of DCC 1, DCC 2, DCC 6, DCC 9, and DCC 10) and so on. In TABLE 1 are listed types of reactions and data which are processed by the code.

Calculations of different nuclides, reaction types and data types can be continuously carried out and the corresponding results are obtained. Then it should be noticed that angular or energy distribution data (DCC 2, DCC 6, DCC 9 and DCC 10) must be always read subsequently to cross sections (DCC 1). Consequently, fission cross section is also necessary for the

calculation of fission spectrum χ before energy distribution data, though fission cross section has no influence on the results. Total cross section also must be read before all cross sections, when $\phi_s(\sigma_t+\sigma_0)^{-1}$ spectrum is used. In case where both angular and energy distribution data in the same energy interval are prepared in ENDF data, either the former or the latter should be chosen as input data.

The procedure for reading and examination of data and the rearrangement is almost the same as in PROF GROUCH-M[7], but the whole structure of the code has been been quitely changed, and some subroutines for numerical calculations have been considerably modified, removed and added. The block diagrams of processing data are shown in **Figs. 1～4.**

PROF GROUCH-G can read data of ENDF/A format either in the form of cards or directly from the ENDF/A library tape whose number for reading is specified by an input. The cards from the ENDF/A tape is prepared by use of DFSR 2[1][7] code. PROF GROUCH-G can process UKNDL and ENDF/B data also, because codes converting them to ENDF/A format have been developed[9].

In order to calculate the products (cross section) × (probability (here angular or energy distribution)) × (spectrum) or (cross section) × (spectrum), it is necessary to rearrange energy points of data by using interpolation rules. For instance, the procedure of producing probabilities of DCC 2 data at the same energy points as those of cross sections (DCC 1) was given in PROF GROUCH-M (see **Tables 2. 2. 3 and 2. 2. 4** in the previous report[7]). Further description will not be repeated, because the procedure in PROF GROUCH-G is the same.

In PROF GROUCH-G the maximum number (M) of energy points admissible initially in each group (cf. PROF GROUCH-M) has been extended from 200 to 500 (note that the M does not contain the mesh points increased by interpolation). And the maximum number (LDB*) of incident energy points at which probability is given, has been also increased to 150, and the maximum number of initial data points is 2500. The length of data block (LDB*) in DCC 2 is 100. Therefore it is not necessary to divide the ENDF/A data of some nuclides listed in the previous report[7] into a few subblocks. The UK data converted into ENDF/A format also can be processed without modifying the data block.

2. 4 Method of Numerical Integrations

2. 4. 1 Calculations of Cross Sections

Data are rearranged in the same manner as those for which NDBA=1, i. e., [E_1, σ_1, E_2, σ_2……] (see ENDF format). Integrations of the product (cross section : σ) × (spectrum : ϕ) and of ϕ are performed over individual group intervals. The same energy mesh points as determined for interpolation of σ are used for integrations of $\sigma\phi$ and ϕ, in order to avoid an error brought by the difference between both mesh structures, espeically for $\phi=\phi_s(\sigma_t+\sigma_0)^{-1}$.

The number of interpolated points between the initial energy points of cross section is determined as follows. Let E_l be the l-th initial energy point and σ_l be the value of cross section at E_l. If the quantity $\gamma=|\sigma_{l+1}-\sigma_l|/(\sigma_{l+1}+\sigma_l)$ is greater than ε, the number MESHD of energy points interpolated between E_l and E_{l+1} is determined as the integer part of $\{(\gamma/\varepsilon)+1.0\}$. Final energy points $E_{l'}$ which are used for integrations are determined by dividing equally

* See ENDF/A format in BNL-8381

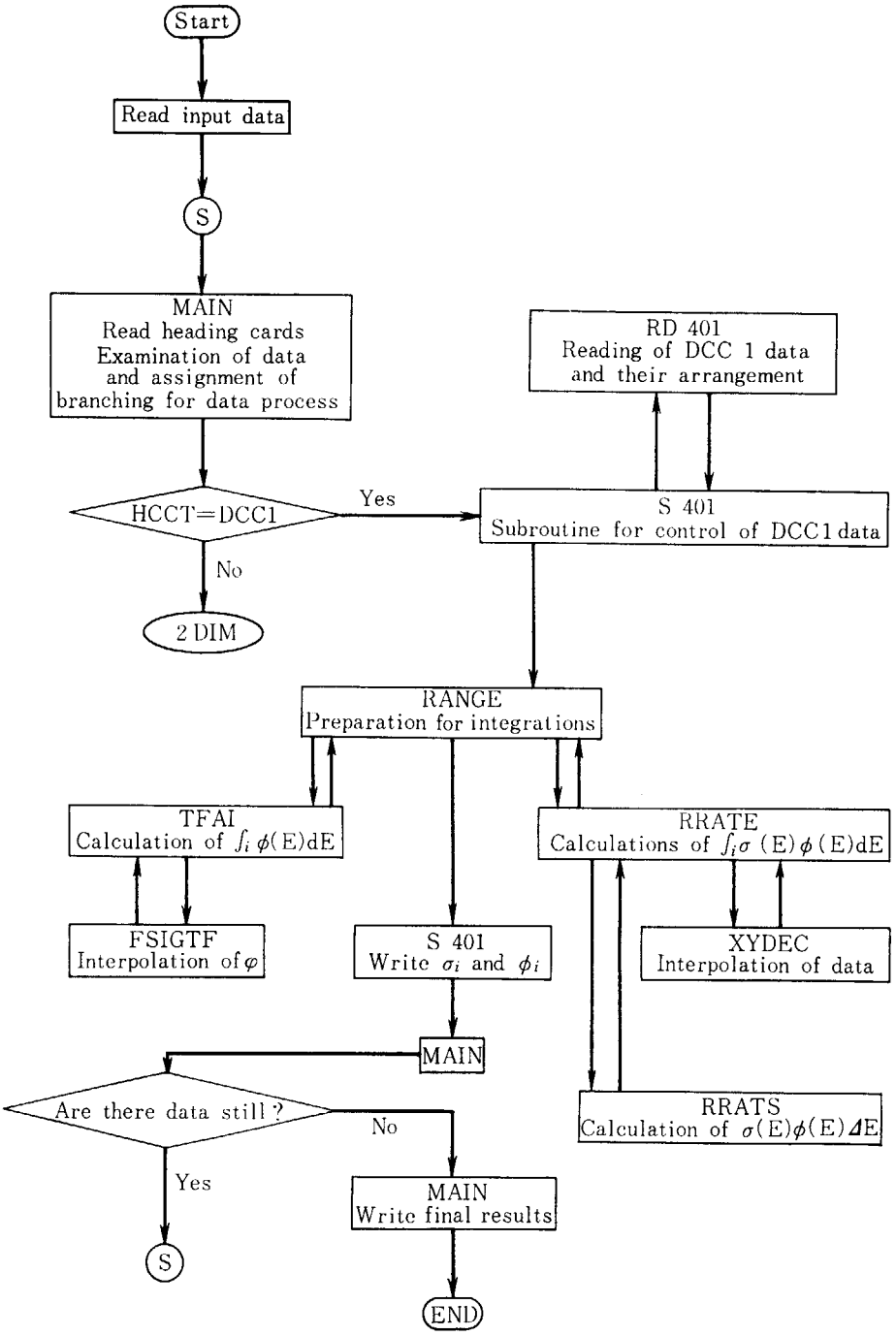

Fig. 1 Block diagram I for processing DCC1 data

in lethargy the interval between E_l and E_{l+1} into sub-intervals by MESHD. The ε is set equal to 0.1 in the code, by considering the computation time and the accuracy of integrations.

The integration over a sub-interval between $E_{l'}$ and $E_{l'+1}$ is given by an average of the values at $E_{l'}$ and $E_{l'+1}$, i. e., by the trapezoid formula.

When reactions of the same nuclide are continuously processed, the sum of the reactions is obtained. For instance, when capture and fission cross sections are continuously processed, absorption cross section also is obtained as final results.

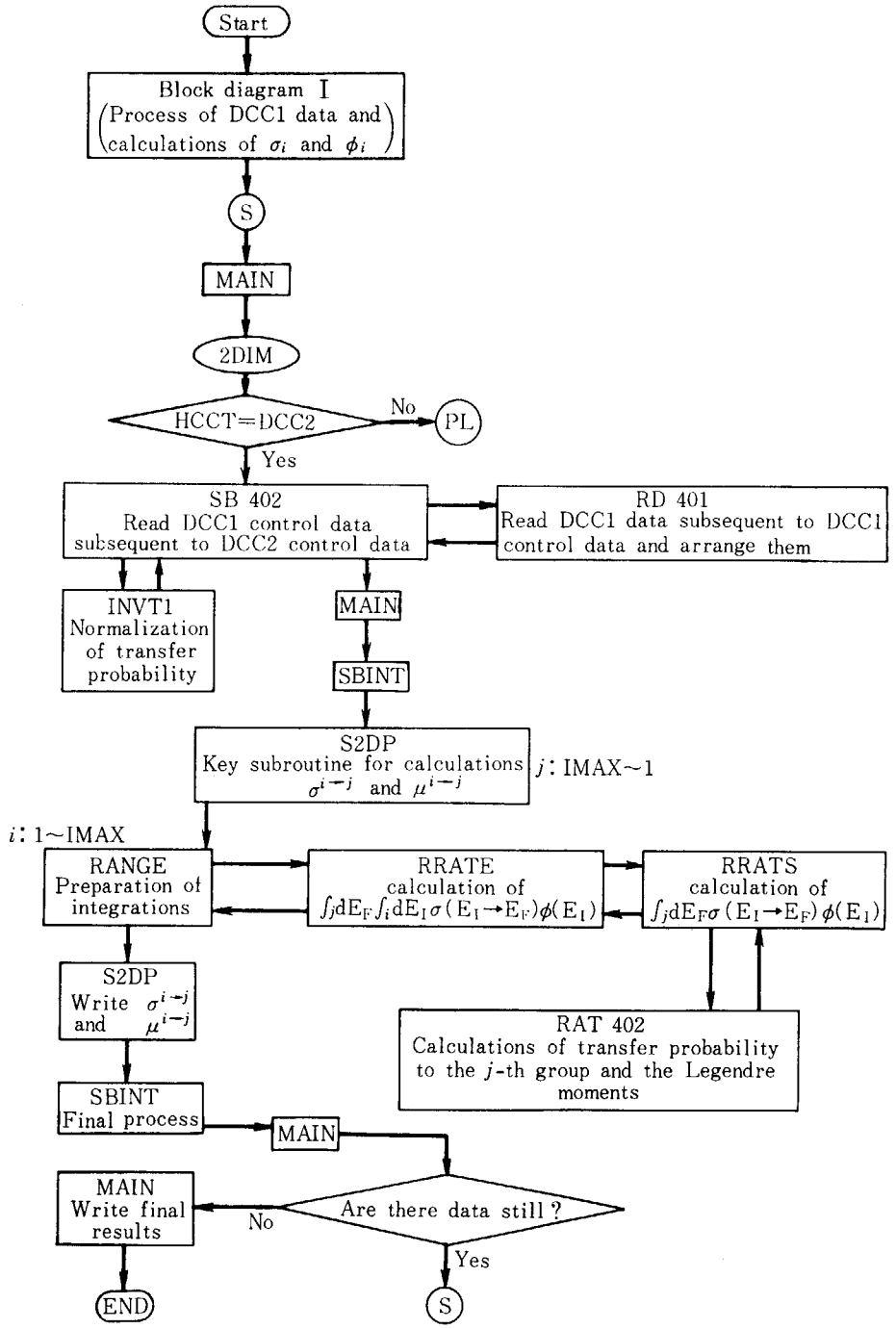

Fig. 2 Block diagram II for processing DCC 1 and DCC 2 data

2. 4. 2 Calculation of Transfer Matrices

The calculation of $\int dE_F \int dE_I \sigma \cdot P \cdot \phi$ for obtaining the transfer matrix $\sigma^{i\to j}$ in the code is performed by integrating it over all initial group i (the group containing incident energy) as fixing final group j (the group containing the energy of scattered neutron). The maximum number of the difference between the initial and final group is limited to 30 including the initial group itself, i. e., the maximum of j is $i+29$. This number is large enough for all cases except for hydrogen and the continuum level of inelastic scattering. However for the continuum level of inelastic scattering, errors brought by this truncation have been proved to be admissible in

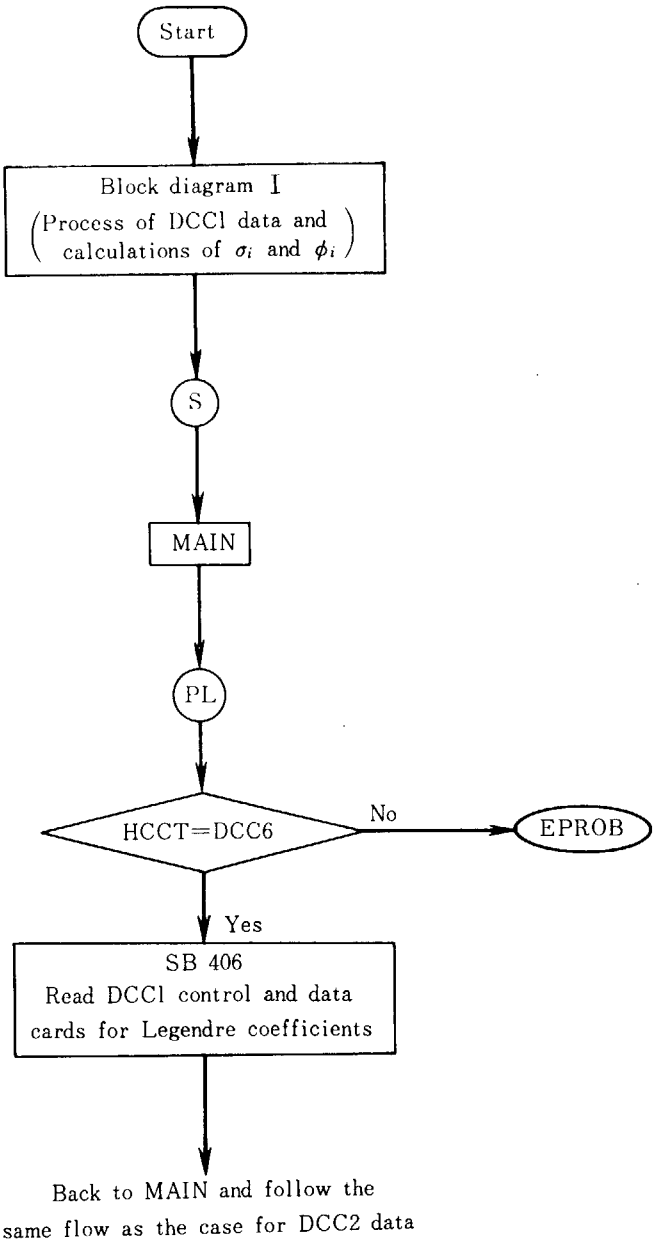

Fig. 3 Block diagram III for processing DCC 6 data

practice. Moreover it should be noticed that when j is larger than IMAX (maximum group number given by an input), the calculation of $\sigma^{i\to j}$ is not carried out.

Before calculations of integrations probability is renormalized in the code, but because of an error brought by truncation and numerical procedure, $\sum_j \sigma^{i\to j}$ does not precisely coincide with σ_i obtained from cross section data only. Hence the $\sigma^{i\to j}$ is finally again renormalized to make $\sum_j \sigma^{i\to j}$ equal to σ_i.

In the present code P_0 and P_1 components of Legendre moments can be obtained from angular distribution data. For higher moments only treatments of the final stage are not ready yet. For energy distribution data only P_0 component is obtained.

The number MESHD of interpolated points between the initial incident energy points for the integration $\int dE_F \int dE_I \sigma \cdot P \cdot \phi$ is determined as follows. In this case an another quantity besides the γ is necessary for reducing the error of the integration. Especially for the calculation

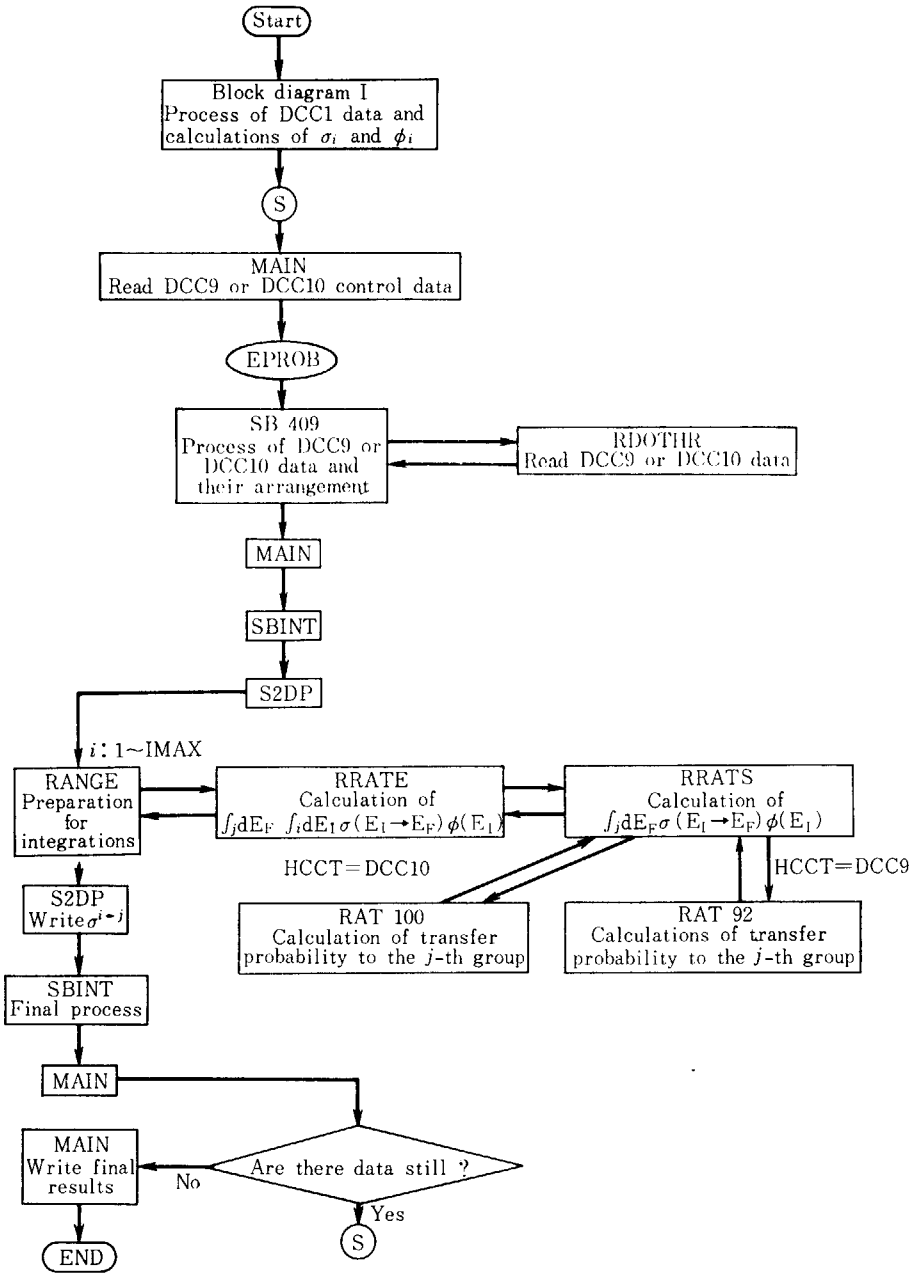

Fig. 4 Block diagram IV for processing DCC 1 and DCC 9 or DCC 10

of an elastic scattering matrix $\sigma_s^{i \to J}$ $(J<i)$, we must carefully determined the number MESHD in the energy interval from the lower energy boundary of the i-th group E_{Li} to E_{Li}/α, from which scattered neutrons are slowed down into group J. α is given by $\{(A-1)/(A+1)\}^2$. Even if scattering cross section is constant, it is necessary to determine the MESHD depending on the value of α. In the code the method determining MESHD of the i-th group differs between above and below E_{Li}/α.

If the energy point E_i is above E_{Li}/α, MESHD is the integer part of $\{(E_{l+1}-E_l)/(\text{AMESH 2}\cdot E_{Li})+1\}$, and if the E_l is below E_{Li}/α, MESHD takes a larger value of the integer part of $\{(E_{l+1}-E_l)/(\text{AMESH 1}\cdot(1/\alpha-1)\cdot E_{Li})+1\}$ and the integer part of $\{(\gamma/0.1)+1.0\}$. AMESH 1 and AMESH 2 are given by inputs and when those are less than or equal to zero, values of AMESH 1=0.1 and AMESH 2=0.025 are set respectively in the code. Next the MESHD below E_{Li}/α is compared with MESH(I) of an input specified by a user and the larger value of both is adopted as final MESHD.

In case of calculating inelastic scattering matrices, MESHD is the same as that obtained in 2. 4. 1.

It should be noticed that when both elastic and inelastic scattering for the same nuclide are processed, the sum of $\sigma_s^{i\to j}$ and $\sigma_{in}^{i\to j}$ is finally obtained in form of card and list. When we want $\sigma_s^{i\to j}$ and $\sigma_{in}^{i\to j}$ individually as final results, it is necessary to process both data separately.

3. Input Data and the Restrictions

Control input data before the ENDF/A data (or data converted to the ENDF/A format) are as follows.

1: Format (I 1, 12 A 6) ; NFC, CCRD

NFC: $\begin{cases} =0 & \text{indicates continuation of the card \# 1.} \\ \neq 0 & \text{indicates last information of the card \# 1.} \end{cases}$

CCRD: Title, comment etc.

2: Format (4 I 5) ; IMAX, LMAXI, ITAPE, MSIGS

IMAX: Number of groups (≤ 70).

LMAXI: Number of Legendre moments required (≤ 2).

ITAPE: If ITAPE≤ 0, the ENDF/A data are read in card form, and if ITAPE>0, the data are read from a tape with the number specified by ITAPE.

MSIGS: $\begin{cases} =0 & \text{indicates that the result for DCC 6 is cross section itself.} \\ \neq 0 & \text{indicates that the result for DCC 6 is normalized to unity.} \end{cases}$

3: Format (14 I 5) ; MESH (I), I=1, IMAX

MESH (I) is used for calculations of elastic scattering matrices and gives an admissible minimum number of interpolation between initial energy points of the input data contained below EL(I+1)/α in the I-th group. The final interpolated number may increased more than MESH (I), according to the rule set in the code. If MESH (I)≤ 0, the interpolation is not performed. For MESH (I)>30, the MESH (I) is set to be equal to 30 in the code.

4: Format (4 E 15. 8) ; EMAX, EMIN, ALPHA, EPS4

EMAX: Upper energy limit of the highest group.

EMIN: Lower energy limit of the lowest group.

ALPHA: Power α to be used for standard weighting spectrum $\phi_s=1/E^\alpha$ below the energy ESPEC.

EPS4: Constant determining the integration interval of μ for DCC6. If EPS4≤ 0, EPS4 is set equal to 1/16 in the code.

5: Format (6 E 12. 5) ; EL(I), I= 2, IMAX+1

EL (I+1) is the lower energy boundary of the I-th group. Note EL(1)=EMAX.

6: Format (4 E 15. 8) ; A0, A1, A2, ESPEC

A0, A1, A2: Constants for fission spectrum, $A_0 e^{-E/A_1} \sinh \sqrt{A_2 E}$. An arbitrary value does well for A_0, because A_0 is modified after reading so that at ESPEC the value of fission spectrum may be connected with that of $1/E^\alpha$.

ESPEC: ϕ_s(E) is fission spectrum above the energy ESPEC and $\phi_s(E)=1/E^\alpha$ below ESPEC.

7: Format (A 3) ; ENUNI

Energy unit used in the code, i. e., "EV", "MEV" etc.

8: Format (3I5); NDIV, IPRT1, IPRT2

NDIV: $\begin{cases} =0 & \text{gives transfer matrix } \sigma^{i\to j}. \\ \neq 0 & \text{gives transfer probability } \sigma^{i\to j}/\Delta E_j. \end{cases}$

IPRT1: $\begin{cases} \neq 0 & \text{gives intermediate results of the coefficients of Legendre expansion.} \\ =0 & \text{does not give above results.} \end{cases}$

IPRT2: $\begin{cases} \neq 0 & \text{gives intermediate results of } \sigma^{i\to j} \text{ and } \mu^{i\to j}. \\ =0 & \text{does not give above results.} \end{cases}$

9: Format (I5, 3E15.5); KCALF, SIGMA0, AMESH1, AMESH2

KCALF: $\begin{cases} \leq 0 & \text{for } \phi=\phi_s. \\ >0 & \text{for } \phi=\phi_s(\sigma_t+\sigma_0)^{-1}. \end{cases}$

SIGMA0: Value of σ_0 in case of KCALF$>$0.

AMESH1: Constant used for determining the number of interpolation below E_{Li}/α for the calculation of $\sigma_s^{i\to j}(j>i)$, where E_{Li} is the lower energy boundary of the i-th group. If AMESH1$\leq$0, AMESH1 is set equal to 0.1 in the code.

AMESH2: Constant used for determining the number of interpolation above E_{Li}/α for the calculation of $\sigma_s^{i\to j}$.
If AMESH2$\leq$0, AMESH2 is set equal to 0.025 in the code.

#10: Format (2A5); ICALP, LCACP

ICALP: ID number of lst block of ENDF/A data processed.

LCALP: ID number of 1st block of ENDF/A data processed.
The ID number is specified in columns from 73 to 77.

ENDF/A format data follow above input data.

4. Output Data

4.1 Description of Output Data

The following results are obtained from the code.

lst page: List of input data

1) Title
2) Group boundaries in an energy unit: EL(I).
3) Maximum numbers of interpolated points for each group: MESH(I).
4) AMESH1 and AMESH2 used for determining the number of interpolation for the calculation of the elastic matrix $\sigma_s^{i\to j}$.
5) Coefficients of fission spectrum and ESPEC.
6) σ_0 (in case of using $\phi_s(\sigma_t+\sigma_0)^{-1}$ spectrum).

2nd page: List of ENDF/A data

7) Heading and control data of ENDF/A formats.
8) First and last values of energy and its dependent variable of DCC 1 data.

3rd page: calculation results of cross section (DCC 1 data)

9) Effective cross section.
10) Flux used for averaging.

In case of processing cross section data of various reactions continuously, the outputs of 7)

~10) are edited iteratively. When scattering probability data (DCC 2, DCC 6, DCC 9 and DCC 10) follow cross section data (DCC 1), the code prints :

11) Heading and control data of ENDF/A formats, and informations on DCC 2, DCC 6, DCC 9 or DCC 10 data.

If the data are DCC 2 type :

12) An arranged two-dimensional array of scattering probability and its renormalized array are listed.

Using the options IPRT1 and IPRT2, the following intermediate results are obtained :

13) The intermediate results of $\sigma^{i\to j}$ and $\mu^{i\to j}$, and of their corresponding Legendre components. For DCC 9 and DCC 10, $\mu^{i\to j}$ and the P_1 component are not obtained.

Finally, the following results are obtained for every isotopes.

14) Final results.

The summation of all cross sections, except for total cross section, processed for the same isotope is obtained. When scattering probability data also are processed, the summation $\sum_j \sigma^{i\to j}$, μ (for DCC 2 and DCC 6) and $\sigma^{i\to j}$ are listed.

Every cross sections, fluxes, the summation of cross sections for the same isotope, μ (for DCC 2 and DCC 6), $\sigma^{i\to j}$ and $\sigma'^{i\to j}$ (see Eq. (20)) are obtained also in card form.

4. 2 Examples of Output Data

(1) Case of processing only cross section data (DCC 1)

TABLE 2 shows the results for a case where the data of all discrete and continuum levels of inelastic scattering of ^{238}U have been continuously processed with using the standard weighting spectrum $\phi_s(E)$. The gruop structure of the example is similar to that of the Russian set. The "LOWER BOUNDARY" in the first page means ESPEC. The "SUMMATION OF ONE DIMENSIONAL DATA" in the final page gives the total inelastic scattering cross section of ^{235}U. Cross sections of individual levels are listed in the pages following immediately after lists of heading cards of the corresponding levels.

In TABLE 3 are presented the results of total and elastic scattering cross sections of Fe in case of using the spectrum $\phi_s(E)(\sigma_t(E)+\sigma_0)^{-1}$ for $\sigma_0=10^2$ barns. The number of groups is 70 obtained by dividing each group of the Russian set into two or three groups. The "SUMMATION OF ONE DIMENSIONAL DATA" in the final page gives only the result of elastic scattering cross section.

(2) Case of processing a set of cross section (DCC 1) and scattering probability data (DCC 2, DCC 6, DCC 9 and DCC 10)

In TABLE 4 are shown the results of elastic scattering of natural boron in case of processing cross section (DCC 1) and angular distribution data (DCC 2) with use of the spectrum $\phi_s(E)$. In the lists subsequent to the result of cross section, informations on DCC 2 data and the intermediate results of calculations are given. The intermediate results of the example have been obtained by setting IPRT1=0 and IPRT2≠0. The symbols LGF, SIG and MU represent respectively the final group into which neutrons are scattered, $\sigma_s^{i\to LGF}$ and $\mu^{i\to LGF}$. And the symbol LGI means the range of the initial group i.

Next to the above list the final results are shown by the titles subsequent to "SUMMATION OF ONE DIMENSIONAL DATA". The values of $\sum \sigma^{i\to j}$, μ^i and $\sigma^{i\to j}$ of the first three

groups are set to be zero, because the scattering probability data of that energy region is not given in the input data converted from the UKNDL[2]. Values in "SUMMATION OF TRANSFER MATRICES" indicate those before the normalization in order to know an error brought by numerical integrations.

For the other sets of cross section data (DCC 1) and DCC 6 or DCC 9 or DCC 10, almost the same results as for the set of DCC 1 and DCC 2 are also obtained.

Acknowledgment

The authors wish to express their gratitude to users of the code for their comments on it.

References

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TABLE 1 Data Processed by PROF GROUCH-G

Data form	Reaction type	Data type
C	Total	Cross section
	Elastic scattering	〃
	Inelastic scattering	〃
	Pair production	〃
DCC 1	Triplet production	〃
	Fission	〃
	Parasitic absorption	〃
	(n, γ)	〃
	(n, p)	〃
	(n, t)	〃
	(n, ^{3}He)	〃
	(n, α)	〃
	(n, 2α)	〃
P (probability) DCC 2, DCC 6 DCC 9 and DCC 10	Elastic scattering Inelastic scattering Pair production Triplet production Fission	Angular and energy distribution

TABLE 2 Output for processing only DCC 1 data of inelastic scattering cross section of ^{238}U with use of $\phi_s(E)$

```
      PRODUCTIVE CALCULATION OF *U238-INELASTIC*
      GROUP STRUCTURE IS THE SAME AS ESELEM     * 1/E WEIGHT *
      DATA ARE TAKEN FROM A/W      JUL./30/1968      T.TONE

EL=    0.10500000E 08   0.65000000E 07   0.40000000E 07   0.19951000E 07   0.13969000E 07   0.79882000E 06

EL=    0.40127000E 06   0.19994000E 06   0.99628000E 05   0.46152000E 05   0.21380000E 05   0.99845999E 04

EL=    0.46253000E 04   0.21500000E 04   0.10000000E 04   0.46500000E 03   0.21500000E 03   0.10000000E 03

EL=    0.46500000E 02   0.21500000E 02   0.10000000E 02   0.46500000E 01   0.21500000E 01   0.10000000E 01

EL=    0.46500000E 00   0.21500000E 00

MESH=              1                1                1                1                1                1

MESH=              1                1                1                1                1                1

MESH=              1                1                1                1                1                1

MESH=              1                1                1                1                1                1

MESH=              1
            AMESH1 =     0.10000
            AMESH2 =     0.02500

   FISSION SPECTRUM
      A0 = 0.48400E-06     A1 = 0.10000E 07     A2 = 0.20000E-05     LOWER BOUNDARY = 0.10000E 07 EV


   U 238
   U 238  N INELAS  1 N CROS C E1        BN A/W  41  0 63  1.000E-03  1.500E 07EV A0041  0
      50     1    92   238      1     4      1      1      1      1      1      2 A0041  1
       1     2     1     0      0     0      0    128     41      0     63      0 A0041  2
    2.3807E 02 -4.4000E 04  0.          1.0000E 00  1.0000E-03  1.5000E 07 A0041  3
   ALDERMASTON/WINFRITH DATA FILE, 7/1/64     NIN= 5   GCN= 1   PCN= 5     A0041  4
   AEEW R351, 2/64, BARRINGTON ETAL,    AWRE 0-79/63, 1/64, K.PARKER        A0041  5
   DCC1     401      1      5      0   124      0      0 -0.          0.      A0041  6
      0.46000000E 05     0.10000000E-02     0.20000000E 07     0.10000000E-02   (FIRST AND LAST VALUE)
   NDTYP=1
```

```
*** U 238 (N,INELAS) 1,N CROS C(EI,  ,  ) ***

    SEC= 1 (LGI=1...25)
        0.                  0.                  0.57476375E-04      0.66619598E-01      0.73184316E 00      0.15274226E 01
        0.13310057E 01      0.89416164E 00      0.21200201E 00      0.48062913E-04      0.                  0.
        0.                  0.                  0.                  0.                  0.                  0.
        0.                  0.                  0.                  0.                  0.                  0.
        0.

    (TOTAL SEC) *** (LGI=1...25)
        0.                  0.                  0.57476375E-04      0.66619598E-01      0.73184316E 00      0.15274226E 01
        0.13310057E 01      0.89416164E 00      0.21200201E 00      0.48062913E-04      0.                  0.
        0.                  0.                  0.                  0.                  0.                  0.
        0.                  0.                  0.                  0.                  0.                  0.
        0.


*** FLUX ***
                    0.                  0.                  8.4291242 E-01      4.7372668 E-01      5.8141658 E-01      6.8869995 E-01
                    6.9738338 E-01      6.9951868 E-01      7.6963085 E-01      7.7010402 E-01      0.                  0.
                    0.                  0.                  0.                  0.                  0.                  0.
                    0.                  0.                  0.                  0.                  0.                  0.
                    0.

            U 238
            U 238  N INELAS  2 N CROS C EI        BN A/W  44  0 63  1.000E-03  1.500E 07EV A0044  0
               46     1     92   238     1     4      2     1      1     1     1      2 A0044  1
                1     2      1     0     0     0      0   128     44     0    63      0 A0044  2
             2.3807E 02 -1.460UE 05  0.          1.0000E 00  1.0000E-03  1.5000E 07 A0044  3
            ALDERMASTON/WINFRITH DATA FILE, 7/1/64    NIN= 5   GCN= 1   PCN= 6     A0044  4
            AEEW R351, 2/64, BARRINGTON ETAL,   AWRE 0-79/63,  1/64, K.PARKER      A0044  5
            DCC1    401     1     5     0   113       0     0 -0.         0.       A0044  6
               0.15000000E 06     0.10000000E-02     0.20000000E 07     0.10000000E-02   (FIRST AND LAST VALUE)
            NDTYP=1

*** U 238 (N,INELAS) 2,N CROS C(EI,  ,  ) ***

    SEC= 1 (LGI=1...25)
        0.                  0.                  0.57653844E-04      0.29017699E 00      0.58414833E 00      0.28631179E 00
        0.58651783E-01      0.35761356E-02      0.                  0.                  0.                  0.
        0.                  0.                  0.                  0.                  0.                  0.
        0.                  0.                  0.                  0.                  0.                  0.
        0.

    (TOTAL SEC) *** (LGI=1...25)
        0.                  0.                  0.57653844E-04      0.29017699E 00      0.58414833E 00      0.28631179E 00
        0.58651783E-01      0.35761356E-02      0.                  0.                  0.                  0.
        0.                  0.                  0.                  0.                  0.                  0.
        0.                  0.                  0.                  0.                  0.                  0.
        0.


*** FLUX ***
                    0.                  0.                  8.4291242 E-01      4.7372574 E-01      5.8141658 E-01      6.8869995 E-01
                    6.9701371 E-01      6.9668743 E-01      0.                  0.                  0.                  0.
                    0.                  0.                  0.                  0.                  0.                  0.
                    0.                  0.                  0.                  0.                  0.                  0.
                    0.

            U 238
            U 238  N INELAS  3 N CROS C EI        BN A/W  47  0 63  1.000E-03  1.500E 07EV A0047  0
               42     1     92   238     1     4      3     1      1     1     1      2 A0047  1
                1     2      1     0     0     0      0   128     47     0    63      0 A0047  2
             2.3807E 02 -3.000UE 05  0.          1.0000E 00  1.0000E-03  1.5000E 07 A0047  3
            ALDERMASTON/WINFRITH DATA FILE, 7/1/64    NIN= 5   GCN= 1   PCN= 7     A0047  4
            AEEW R351, 2/64, BARRINGTON ETAL,   AWRE 0-79/63,  1/64, K.PARKER      A0047  5
            DCC1    401     1     5     0   102       0     0 -0.         0.       A0047  6
               0.31000000E 06     0.10000000E-02     0.20000000E 07     0.10000000E-02   (FIRST AND LAST VALUE)
            NDTYP=1

*** U 238 (N,INELAS) 3,N CROS C(EI,  ,  ) ***

    SEC= 1 (LGI=1...25)
        0.                  0.                  0.57476375E-04      0.40409434E-01      0.90498418E-01      0.53319902E-01
        0.34631272E-02      0.                  0.                  0.                  0.                  0.
        0.                  0.                  0.                  0.                  0.                  0.
        0.                  0.                  0.                  0.                  0.                  0.
        0.

    (TOTAL SEC) *** (LGI=1...25)
        0.                  0.                  0.57476375E-04      0.40409434E-01      0.90498418E-01      0.53319902E-01
        0.34631272E-02      0.                  0.                  0.                  0.                  0.
        0.                  0.                  0.                  0.                  0.                  0.
        0.                  0.                  0.                  0.                  0.                  0.
        0.


*** FLUX ***
                    0.                  0.                  8.4291242 E-01      4.7372691 E-01      5.8141658 E-01      6.8869995 E-01
                    6.9674813 E-01      0.                  0.                  0.                  0.                  0.
                    0.                  0.                  0.                  0.                  0.                  0.
                    0.                  0.                  0.                  0.                  0.                  0.
                    0.

            U 238
            U 238  N INELAS  4 N CROS C EI        BN A/W  50  0 63  1.000E-03  1.500E 07EV A0050  0
               36     1     92   238     1     4      4     1      1     1     1      2 A0050  1
                1     2      1     0     0     0      0   128     50     0    63      0 A0050  2
             2.3807E 02 -7.000UE 05  0.          1.0000E 00  1.0000E-03  1.5000E 07 A0050  3
            ALDERMASTON/WINFRITH DATA FILE, 7/1/64    NIN= 5   GCN= 1   PCN= 8     A0050  4
            AEEW R351, 2/64, BARRINGTON ETAL,   AWRE 0-79/63,  1/64, K.PARKER      A0050  5
            DCC1    401     1     5     0    82       0     0 -0.         0.       A0050  6
               0.71000000E 06     0.10000000E-02     0.20000000E 07     0.10000000E-02   (FIRST AND LAST VALUE)
            NDTYP=1
```

```
*** U 238 (N,INELAS) 4,N CROS C(EI,  ,  ) ***

    SEC= 1 (LGI=1...25)
        0.              0.              0.57704802E-04  0.17959515E 00  0.46518985E 00  0.10958495E-01
        0.              0.              0.              0.              0.              0.
        0.              0.              0.              0.              0.              0.
        0.              0.              0.              0.              0.              0.
        0.

    (TOTAL SEC) *** (LGI=1...25)
        0.              0.              0.57704802E-04  0.17959515E 00  0.46518985E 00  0.10958495E-01
        0.              0.              0.              0.              0.              0.
        0.              0.              0.              0.              0.              0.
        0.              0.              0.              0.              0.              0.
        0.

*** FLUX ***
            0.              0.              8.4291242 E-01  4.7372597 E-01  5.8141658 E-01  6.8875705 E-01
            0.              0.              0.              0.              0.              0.
            0.              0.              0.              0.              0.              0.
            0.              0.              0.              0.              0.              0.
            0.

          U 238
          U 238  N INELAS  5 N CROS C EI       BN A/W  53  0 63  1.000E-03  1.500E 07EV A0053  0
             23     1    92   238     1     4      5     1     1     1     1     2 A0053  1
              1     2     1     0     0     0      0   128    53     0    63     0 A0053  2
           2.3807E 02 -9.800UE 05  0.          1.0000E 00  1.0000E-03  1.5000E 07 A0053  3
          ALDERMASTON/WINFRITH DATA FILE, 7/1/64    NIN= 5   GCN= 1   PCN= 9     A0053  4
          AEEW R351, 2/64, BARRINGTON ETAL,   AWRE 0-79/63,  1/64, K.PARKER      A0053  5
          DCC1    401     1     5     0    45      0     0 -0.          0.        A0053  6
             0.99000000E 06    0.10000000E-02    0.20100000E 07    0.10000000E-02   (FIRST AND LAST VALUE)
          NDTYP=1

      *** U 238 (N,INELAS) 5,N CROS C(EI,  ,  ) ***

          SEC= 1 (LGI=1...25)
              0.              0.              0.10664659E-02  0.37472566E 00  0.34777647E 00  0.
              0.              0.              0.              0.              0.              0.
              0.              0.              0.              0.              0.              0.
              0.              0.              0.              0.              0.              0.
              0.

          (TOTAL SEC) *** (LGI=1...25)
              0.              0.              0.10664659E-02  0.37472566E 00  0.34777647E 00  0.
              0.              0.              0.              0.              0.              0.
              0.              0.              0.              0.              0.              0.
              0.              0.              0.              0.              0.              0.
              0.

      *** FLUX ***
                  0.              0.              8.4290313 E-01  4.7372717 E-01  5.8141728 E-01  0.
                  0.              0.              0.              0.              0.              0.
                  0.              0.              0.              0.              0.              0.
                  0.              0.              0.              0.              0.              0.
                  0.

            U 238
            U 238  N INELAS  6 N CROS C EI       BN A/W  56  0 63  1.000E-03  1.500E 07EV A0056  0
               22     1    92   238     1     4      6     1     1     1     1     2 A0056  1
                1     2     1     0     0     0      0   128    56     0    63     0 A0056  2
             2.3807E 02 -1.060UE 06  0.          1.0000E 00  1.0000E-03  1.5000E 07 A0056  3
            ALDERMASTON/WINFRITH DATA FILE, 7/1/64    NIN= 5   GCN= 1   PCN= 10    A0056  4
            AEEW R351, 2/64, BARRINGTON ETAL,   AWRE 0-79/63,  1/64, K.PARKER      A0056  5
            DCC1    401     1     5     0    41      0     0 -0.          0.        A0056  6
               0.10700000E 07    0.10000000E-02    0.20100000E 07    0.10000000E-02   (FIRST AND LAST VALUE)
            NDTYP=1

      *** U 238 (N,INELAS) 6,N CROS C(EI,  ,  ) ***

          SEC= 1 (LGI=1...25)
              0.              0.              0.14380618E-02  0.41957524E 00  0.19576222E 00  0.
              0.              0.              0.              0.              0.              0.
              0.              0.              0.              0.              0.              0.
              0.              0.              0.              0.              0.              0.
              0.

          (TOTAL SEC) *** (LGI=1...25)
              0.              0.              0.14380618E-02  0.41957524E 00  0.19576222E 00  0.
              0.              0.              0.              0.              0.              0.
              0.              0.              0.              0.              0.              0.
              0.              0.              0.              0.              0.              0.
              0.

      *** FLUX ***
                  0.              0.              8.4290313 E-01  4.7372895 E-01  5.8141506 E-01  0.
                  0.              0.              0.              0.              0.              0.
                  0.              0.              0.              0.              0.              0.
                  0.              0.              0.              0.              0.              0.
                  0.

            U 238
            U 238  N INELAS 98 N CROS C EI       BN A/W  59  0 63  1.000E-03  1.500E 07EV A0059  0
               32     1    92   238     1     4     98     1     1     1     1     2 A0059  1
                1     2     1     0     0     0      0   128    59     0    63     0 A0059  2
             2.3807E 02 -4.400UE 05  0.          1.0000E 00  1.0000E-03  1.5000E 07 A0059  3
            ALDERMASTON/WINFRITH DATA FILE, 7/1/64    NIN= 5   GCN= 1   PCN= 15    A0059  4
            AEEW R351, 2/64, BARRINGTON ETAL,   AWRE 0-79/63,  1/64, K.PARKER      A0059  5
            DCC1    401     1     5     0    72      0     0 -0.          0.        A0059  6
               0.12700000E 07    0.10000000E-02    0.15000000E 08    0.14700000E 00   (FIRST AND LAST VALUE)
            NDTYP=1
```

```
*** U 238 (N,INELAS)98,N CROS C(EI,  ,  ) ***

    SEC= 1 (LGI=1...25)
        0.12891453E 01    0.25135687E 01    0.25837421E 01    0.11975995E 01    0.16279929E-01    0.
        0.                0.                0.                0.                0.                0.
        0.                0.                0.                0.                0.                0.
        0.                0.                0.                0.                0.                0.
        0.

    (TOTAL SEC) *** (LGI=1...25)
        0.12891453E 01    0.25135687E 01    0.25837421E 01    0.11975995E 01    0.16279929E-01    0.
        0.                0.                0.                0.                0.                0.
        0.                0.                0.                0.                0.                0.
        0.                0.                0.                0.                0.                0.
        0.


*** FLUX ***
                  4.9996148 E-02    2.6480451 E-01    8.4324598 E-01    4.7372947 E-01    5.8139205 E-01    0.
                  0.                0.                0.                0.                0.                0.
                  0.                0.                0.                0.                0.                0.
                  0.                0.                0.                0.                0.                0.
                  0.

***SUMMATION OF ONE DIMENSIONAL DATA
                  1.2891453 E 00    2.5135687 E 00    2.5864769 E 00    2.5687016 E 00    2.4314984 E 00    1.8780128 E 00
                  1.3931206 E 00    8.9773777 E-01    2.1200201 E-01    4.8062913 E-05    0.                0.
                  0.                0.                0.                0.                0.                0.
                  0.                0.                0.                0.                0.                0.
                  0.
```

TABLE 3 Output for processing DCC 1 data of total and elastic scattering cross sections of Fe with use of $\phi_s(\sigma_t+\sigma_0)^{-1}$

```
      CALCULATION FOR ABN-TYPE
         SIGO=100.       FE *T, E)
       TITLE NO OWARI

 EL=   0.10500000E C8   0.83000000E 07   0.65000000E 07   0.51000000E 07   0.40000000E 07   0.31000000E 07
 EL=   0.25000000E C7   0.19000000E 07   0.14000000E 07   0.11000000E 07   0.80000000E 06   0.63000000E 06
 EL=   0.50000000E C6   0.40000000E C6   0.31000000E 06   0.25000000E 06   0.20000000E 06   0.15000000E 06
 EL=   0.12000000E C6   0.10000000E C6   0.77300000E 05   0.59800000E 05   0.46500000E 05   0.36000000E 05
 EL=   0.27800000E 05   0.21500000E 05   0.16600000E 05   0.12900000E 05   0.10000000E 05   0.77300000E 04
 EL=   0.59800000E C4   0.46500000E 04   0.36000000E 04   0.27800000E 04   0.21500000E 04   0.16600000E 04
 EL=   0.12900000E C4   0.10000000E C4   0.77300000E 03   0.59800000E 03   0.46500000E 03   0.36000000E 03
 EL=   0.27800000E 03   0.21500000E 03   0.16600000E 03   0.12900000E 03   0.10000000E 03   0.77299988E 02
 EL=   0.59799988E 02   0.46500000E 02   0.36000000E 02   0.27799988E 02   0.21500000E 02   0.16599991E 02
 EL=   0.12900000E C2   0.10000000E 02   0.77299995E 01   0.59799995E 01   0.46499996E 01   0.35999994E 01
 EL=   0.27799997E 01   0.21499996E 01   0.16599998E 01   0.12900000E 01   0.10000000E 01   0.77299994E 00
 EL=   0.59799999E 00   0.46499997E 00   0.35999995E 00   0.27800000E 00   0.21499997E 00

 MESH=              1              1              1              1              1              1
 MESH=              1              1              1              1              1              1
 MESH=              1              1              1              1              1              1
 MESH=              1              1              1              1              1              1
 MESH=              1              1              1              1              1              1
 MESH=              1              1              1              1              1              1
 MESH=              1              1              1              1              1              1
 MESH=              1              1              1              1              1              1
 MESH=              1              1              1              1              1              1
 MESH=              1              1              1              1              1              1
 MESH=              1              1              1              1              1              1
 MESH=              1              1              1              1

          AMESH1 =     0.10000
          AMESH2 =     0.02500

   FISSION SPECTRUM
      A0 = 0.48400E-06     A1 = 0.10000E 07     A2 = 0.20000E-05     LOWER BOUNDARY = 0.10000E 07 EV

   ** SIGMA0 = 0.10000E 03 **
```

```
FE  0  N TOTAL   0   CROS C EI        BN UK-  36  0  0  1.000E-04  1.500E 07EV E0291  0
  270     0     26     0     1     1     0     0     1     1     1     2 E0291  1
    1     0      1     0     0     0     0     0     0     0     0     0 E0291  2
 5.5845E 01  0.0          0.0          1.0000E 00  1.0000E-04  1.5000E 07 E0291  3
ENR      200      1     2     0     0     0     0  1.0000E-04  2.7820E 06 E0291  4
DCC1     401      1     5     0   690     0     0  0.0          0.0          E0291  5
   9.9999999E-05  4.6000000E 01    2.7820000E 06    3.1839990E 00          (FIRST AND LAST VALUE)
   0.9999999E-04  0.1460000E 03    0.2782000E 07    0.1031839E 03   (FIRST AND LAST VALUE)=SIG.TOT(    1, 1379)
ENR      200      2     2     0     0     0     0  2.7820E 06  1.5000E 07 E0291236
DCC1     401      1     5     0    92     0     0  0.0          0.0          E0291237
   2.7820000E 06  3.1839990E 00    1.5000000E 07    3.2034997E 00          (FIRST AND LAST VALUE)
   2.7820000E 07  0.1031839E 03    0.1500000E 08    0.1032034E 03   (FIRST AND LAST VALUE)=SIG.TOT( 1381, 1563)

FE  0  N ELAST   0 N CROS C EI        BN UK-  36  0  0  1.000E-04  1.500E 07EV E0292  0
  270     1     26     0     1     2     0     1     1     1     1     2 E0292  1
    1     0      1     0     0     0     0     0     0     0     0     0 E0292  2
 5.5845E 01  0.0          0.0          1.0000E 00  1.0000E-04  1.5000E 07 E0292  3
ENR      200      1     2     0     0     0     0  1.0000E-04  2.7820E 06 E0292  4
DCC1     401      1     5     0   690     0     0  0.0          0.0          E0292  5
   9.9999999E-05  5.7999992E 00    2.7820000E 06    2.2886991E 00          (FIRST AND LAST VALUE)
ENR      200      2     2     0     0     0     0  2.7820E 06  1.5000E 07 E0292236
DCC1     401      1     5     0    92     0     0  0.0          0.0          E0292237
   2.7820000E 06  2.2886991E 00    1.5000000E 07    1.1299991E 00          (FIRST AND LAST VALUE)
```

*** FE 0 (N,TOTAL) 0, CROS C(EI, ,) ***

SEC= 1 (LGI=1...70)

0.32149353E 01	0.35306244E 01	0.36883392E 01	0.36867065E 01	0.34729919E 01	0.33255157E 01	
0.31366151E 01	0.28681335E 01	0.25450439E 01	0.24707031E 01	0.30222321E 01	0.26513315E 01	
0.37592773E 01	0.32530975E 01	0.24235077E 01	0.31864929E 01	0.37312164E 01	0.41543427E 01	
0.29002360E 01	0.63298035E 01	0.40079041E 01	0.43726196E 01	0.54467773E 01	0.18713501E 02	
0.51777649E 01	0.22221832E 01	0.37470551E 01	0.57673187E 01	0.11027100E 02	0.18883423E 02	
0.82786865E 01	0.54957581E 01	0.52636414E 01	0.59508362E 01	0.68818817E 01	0.77271271E 01	
0.92123108E 01	0.93731232E 01	0.99596863E 01	0.10396744E 02	0.10735397E 02	0.10999878E 02	
0.11167454E 02	0.11314346E 02	0.11393158E 02	0.11428055E 02	0.11443283E 02	0.11454437E 02	
0.11472397E 02	0.11475403E 02	0.11479202E 02	0.11484665E 02	0.11493881E 02	0.11505783E 02	
0.11519958E 02	0.11536255E 02	0.11554703E 02	0.11575851E 02	0.11599274E 02	0.11626755E 02	
0.11659348E 02	0.11694199E 02	0.11734177E 02	0.11779770E 02	0.11829559E 02	0.11888702E 02	
0.11955063E 02	0.12030380E 02	0.12117645E 02	0.12215927E 02			

(TOTAL SEC) *** (LGI=1...70)

0.32149353E 01	0.35306244E 01	0.36883392E 01	0.36867065E 01	0.34729919E 01	0.33255157E 01	
0.31366151E 01	0.28681335E 01	0.25450439E 01	0.24707031E 01	0.30222321E 01	0.26513315E 01	
0.37592773E 01	0.32530975E 01	0.24235077E 01	0.31864929E 01	0.37312164E 01	0.41543427E 01	
0.29002360E 01	0.63298035E 01	0.40079041E 01	0.43726196E 01	0.54467773E 01	0.18713501E 02	
0.51777649E 01	0.22221832E 01	0.37470551E 01	0.57673187E 01	0.11027100E 02	0.18883423E 02	
0.82786865E 01	0.54957581E 01	0.52636414E 01	0.59508362E 01	0.68818817E 01	0.77271271E 01	
0.92123108E 01	0.93731232E 01	0.99596863E 01	0.10396744E 02	0.10735397E 02	0.10999878E 02	
0.11167454E 02	0.11314346E 02	0.11393158E 02	0.11428055E 02	0.11443283E 02	0.11454437E 02	
0.11472397E 02	0.11475403E 02	0.11479202E 02	0.11484665E 02	0.11493881E 02	0.11505783E 02	
0.11519958E 02	0.11536255E 02	0.11554703E 02	0.11575851E 02	0.11599274E 02	0.11626755E 02	
0.11659348E 02	0.11694199E 02	0.11734177E 02	0.11779770E 02	0.11829559E 02	0.11888702E 02	
0.11955063E 02	0.12030380E 02	0.12117645E 02	0.12215927E 02			

*** FLUX ***

3.65960923E-05	1.29267806E-04	3.09529947E-04	5.64257847E-04	8.73690937E-04	9.06016212E-04
1.25363795E-03	1.35200541E-03	9.43141524E-04	1.01611624E-03	2.31877342E-03	2.25147605E-03
2.15046343E-03	2.40796061E-03	2.09974684E-03	2.16220692E-03	2.77131237E-03	2.13958882E-03
1.77176297E-03	2.41457298E-03	2.46388093E-03	2.41007656E-03	2.42719054E-03	2.12415308E-03
2.41532177E-03	2.53046118E-03	2.43100710E-03	2.40818970E-03	2.31680833E-03	2.15365924E-03
2.32165121E-03	2.42597237E-03	2.45573372E-03	2.42605060E-03	2.42027827E-03	2.34123319E-03
2.35139843E-03	2.55435553E-03	2.33483128E-03	2.27930211E-03	2.31192634E-03	2.32901052E-03
2.31179781E-03	2.32436694E-03	2.26492435E-03	2.28766166E-03	2.31062993E-03	2.30353139E-03
2.25730799E-03	2.29756720E-03	2.32015178E-03	2.30676495E-03	2.32062116E-03	2.26319768E-03
2.28954852E-03	2.31483020E-03	2.30282173E-03	2.25682557E-03	2.29502097E-03	2.31801718E-03
2.30702479L-03	2.31823884E-03	2.25858204E-03	2.28422135E-03	2.30344571E-03	2.29584426E-03
2.24917941E-03	2.28618830E-03	2.30786577E-03	2.29178555E-03		

*** FE 0 (N,ELAST) 0,N CROS C(EI, ,) ***

SEC= 1 (LGI=1...70)

0.18152962E 01	0.21443005E 01	0.23297539E 01	0.22693338E 01	0.22813969E 01	0.23630152E 01
0.22970629E 01	0.22302628E 01	0.21284046E 01	0.22710209E 01	0.30244150E 01	0.26465282E 01
0.37562799E 01	0.32649155E 01	0.24301033E 01	0.31890669E 01	0.37950144E 01	0.42793713E 01
0.29006672E 01	0.66294899E 01	0.41735220E 01	0.43718300E 01	0.54455833E 01	0.21678406E 02
0.63901510E 01	0.22163916E 01	0.37416410E 01	0.57617216E 01	0.11123222E 02	0.19170624E 02
0.83416834E 01	0.54925241E 01	0.52554979E 01	0.59390068E 01	0.68537159E 01	0.76412354E 01
0.84268742E 01	0.93192663E 01	0.99409733E 01	0.10380540E 02	0.10710527E 02	0.10968756E 02
0.11160350E 02	0.11285377E 02	0.11355880E 02	0.11388144E 02	0.11399502E 02	0.11400007E 02
0.11400002E 02	0.11399997E 02	0.11400002E 02	0.11399989E 02	0.11399994E 02	0.11399997E 02
0.11399991E 02	0.11399989E 02	0.11399994E 02	0.11400002E 02	0.11399995E 02	0.11399993E 02
0.11399995E 02	0.11400001E 02	0.11399993E 02	0.11399998E 02	0.11399992E 02	0.11399995E 02
0.11399989E 02	0.11399998E 02	0.11399996E 02	0.11400000E 02		

(TOTAL SEC) *** (LGI=1...70)

0.18152962E 01	0.21443005E 01	0.23297539E 01	0.22693338E 01	0.22813969E 01	0.23630152E 01
0.22970629E 01	0.22302628E 01	0.21284046E 01	0.22710209E 01	0.30244150E 01	0.26465282E 01
0.37562799E 01	0.32649155E 01	0.24301033E 01	0.31890669E 01	0.37950144E 01	0.42793713E 01
0.29006672E 01	0.66294899E 01	0.41735220E 01	0.43718300E 01	0.54455833E 01	0.21678406E 02
0.63901510E 01	0.22163916E 01	0.37416410E 01	0.57617216E 01	0.11123222E 02	0.19170624E 02
0.83416834E 01	0.54925241E 01	0.52554979E 01	0.59390068E 01	0.68537159E 01	0.76412354E 01
0.84268742E 01	0.93192663E 01	0.99409733E 01	0.10380540E 02	0.10710527E 02	0.10968756E 02
0.11160350E 02	0.11285377E 02	0.11355880E 02	0.11388144E 02	0.11399502E 02	0.11400007E 02
0.11400002E 02	0.11399997E 02	0.11400002E 02	0.11399989E 02	0.11399994E 02	0.11399997E 02
0.11399991E 02	0.11399989E 02	0.11399994E 02	0.11400002E 02	0.11399995E 02	0.11399993E 02
0.11399995E 02	0.11400001E 02	0.11399993E 02	0.11399998E 02	0.11399992E 02	0.11399995E 02
0.11399989E 02	0.11399998E 02	0.11399996E 02	0.11400000E 02		

```
*** FLUX ***
 3.65901069E-05  1.29267923E-04  3.09530413E-04  5.64258313E-04  8.73693032E-04  9.06017842E-04
 1.25364048E-03  1.39200620E-03  9.43142455E-04  1.01611787E-03  2.31877714E-03  2.25147977E-03
 2.19048529E-03  2.40799365E-03  2.09975056E-03  2.16220878E-03  2.77131982E-03  2.13959441E-03
 1.77176390E-03  2.41457485E-03  2.46388465E-03  2.41007842E-03  2.42719427E-03  2.12415680E-03
 2.41532549E-03  2.53046490E-03  2.43100896E-03  2.40818784E-03  2.31681019E-03  2.15366110E-03
 2.32165367E-03  2.42597610E-03  2.45573558E-03  2.42605247E-03  2.42027827E-03  2.34123878E-03
 2.33140029E-03  2.33435925E-03  2.33483315E-03  2.27930397E-03  2.31192820E-03  2.32901052E-03
 2.31180154E-03  2.32436880E-03  2.26492621E-03  2.28766166E-03  2.31063180E-03  2.30353326E-03
 2.25736799E-03  2.29756907E-03  2.32015178E-03  2.30676681E-03  2.32062116E-03  2.26319768E-03
 2.26955038E-03  2.31483206E-03  2.30282359E-03  2.25682557E-03  2.29502283E-03  2.31801718E-03
 2.30702479E-03  2.31823884E-03  2.25858204E-03  2.28422135E-03  2.30344757E-03  2.29584612E-03
 2.24918127E-03  2.28619017E-03  2.30786577E-03  2.29178555E-03

***SUMMATION OF ONE DIMENSIONAL DATA
 1.81529617E 00  2.14430346E 00  2.32975388E 00  2.26933384E 00  2.28139687E 00  2.36301517E 00
 2.23706267E 00  2.23026276E 00  2.12840462E 00  2.27102089E 00  3.02441502E 00  2.64652824E 00
 3.75627995E 00  3.23491547E 00  2.43010330E 00  3.18906689E 00  3.79501438E 00  4.27937126E 00
 2.90866719E 00  0.62948990E C0  4.17352200E 00  4.37182999E 00  5.44558334E 00  2.16784058E 01
 0.39C151102E 00  2.21039156E C0  3.74164104E 00  5.76172161E 00  1.11232224E 01  1.91706238E 01
 0.34166339E 00  5.49252415E 00  5.25549793E 00  5.93900661E 00  6.85371590E 00  7.64123535E 00
 0.42667416E 00  9.31926632E C0  9.94097328E 00  1.03805399E 01  1.07105274E 01  1.09687557E 01
 1.11603498E 01  1.12653765E C1  1.13558798E 01  1.13881445E 01  1.13995018E 01  1.14000072E 01
 1.14000025E 01  1.13999366E 01  1.14000025E 01  1.13999891E 01  1.13999939E 01  1.13999968E 01
 1.13999916E 01  1.13999691E C1  1.13999939E 01  1.14000015E 01  1.13999949E 01  1.13999929E 01
 1.13999949E 01  1.14000306E C1  1.13999929E 01  1.13999977E 01  1.13999920E 01  1.13999949E 01
 1.13999691E 01  1.13999977E C1  1.13999958E 01  1.13999996E 01
```

TABLE 4 Output for processing a set of DCC 1 and DCC 2 data of elastic cross section of boron with use of $\phi_s(E)$

```
      E0392-F0393   B 0(N,ELAST)  1/E   ABN-69
 EL=  0.10500000E 08  0.83000000E 07  0.65000000E 07  0.51000000E 07  0.40000000E 07  0.31000000E 07
 EL=  0.25000000E 07  0.19000000E 07  0.14000000E 07  0.11000000E 07  0.80000000E 06  0.63000000E 06
 EL=  0.50000000E 06  0.40000000E 06  0.31000000E 06  0.25000000E 06  0.20000000E 06  0.15000000E 06
 EL=  0.12000000E 06  0.10000000E 06  0.77300000E 05  0.59800000E 05  0.46500000E 05  0.36000000E 05
 EL=  0.27800000E 05  0.21500000E 05  0.16600000E 05  0.12900000E 05  0.10000000E 05  0.77300000E 04
 EL=  0.59800000E 04  0.46500000E 04  0.36000000E 04  0.27800000E 04  0.21500000E 04  0.16600000E 04
 EL=  0.12900000E 04  0.10000000E 04  0.77300000E 03  0.59800000E 03  0.46500000E 03  0.36000000E 03
 EL=  0.27800000E 03  0.21500000E 03  0.16600000E 03  0.12900000E 03  0.10000000E 03  0.77300000E 02
 EL=  0.59800000E 02  0.46500000E 02  0.36000000E 02  0.27800000E 02  0.21500000E 02  0.16600000E 02
 EL=  0.12900000E 02  0.10000000E 02  0.77300000E 01  0.59800000E 01  0.46500000E 01  0.36000000E 01
 EL=  0.27800000E 01  0.21500000E 01  0.16600000E 01  0.12900000E 01  0.10000000E 01  0.77300000E 00
 EL=  0.59800000E 00  0.46500000E 00  0.36000000E 00  0.27800000E 00
 MESH=          20              20              20              20              20              20
 MESH=          20              20              20              20              20              20
 MESH=          20              20              20              20              20              20
 MESH=          20              20              20              20              20              20
 MESH=          20              20              20              20              20              20
 MESH=          20              20              20              20              20              20
 MESH=          20              20              20              20              20              20
 MESH=          20              20              20              20              20              20
 MESH=          20              20              20              20              20              20
 MESH=          20              20              20              20              20              20
 MESH=          20              20              20              20              20              20
 MESH=          20              20              20
      AMESH1 =     0.10000
      AMESH2 =     0.02500

  FISSION SPECTRUM
    A0 = 0.46400E-06     A1 = 0.10000E 07     A2 = 0.20000E-05     LOWER BOUNDARY = 0.10000E 07 EV

B   0
B   0  N ELAST   0 N CROS C EI        BN UK=  15 -0 -0  1.000E-04  1.500E 07EV E0392  0
   50     1     5     0     1     2     0     1     1     1     1     2 E0392  1
    1     0     1     0    -0    -0    -0    -0    -0    -0    -0    -0 E0392  2
 1.0820E 01  0.          0.          1.0000E 00  1.0000E-04  1.5000E 07 E0392  3
ENR     200     1     2    -0    -0    -0     0  1.0000E-04  1.0000E 00 E0392  4
DCC1    401     1     5     0     3    -0     0  0.          -0.         E0392  5
   0.10000000E-03    0.40000000E 01    0.10000000E 01    0.40000000E 01   (FIRST AND LAST VALUE)
NDTYP=1
ENR     200     2     2    -0    -0    -0     0  1.0000E 00  1.5000E 07 E0392  7
DCC1    401     1     5     0   118    -0     0  0.          -0.         E0392  8
   0.10000000E 01    0.40000000E 01    0.15000000E 08    0.73000000E 00   (FIRST AND LAST VALUE)
NDTYP=1
```

```
    *** B   0 (N,ELAST ) 0,N CROS C(EI,  ,  ) ***

        SEC= 1 (LGI=1,..,69)
            0.61457714E 00    0.77562837E 00    0.89533529E 00    0.93713218E 00    0.93122531E 00    0.13242718E 01
            0.14107153E 01    0.18533349E 01    0.26136521E 01    0.17163493E 01    0.22584922E 01    0.27906616E 01
            0.43671395E 01    0.33654567E 01    0.33984017E 01    0.34965444E 01    0.36181000E 01    0.37106938E 01
            0.37735494E 01    0.38113357E 01    0.38456340E 01    0.38833012E 01    0.38429292E 01    0.38052859E 01
            0.37735151E 01    0.37503725E 01    0.37701135E 01    0.39273854E 01    0.39850834E 01    0.39587853E 01
            0.39348288E 01    0.39239331E 01    0.39184040E 01    0.39231325E 01    0.39431922E 01    0.39620666E 01
            0.39808736E 01    0.39322390E 01    0.38502166E 01    0.37946761E 01    0.37299218E 01    0.37005686E 01
            0.36845494E 01    0.37145200E 01    0.38022775E 01    0.39398446E 01    0.40520032E 01    0.41449739E 01
            0.42174041E 01    0.42747371E 01    0.42888366E 01    0.42249353E 01    0.41575542E 01    0.40921153E 01
            0.40279351E 01    0.40000000E 01    0.40000000E 01    0.40000000E 01    0.40000000E 01    0.40000000E 01
            0.40000000E 01    0.40000000E 01    0.40000000E 01    0.40000000E 01    0.39999999E 01    0.40000000E 01
            0.40000000E 01    0.39999999E 01    0.40000000E 01

        (TOTAL SEC) *** (LGI=1,..,69)
            0.61457714E 00    0.77562837E 00    0.89533529E 00    0.93713218E 00    0.93122531E 00    0.13242718E 01
            0.14107153E 01    0.18533349E 01    0.26136521E 01    0.17163493E 01    0.22584922E 01    0.27906616E 01
            0.43671395E 01    0.33654567E 01    0.33984017E 01    0.34965444E 01    0.36181000E 01    0.37106938E 01
            0.37735494E 01    0.38113357E 01    0.38456340E 01    0.38833012E 01    0.38429292E 01    0.38052859E 01
            0.37735151E 01    0.37503725E 01    0.37701135E 01    0.39273854E 01    0.39850834E 01    0.39587853E 01
            0.39348288E 01    0.39239331E 01    0.39184040E 01    0.39231325E 01    0.39431922E 01    0.39620666E 01
            0.39808736E 01    0.39322390E 01    0.38502166E 01    0.37946761E 01    0.37299218E 01    0.37005686E 01
            0.36845494E 01    0.37145200E 01    0.38022775E 01    0.39398446E 01    0.40520032E 01    0.41449739E 01
            0.42174041E 01    0.42747371E 01    0.42888366E 01    0.42249353E 01    0.41575542E 01    0.40921153E 01
            0.40279351E 01    0.40000000E 01    0.40000000E 01    0.40000000E 01    0.40000000E 01    0.40000000E 01
            0.40000000E 01    0.40000000E 01    0.40000000F 01    0.40000000E 01    0.39999999E 01    0.40000000E 01
            0.40000000E 01    0.39999999E 01    0.40000000F 01

*** FLUX ***
            1.1011415 E-02    3.9072069 E-02    9.3491600 E-02    1.7029552 E-01    2.6356212 E-01    2.7179142 E-01
            3.7546245 E-01    4.0372466 E-01    2.8072850 E-01    3.0212353 E-01    2.3923804 E-01    2.3125067 E-01
            2.2315911 E-01    2.5530555 E-01    2.1612900 E-01    2.2499999 E-01    2.9166663 E-01    2.2499998 E-01
            1.8333330 E-01    2.5795049 E-01    2.5746224 E-01    2.5257416 E-01    2.5669800 E-01    2.5956831 E-01
            2.5982095 E-01    2.5979332 E-01    2.5292141 E-01    2.5740309 E-01    2.6033051 E-01    2.5951640 E-01
            2.5257416 E-01    2.5873654 E-01    2.5926830 E-01    2.5775502 E-01    2.6154382 E-01    2.5292141 E-01
            2.5740307 E-01    2.5825857 E-01    2.5730286 E-01    2.5257417 E-01    2.5669801 E-01    2.5956831 E-01
            2.5775503 E-01    2.5979333 E-01    2.5292141 E-01    2.5740307 E-01    2.6033050 E-01    2.5940724 E-01
            2.5421475 E-01    2.5873655 E-01    2.5917148 E-01    2.5982096 E-01    2.6154383 E-01    2.5485662 E-01
            2.5740308 E-01    2.6033052 E-01    2.5951640 E-01    2.5421476 E-01    2.5873654 E-01    2.6137088 E-01
            2.5982096 E-01    2.6154384 E-01    2.5485662 E-01    2.5740309 E-01    2.6033051 E-01    2.5951641 E-01
            2.5421473 E-01    2.5873654 E-01    2.6137087 E-01

        B   0
        B   0  N ELAST   0 N ANGD P CC FI       UK-  15 -0 -0  1.000E-04  6.000E 06EV E0393  0
           36     1     5     0     1     2      0     1     2     2     0     2 E0393  1
            1     0    10     1    -0    -0     -0    -0    -0    -0    -0    -0 E0393  2
         1.0820E 01  0.           0.          1.0000E 00  1.0000E-04  6.000E 06 E0393  3
        DCC2    402     0     1     0     6      0     0  0.          -0.         E0393  4
        DCC1    401     1     2     0     2     -0     0  1.0000E-04 -0.         E0393  5
          -0.10000000E 01    0.50000000E 00    0.10000000E 01    0.50000000E 00   (FIRST AND LAST VALUE)
        DCC1    401     1     2     0     2     -0     0  1.0000E 00 -0.         E0393  7
          -0.10000000E 01    0.50000000E 00    0.10000000E 01    0.50000000E 00   (FIRST AND LAST VALUE)
        DCC1    401     6     2     0    21     -0     0  1.0000E 04 -0.         E0393  9
          -0.10000000E 01    0.35400000E 00    0.99999999E 00    0.78000000E 00   (FIRST AND LAST VALUE)
        DCC1    401     6     2     0    21     -0     0  7.5000E 05 -0.         E0393 15
          -0.10000000E 01    0.85300000F 00    0.99999999E 00    0.77100000E 00   (FIRST AND LAST VALUE)
        DCC1    401     1     2     0    18     -0     0  2.0000E 06 -0.         E0393 21
          -0.10000000E 01    0.42300000F 00    0.10000000E 01    0.22600000E 01   (FIRST AND LAST VALUE)
        DCC1    401     1     2     0    17     -0     0  6.0000E 06 -0.         E0393 28
          -0.10000000E 01    0.18200000E 00    0.10000000E 01    0.33600000E 01   (FIRST AND LAST VALUE)

    ** ARRANGED DATA **
    I= 1  EI= 0.10000000E-03  DATA(X,Y)
              -0.10000000E 01    0.50000000E 00   -0.90000000E 00    0.50000000E 00   -0.80000000E 00    0.50000000E 00
              -0.70000000E 00    0.50000000E 00   -0.60000000E 00    0.50000000E 00   -0.50000000E 00    0.50000000E 00
              -0.40000001E 00    0.50000000E 00   -0.30000001E 00    0.50000000E 00   -0.20000000E 00    0.50000000E 00
              -0.10000001E 00    0.50000000E 00   -0.74505806E-08    0.50000000E 00    0.99999994E-01    0.50000000E 00
               0.19999999E 00    0.50000000E 00    0.29999999E 00    0.50000000E 00    0.39999999E 00    0.50000000E 00
               0.49999999E 00    0.50000000E 00    0.59999999E 00    0.50000000E 00    0.69999999E 00    0.50000000E 00
               0.79999998E 00    0.50000000E 00    0.89999999E 00    0.50000000E 00    0.99999999E 00    0.50000000E 00
    ** TOTAL P= 0.99999999E 00

    ** RE-NORMALIZED DATA **
    I= 1  EI= 0.10000000E-03  DATA(X,Y)
              -0.10000000E 01    0.50000000E 00   -0.90000000E 00    0.50000000E 00   -0.80000000E 00    0.50000000E 00
              -0.70000000E 00    0.50000000E 00   -0.60000000E 00    0.50000000E 00   -0.50000000E 00    0.50000000E 00
              -0.40000001E 00    0.50000000E 00   -0.30000001E 00    0.50000000E 00   -0.20000000E 00    0.50000000E 00
              -0.10000001E 00    0.50000000E 00   -0.74505806E-08    0.50000000E 00    0.99999994E-01    0.50000000E 00
               0.19999999E 00    0.50000000E 00    0.29999999E 00    0.50000000E 00    0.39999999E 00    0.50000000E 00
               0.49999999E 00    0.50000000E 00    0.59999999E 00    0.50000000E 00    0.69999999E 00    0.50000000E 00
               0.79999998E 00    0.50000000E 00    0.89999999E 00    0.50000000E 00    0.99999999E 00    0.50000000E 00
    ** TOTAL P= 0.99999999E 00

    ** ARRANGED DATA **
    I= 2  EI= 0.10000000E 01  DATA(X,Y)
              -0.10000000E 01    0.50000000E 00   -0.90000000E 00    0.50000000E 00   -0.80000000E 00    0.50000000E 00
              -0.70000000E 00    0.50000000E 00   -0.60000000E 00    0.50000000E 00   -0.50000000E 00    0.50000000E 00
              -0.40000001E 00    0.50000000E 00   -0.30000001E 00    0.50000000E 00   -0.20000000E 00    0.50000000E 00

B   0  N ELAST   0 N ANGD P CC FI       UK-  15 -0 -0  1.000E-04  6.000E 06EV E0393 28
NENR= 1(S2DP)

*LGF = 69  E( 2.78000E-01 ,.. 3.60000E-01),  LGI= 4,..,70
 SIG,
            0.          0.          0.          0.          0.          0.
            0.          0.          0.          0.          0.          0.
            0.          0.          0.          0.          0.          0.
            0.          0.          0.          0.          0.          0.
            0.          0.          0.          0.          0.          0.
            0.          0.          0.          0.          0.          0.
            0.          0.          0.          0.          0.          0.
            0.          0.          0.          0.          0.          0.
            0.          0.          0.          0.          0.          0.
            0.          0.          0.          0.          0.          0.
            0.          0.          0.          2.4324458 E-01    2.2520458 E 00    1.5332304 E 00
```

```
MU
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.  -7.8833385 E-01  -1.8687815 E-01   5.5395357 E-01
          0.

*LGF = 68  E( 3.60000E-01 ... 4.65000E-01);  LGI= 4...70
 SIG.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.  2.5755130 E-01   2.2613058 E 00   1.5193497 E 00   0.
          0.
 MU
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.  -7.8036164 E-01  -1.8037993 E-01   5.5815683 E-01   0.
          0.

*LGF = 67  E( 4.65000E-01 ... 5.98000E-01);  LGI= 4...70
 SIG.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.  2.3453153 E-01   2.2189856 E 00   1.4954489 E 00   0.          0.
          0.
 MU
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.  -7.8968767 E-01  -1.8098225 E-01   5.6538679 E-01   0.          0.
          0.

*LGF = 66  E( 5.98000E-01 ... 7.73000E-01);  LGI= 4...70
 SIG.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
  2.3372891 E-01   2.2377153 E 00   1.5234623 E 00   0.          0.          0.
          0.
 MU
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
          0.          0.          0.          0.          0.          0.
```

***SUMMATION OF ONE DIMENSIONAL DATA

6.1457714 E-01	7.7562837 E-01	8.9533529 E-01	9.3713218 E-01	9.3122531 E-01	1.3242718 E 00
1.4107153 E 00	1.8533349 E 00	2.6136521 E 00	1.7163493 E 00	2.2584922 E 00	2.7906616 E 00
4.3671395 E 00	3.3654567 E 00	3.3984017 E 00	3.4965444 E 00	3.6181000 E 00	3.7106938 E 00
3.7735494 E 00	3.8113357 E 00	3.8456340 E 00	3.8833012 E 00	3.8429292 E 00	3.8052859 E 00
3.7735151 E 00	3.7503725 E 00	3.7701135 E 00	3.9273854 E 00	3.9850834 E 00	3.9587853 E 00
3.9348288 E 00	3.9239331 E 00	3.9184040 E 00	3.9231325 E 00	3.9431922 E 00	3.9620666 E 00
3.9808736 E 00	3.9322390 E 00	3.8502166 E 00	3.7946761 E 00	3.7299218 E 00	3.7005686 E 00
3.6845494 E 00	3.7145200 E 00	3.8022775 E 00	3.9398446 E 00	4.0520032 E 00	4.1449739 E 00
4.2174041 E 00	4.2747371 E 00	4.2888366 E 00	4.2249353 E 00	4.1575542 E 00	4.0921153 E 00
4.0279351 E 00	4.0000000 E 00	4.0000000 E 00	4.0000000 E 00	4.0000000 E 00	4.0000000 E 00
4.0000000 E 00	4.0000000 E 00	4.0000000 E 00	4.0000000 E 00	3.9999999 E 00	4.0000000 E 00
4.0000000 E 00	3.9999999 E 00	4.0000000 E 00			

***SUMMATION OF TRANSFER MATRICES

0.	0.	0.	9.3881141 E-01	9.2727223 E-01	1.3224395 E 00
1.4098468 E 00	1.8516675 E 00	2.6091307 E 00	1.7135456 E 00	2.2522084 E 00	2.7872913 E 00
4.3632934 E 00	3.3650933 E 00	3.3957805 E 00	3.4900144 E 00	3.6088105 E 00	3.7067040 E 00
3.7708358 E 00	3.8112252 E 00	3.8434588 E 00	3.8842100 E 00	3.8436176 E 00	3.8061421 E 00
3.7753224 E 00	3.7507330 E 00	3.7678833 E 00	3.9162952 E 00	3.9867568 E 00	3.9604374 E 00
3.9353989 E 00	3.9243261 E 00	3.9189361 E 00	3.9228452 E 00	3.9418665 E 00	3.9617393 E 00
3.9797339 E 00	3.9338854 E 00	3.8513045 E 00	3.7958940 E 00	3.7309593 E 00	3.7010479 E 00
3.6844793 E 00	3.7124519 E 00	3.8000469 E 00	3.9307419 E 00	4.0459402 E 00	4.1390520 E 00
4.2138286 E 00	4.2709867 E 00	4.2894557 E 00	4.2291602 E 00	4.1617656 E 00	4.0960565 E 00
4.0318902 E 00	3.9999992 E 00	3.9999992 E 00	3.9999991 E 00	3.9999991 E 00	3.9999992 E 00
3.9999992 E 00	3.9999992 E 00	3.9999992 E 00	3.9999992 E 00	3.9999992 E 00	3.9999992 E 00
3.9999992 E 00	3.7713955 E 00	1.5332304 E 00			

MU(I)

0.	0.	0.	3.9211763 E-01	3.9212244 E-01	3.9208777 E-01
3.2382640 E-01	4.3278971 E-02	4.3253396 E-02	4.3283811 E-02	1.6243260 E-01	2.0100647 E-01
2.0100668 E-01	2.0100793 E-01	2.0100568 E-01	2.0100769 E-01	2.0100998 E-01	2.0100396 E-01
2.0100560 E-01	2.0100926 E-01	2.0100901 E-01	2.0100904 E-01	2.0100954 E-01	2.0100899 E-01
2.0100977 E-01	2.0100904 E-01	2.0100902 E-01	2.0100915 E-01	6.1463427 E-02	6.1463476 E-02
6.1463535 E-02	6.1463378 E-02	6.1463567 E-02	6.1463455 E-02	6.1463556 E-02	6.1463624 E-02
6.1463574 E-02	6.1463479 E-02	6.1463585 E-02	6.1463520 E-02	6.1463386 E-02	6.1463576 E-02
6.1463455 E-02	6.1463643 E-02	6.1463645 E-02	6.1463613 E-02	6.1463431 E-02	6.1463484 E-02
6.1463731 E-02	6.1463401 E-02	6.1463479 E-02	6.1463215 E-02	6.1463545 E-02	6.1463772 E-02
6.1463561 E-02	6.1463434 E-02	6.1463499 E-02	6.1463740 E-02	6.1463378 E-02	6.1463453 E-02
6.1463228 E-02	6.1463572 E-02	6.1463777 E-02	6.1463594 E-02	6.1463439 E-02	6.1463498 E-02
6.1463747 E-02	1.1326770 E-01	5.5395357 E-01			

SIG(I,J)

J = 1					
0.	0.	0.	5.4330847 E-01	5.3831677 E-01	7.0817327 E-01
8.2588804 E-01	8.1546755 E-01	1.0479494 E 00	7.9664651 E-01	8.9370552 E-01	1.1685626 E 00
1.7438614 E 00	1.5678786 E 00	1.3844752 E 00	1.4616236 E 00	1.8163652 E 00	1.5541171 E 00
1.3563252 E 00	1.7775133 E 00	1.7830826 E 00	1.7837521 E 00	1.7874737 E 00	1.7822618 E 00
1.7588467 E 00	1.7559765 E 00	1.7257799 E 00	1.8057520 E 00	1.5236762 E 00	1.5093660 E 00
1.4727459 E 00	1.4908359 E 00	1.5045995 E 00	1.4953242 E 00	1.5110898 E 00	1.4839496 E 00
1.5039918 E 00	1.5083647 E 00	1.4706914 E 00	1.4224125 E 00	1.4205281 E 00	1.4201169 E 00
1.4052149 E 00	1.4207692 E 00	1.4183044 E 00	1.4811838 E 00	1.5419531 E 00	1.5729490 E 00
1.5733445 E 00	1.6201628 E 00	1.6470429 E 00	1.6149685 E 00	1.5986923 E 00	1.5372348 E 00
1.5267532 E 00	1.5277527 E 00	1.5234626 E 00	1.4954493 E 00	1.5193501 E 00	1.5332307 E 00
1.5250679 E 00	1.5341410 E 00	1.4988477 E 00	1.5123117 E 00	1.5277527 E 00	1.5234626 E 00
1.4954492 E 00	1.5163497 E 00	1.5332304 E 00			
J = 2					
0.	0.	0.	3.4292481 E-01	3.0665608 E-01	5.5002499 E-01
5.4637594 E-01	8.7695861 E-01	1.5303286 E 00	7.7613999 E-01	1.1945222 E 00	1.3811022 E 00
2.3864376 E 00	1.5220252 E 00	1.7147028 E 00	1.9436924 E 00	1.5618066 E 00	1.6287697 E 00
2.1915544 E 00	1.8710127 E 00	1.8802179 E 00	1.9279751 E 00	1.8962975 E 00	1.8625084 E 00
1.8588695 E 00	1.8216790 E 00	1.8717878 E 00	1.9516651 E 00	2.2283005 E 00	2.1951077 E 00
2.2234197 E 00	2.2089672 E 00	2.1885788 E 00	2.2053774 E 00	2.1825203 E 00	2.2320608 E 00
2.2438988 E 00	2.1957636 E 00	2.1335344 E 00	2.1429356 E 00	2.0977526 E 00	2.0662390 E 00
2.0706489 E 00	2.0576460 E 00	2.1456154 E 00	2.2255780 E 00	2.2705431 E 00	2.3032894 E 00
2.3863918 E 00	2.4090846 E 00	2.3940359 E 00	2.3715122 E 00	2.2976705 E 00	2.3021694 E 00
2.2671434 E 00	2.2377157 E 00	2.2189862 E 00	2.2613061 E 00	2.2520462 E 00	2.2342643 E 00
2.2478760 E 00	2.2131419 E 00	2.2527687 E 00	2.2539594 E 00	2.2377157 E 00	2.2189861 E 00
2.2613062 E 00	2.2520458 E 00	0.			
J = 3					
0.	0.	0.	5.0898891 E-02	8.6252455 E-02	6.6073515 E-02
3.8451291 E-02	1.6090870 E-01	3.5374066 E-02	1.4356280 E-01	1.7026449 E-01	2.4099677 E-01
2.3684043 E-01	2.7555287 E-01	2.9922365 E-01	9.1228430 E-02	2.3992808 E-01	5.2780688 E-01
2.2566980 E-01	1.6280967 E-01	1.8233342 E-01	1.7157385 E-01	1.5915806 E-01	1.6051565 E-01
1.5579891 E-01	1.7271702 E-01	1.7254575 E-01	1.6996828 E-01	2.3310674 E-01	2.5431158 E-01
2.3866323 E-01	2.2412995 E-01	2.2722572 E-01	2.2243086 E-01	2.4958201 E-01	2.4605615 E-01
2.3298298 E-01	2.2811072 E-01	2.4599089 E-01	2.2932799 E-01	2.1164117 E-01	2.1421270 E-01
2.0868555 E-01	2.3610484 E-01	2.3835771 E-01	2.3308279 E-01	2.3950702 E-01	2.6873548 E-01
2.5766778 E-01	2.4548972 E-01	2.4775777 E-01	2.3845469 E-01	2.6119142 E-01	2.5271098 E-01
2.3403847 E-01	2.3453160 E-01	2.5755129 E-01	2.4324466 E-01	2.2860381 E-01	2.3250501 E-01
2.2705618 E-01	2.5271711 E-01	2.4838361 E-01	2.3372896 E-01	2.3453158 E-01	2.5755136 E-01
2.4324463 E-01	0.	0.			