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LOS ALAMOS SCIENTIFIC LABORATORY
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GAMLEG - A FORTRAN CODE TO PRODUCE MULTIGROUP CROSS SECTIONS FOR PHOTON TRANSPORT CALCULATIONS

by

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ABSTRACT

GAMLEG is a cross section code which prepares group averages of the Legendre moments of the Klein-Nishina differential scattering cross section. For the isotropic component the group scattering cross section is prepared and compared to the sum of the partial cross sections to insure consistency. The code also accepts as input, absorption, coherent scattering, source, and flux data (for up to 1000 pieces of information at up to 1000 energy points for each type of input), and provides group averages of this data. At the option of the user, cross sections can be flux weighted, source weighted, or unweighted. Up to 100 energy groups can be formed from group energy bounds supplied by the user. Group averages are performed by trapezoidal integration at up to 100 intervals in each group. As written, up to six Legendre component scattering matrices may be prepared for an arbitrary number of elements. Additional moments may be prepared with minor code modification. Cross section output is in a form suitable for input to the Los Alamos DTF and DDF transport codes.

General

GAMLEG is a numerical code designed to produce multigroup photon cross sections for use in Los Alamos S_n-type transport codes. For an optional selection of group energy bounds and an arbitrary input of absorption data, the code performs, with a choice of weighting functions, numerical integrations to provide group-averaged absorption, scattering, and total cross sections. In addition, group-to-group scattering cross section tables are provided by performing averages of the Legendre moments of the Klein-Nishina[1] differential scattering cross section. Provision is also made for including isotropic coherent scattering in scattering cross section averages.

Theory

The general, linear, Boltzmann transport equation can be written

$$\nabla\cdot(\vec{\Omega}\phi) + \sigma_t(\vec{r},E)\phi = \iiint\phi(\vec{r},\vec{\Omega}',E')\sigma_s(E' \rightarrow E,\ \vec{\Omega}'\cdot\vec{\Omega})dE'd\Omega' + S(\vec{r},\vec{\Omega},E) \qquad (1)$$

where ϕ is the particle flux (speed times the particle density), σ_t is the macroscopic total reaction cross section, and σ_s is the macroscopic scattering transfer probability from energies E' to E through an angle whose cosine is that of the angle between the initial particle direction $\vec{\Omega}'$ and

the final particle direction $\vec{\Omega}$. External sources are represented by S. Without loss of generality let

$$\sigma_s(E' \to E, \quad \vec{\Omega}' \cdot \vec{\Omega}) = \sum_{n=0}^{\infty} \frac{2n+1}{4\pi} P_n(\mu_o)\sigma_{sn}(E' \to E) \tag{2}$$

where

$$\mu_o = \vec{\Omega}' \cdot \vec{\Omega} \tag{3}$$

and P_n is a Legendre polynomial. From the orthogonality of the Legendre polynomials, the coefficients σ_{sn} of Eq. (2) are given by

$$\sigma_{sn}(E' \to E) = \int_0^{2\pi} d\omega \int_{-1}^{1} d\mu_o \, P_n(\mu_o)\sigma_s(E' \to E, \ \mu_o) \tag{4}$$

In terms of the angles and cosines

$$\begin{aligned} \mu &= \vec{\Omega} \cdot \vec{e}_r \\ \eta &= \vec{\Omega} \cdot \vec{e}_\theta = \sqrt{1 - \mu^2} \cos \omega \\ \xi &= \vec{\Omega} \cdot \vec{e}_\varphi = \sqrt{1 - \mu^2} \sin \omega \end{aligned} \tag{5}$$

where $\vec{e}_r$, $\vec{e}_\theta$, and $\vec{e}_\varphi$ are unit vectors of an (r, θ, φ) spherical coordinate system, the polynomial $P_n(\mu_o)$ can be expanded to give

$$P_n(\mu_o) = P_n(\mu)P_n(\mu') + 2 \sum_{r=1}^{n} \frac{(n-r)!}{(n+r)!} P_n^r(\mu)P_n^r(\mu')\cos r(\omega - \omega') \tag{6}$$

where the P_n^r are associated Legendre polynomials.

A very general multigroup representation of Eq. (1) can be made by defining the following terms. First, let the average flux in the energy range of group g, say between E_g and E_{g-1}, $g = 1,2,\ldots,G$, be defined by

$$\psi_g(\vec{r},\vec{\Omega}) = \int_{E \text{ in } g} \phi(\vec{r},\vec{\Omega},E)dE \tag{7}$$

Similarly, define the average source in group g as

$$S_g(\vec{r},\vec{\Omega}) = \int_{E \text{ in } g} S(\vec{r},\vec{\Omega},E)dE \tag{8}$$

Next, let the average total cross section in the group be

$$\sigma_t^g(\vec{r},\vec{\Omega}) = \frac{\int_{E \text{ in } g} \sigma_t(\vec{r},E)\phi(\vec{r},E,\vec{\Omega})dE}{\int_{E \text{ in } g} \phi(\vec{r},E,\vec{\Omega})dE} \tag{9}$$

Then, defining the angular integral

$$\phi_n(\vec{r},\vec{\Omega},E') = \frac{2n+1}{4\pi} \iint \phi(\vec{r},\vec{\Omega}',E')P_n(\mu_o)d\Omega' \tag{10}$$

let the average transfer cross section from group h (E' in an energy range from E_h to E_{h-1}) to group g be defined by

$$\sigma_{sn}^{g\leftarrow h}(\vec{r},\vec{\Omega}) = \frac{\int_{E' \text{ in } h} \phi_n(\vec{r},\vec{\Omega},E')dE' \int_{E \text{ in } g} \sigma_{sn}(E' \rightarrow E)dE}{\int_{E' \text{ in } h} \phi_n(\vec{r},\vec{\Omega},E')} \tag{11}$$

By substitution of Eq. (2) in Eq. (1), integration of the result over the energy range of group g, and use of the definitions above, the multigroup transport equation becomes

$$\nabla\cdot(\vec{\Omega}\psi_g) + \sigma_t^g\psi_g = \sum_{n=0}^{\infty}\sum_{h=1}^{G}\sigma_{sn}^{g\leftarrow h}(\vec{r},\vec{\Omega})\int_{E' \text{ in } h}\phi_n(\vec{r},\vec{\Omega},E')dE' + S_g \qquad g = 1,2,\ldots,G \tag{12}$$

Although it is very general, use of Eq. (11) requires a detailed knowledge of the angular flux $\phi(\vec{r},\vec{\Omega},E)$ for performance of the necessary averages. Usually, much less information is available for forming group-averaged cross sections. Assuming that only an energy-dependent function, say f(E), is available to use in group averages, define group averages analogous to those above in the following fashion:

$$\sigma_t^g = \sigma_a^g + \sigma_s^g = \frac{\int_{E \text{ in } g} f(E)\,[\sigma_a(E,\vec{r}) + \sigma_s(\vec{E},r)]dE}{\int_{E \text{ in } g} f(E)dE} \tag{13}$$

and

$$\sigma_{sn}^{g\leftarrow h} = \frac{\int_{E \text{ in } h} f(E')dE' \int_{E \text{ in } g}\sigma_{sn}(E'\rightarrow E)dE}{\int_{E \text{ in } h} f(E')dE'} \tag{14}$$

Averages of the form of Eqs. (13) and (14) are prepared by the code described in this report.

Klein-Nishina Scattering

For Compton scattering by free electrons the differential scattering cross section is given by the Klein-Nishina[2] scattering law

$$\sigma_s(E' \rightarrow E,\ \mu_o) = \sigma_s(E' \rightarrow E)\delta(\mu_o - \tilde{\mu}_o) \quad \text{when} \quad \frac{E'}{1+2E'} < E < E' \tag{15}$$

$$= 0 \quad \text{otherwise}$$

Above,

$$\tilde{\mu}_o = 1 + \frac{1}{E'} - \frac{1}{E}$$

$$\sigma_s(E' \rightarrow E) = \frac{3}{16\pi E'^2}\left[\frac{E'}{E} + \frac{E}{E'} + 2\left(\frac{1}{E'} - \frac{1}{E}\right) + \left(\frac{1}{E'} - \frac{1}{E}\right)^2\right] \tag{16}$$

Energies in Eq. (15) and (16) are measured in units of the electron rest mass, and the cross sections are measured in terms of the Thomson cross section (0.665 barns) per electron. Substituting Eq. (15) in Eq. (4) gives

$$\sigma_{sn}(E' \rightarrow E) = \frac{3}{8E'^2}\left[\frac{E'}{E} + \frac{E}{E'} + 2\left(\frac{1}{E'} - \frac{1}{E}\right) + \left(\frac{1}{E'} - \frac{1}{E}\right)^2\right] P_n\left(1 + \frac{1}{E'} - \frac{1}{E}\right) \tag{17}$$

$$\text{for} \quad \frac{E'}{1+2E'} < E < E'$$

Since the weighting function in Eq. (14) is a function of E', the E portion of the integration of Eq. (17) can be done analytically. Given n, the subroutine SIGLEG (to be described) evaluates the E integral of Eq. (17) at a value of E' and a limit of E.

The Klein-Nishina scattering cross is given by

$$\sigma_s(E) = \int_{\frac{E}{1+2E}}^{E} \sigma_s(E \to E')dE'$$

$$= \frac{3}{8E^2}\left[\ell n(1 + 2E)(E - 2 - 2/E) + 4 + 2E^2(1 + E)/(1 + 2E)^2\right] \tag{18}$$

The above functional dependence is used to form σ_s^g of Eq. (13). Examination of Eqs. (18), (14), and (13) shows that, if the weighting function, f(E), is a constant, then

$$\sigma_s^g - \sum_{h=g}^{G} \sigma_{so}^{h\leftarrow g} = 0 \qquad g = 1,2,\ldots,G \tag{19}$$

and this relation is used to check the accuracy of numerical integrations.

Absorption data is assumed to be given in tabular form, and if integrations require values of absorption cross sections not given in the table, a linear interpolation is performed. Coherent scattering data is also assumed to be given from tables. Coherent scattering is assumed to be isotropic although the actual functional dependence is of the form[1]

$$\sigma_{coh} = (1 + \mu_o^2)\left|F[q(\mu_o), z]\right|^2 \tag{20}$$

For this dependence, assuming F is almost independent of μ_o, $\sigma_{s1} = 0$, and $\sigma_{sn} = 0$ $n > 2$. The $n = 2$ contribution causes negligible correction to discrete eigenvalues of the monoenergetic Boltzmann equation.

General Description of the Code

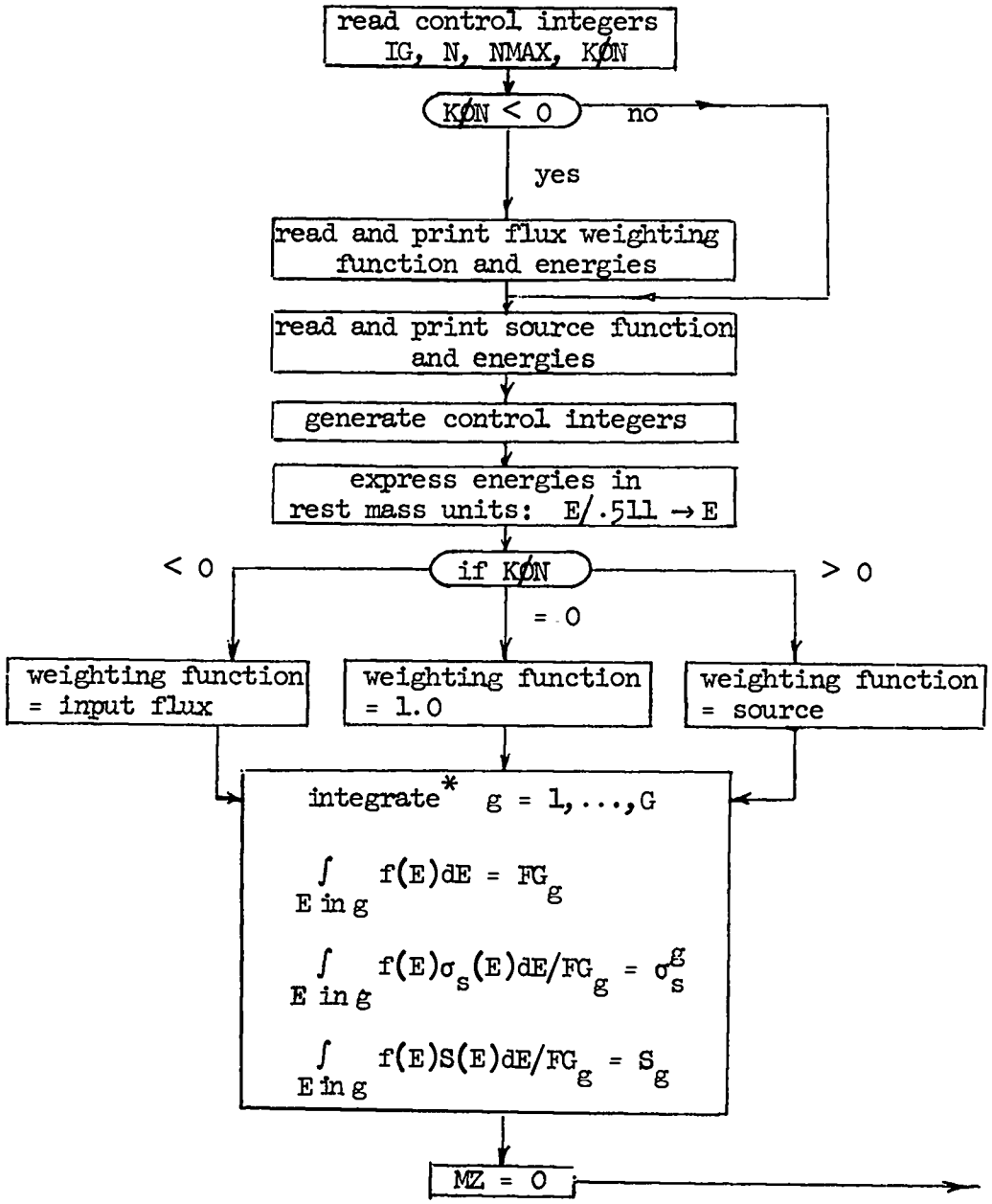
A flow diagram of the code is given in Figure 1. Understanding of the verbal description is facilitated by reference to this figure.

The code begins by reading input control integers describing the number of group energy bounds, the number of integration points per group, the number of Legendre transfer moments to be prepared, and an integer describing what type of weighting function is to be used. Cross sections may be weighted with an input flux distribution or with a source energy distribution, or cross sections may be formed without a weighting function. If an input flux is used as a weighting function, the energies (in Mev) at which it is specified are read, and then the values of the flux are read. Next a source energy distribution is read, first the energies (Mev) at which the source is specified and then the values of the source distribution. Values of the group energy (Mev) bounds are then read. After printing the input thus far read, the code prepares integers needed in the calculation and translates energies to electron rest mass units by dividing by 0.511 Mev. Thus all integrations are computed over intervals expressed in terms of electron rest mass units.

Depending upon the type of weighting selected, the code forms the integral

$$\int_{E\,in\,g} f(E)dE \qquad g = 1,2,\ldots,G \tag{21}$$

by trapezoidal integration. Linear interpolation is performed by a subroutine AL(X,Y,XA,J) which linearly interpolates a function Y (given



$$* \int f(E)dE = \sum_{i=1}^{N+1} T_i f(E_i)$$

$T_i = 0.5$ when $i = 1$, $i = N + 1$

$T_i = 1.0$ otherwise

$$E_i = E_{g+1} + (i - 1)(E_g - E_{g+1})/N$$

Figure 1. Code flow diagram

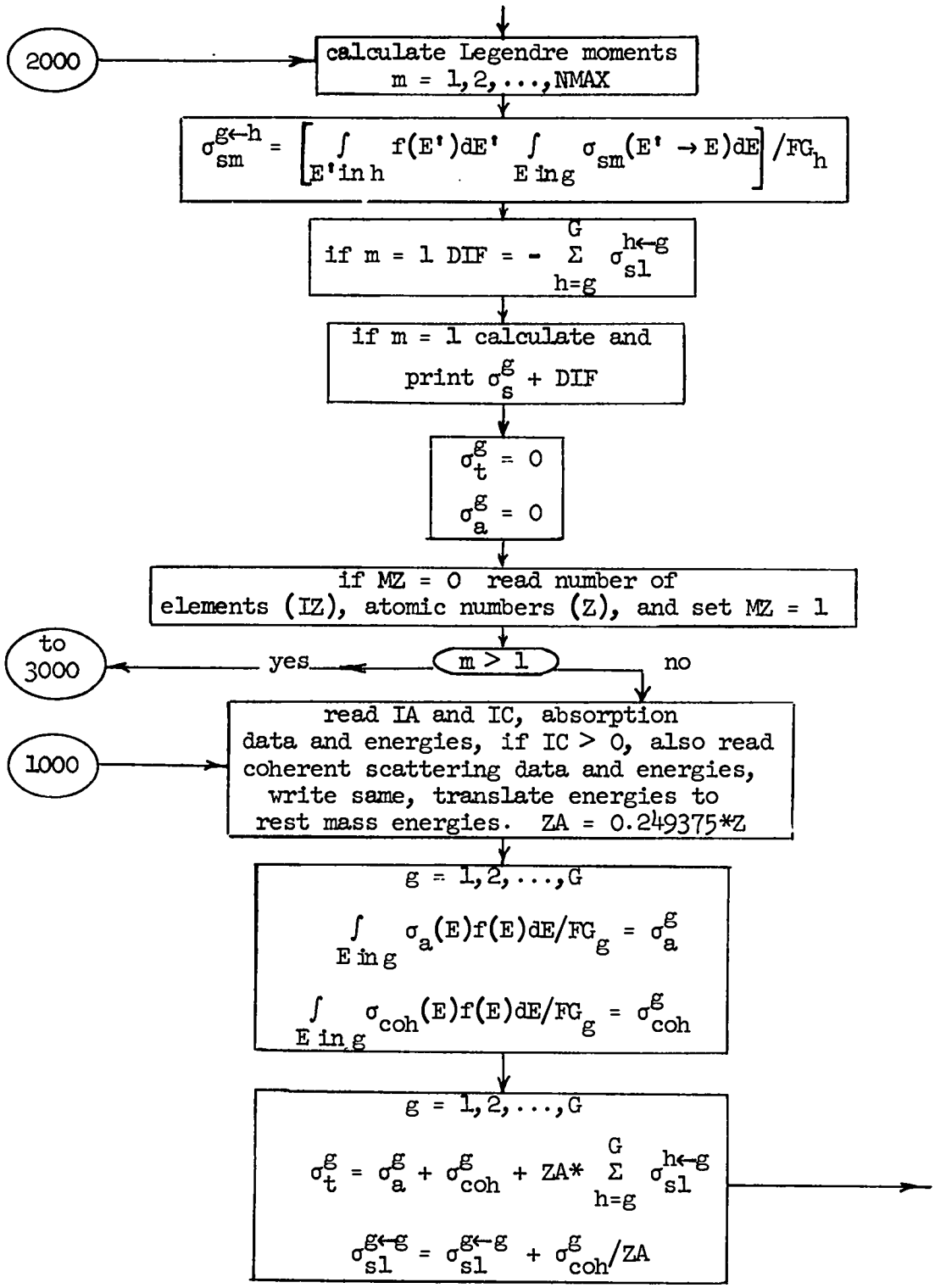


Fig. 1. (Continued)

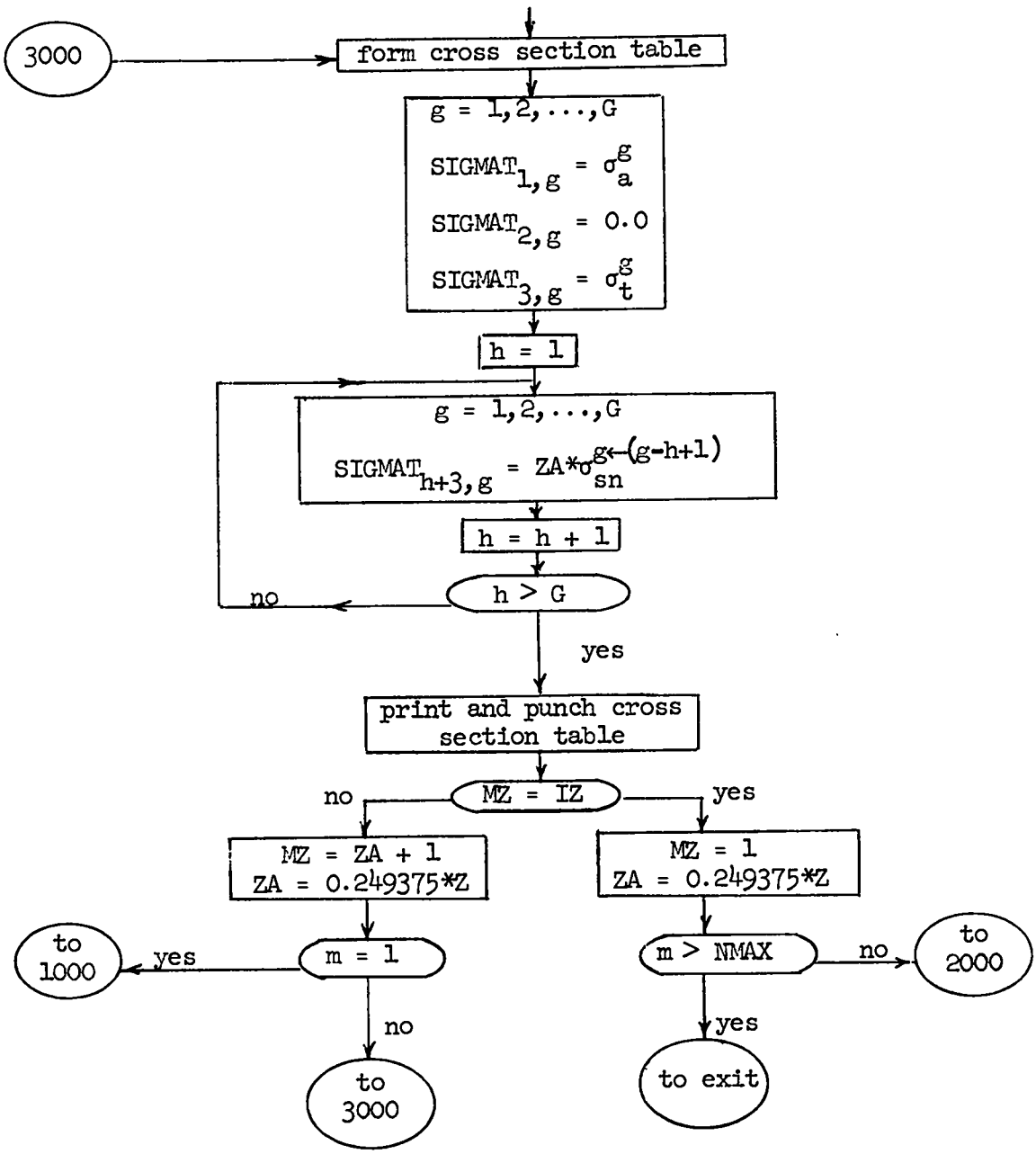


Fig. 1. (Continued)

as a vector) to give its value at X when XA is vector of the J values at which Y is specified. Since cross section averages involve ratios of trapezoidal integrations, the mesh spacing is not multiplied times the integral sum. At the same time the group average of the weighting function is prepared, the detailed behavior of the weighting function is stored, for all groups, for later use, and the integrals

$$\int_{E\ in\ g} f(E)S(E)dE \qquad g = 1,2,\ldots,G \tag{22}$$

and

$$\int_{E\ in\ g} f(E)\sigma_s(E)dE \qquad g = 1,2,\ldots,G \tag{23}$$

are prepared. The scattering cross section is given by a function routine SIGMAS(E) which evaluates Eq. (18) (without the factor of 3/8) at the integration points. Once the integrations are performed over all groups, the integral of Eq. (21) and the ratios

$$\frac{\int_{E\ in\ g} f(E)S(E)dE}{\int_{E\ in\ g} f(E)dE} \equiv S_g$$

$$\frac{\int_{E\ in\ g} f(E)\sigma_s(E)dE}{\int_{E\ in\ g} f(E)dE} \equiv \sigma_s^g \tag{24}$$

are prepared and printed.

Next the integrals of Eq. (14) are performed for each value of n, n = 0,1,...,NMAX-1. Since the transfer cross section Legendre moments require considerable storage space, and since they differ from element to element only in the number of electrons per atom, the code is designed to calculate the zeroth Legendre moment (isotropic) for all selected elements before proceeding to the calculation of the first, second, and higher Legendre moments. Along with the zeroth Legendre moment, the other element dependent quantities, such as the group absorption cross section or the group coherent scattering cross section, are prepared.

A function routine, SIGLEG(N,Y,X), is used to evaluate the E integral in Eq. (14). As written, the routine evaluates the first integral (without the factor of 3/8) of Eq. (17) with n = N-1, ($1 \leq N \leq 6$). The range of N can be extended easily if need arises. Given N, the routine evaluates the integral at an E limit given by X for a value of E' = Y. The SIGLEG routine was written for a 64-bit machine. If a 36-bit machine is to be used, double precision arithmetic must be employed in this routine.

For the E' integration in Eq. (14) trapezoidal integration is used. For E' in group h, h = 1,2,...,G, E must not only be in group g, g = 1,2,...,G, but E must satisfy $E'/(1+2E') < E < E'$. Accordingly, if E is in the range $E_{g+1} < E < E_g$ then the upper limit of the E integration is

$$UL = \text{Minimum of } (E', E_g) \tag{25}$$

and the lower limit is

$$LL = \text{Maximum of } [E'/(1+2E'),\ E_{g+1}] \tag{26}$$

If $UL \leq LL$ the integral is set equal to zero.* This practice is followed except when E is in the last group interval. Then the lower limit is set equal to $E'/(1+2E')$ even if E_{g+1} is larger. Doing so, includes all energy-loss scattering events which result in transfer to energies below the lowest group energy bound in the transfer cross section for scattering to the last group. Once the E' integration of Eq. (14) is complete the result is divided by Eq. (21) (for E in h) to give $\sigma_{sn}^{g\leftarrow h}$. For the n = 0 (N = 1) component of the transfer matrix, the test of Eq. (19) is made and the actual value of the difference is printed.

At this point, if the zeroth Legendre component of the transfer matrix is being formed, the element dependent data are read and printed. First the atomic numbers (Z) of the elements considered are read. Then the quantity $Z(0.665)(3/8)$ is formed for the first element. (This factor transforms the cross sections to units of barns for an element of atomic number Z. The factor 3/8 is that factor previously omitted, while 0.665 is the Thomson cross section). Then absorption, and if desired, coherent scattering energies and data for the first element are read and printed. Next, these energies are translated to units of the

*The subtraction of the integral evaluated at its upper limit minus the integral evaluated at its lower limit should be done in douple precision arithmetic on a 36-bit machine.

electron rest mass energy, and σ^g_{coh} and σ^g_a are formed by trapezoidal integration in accordance with Eq. (13). σ^g_{coh} is added to $\sigma^{g\leftarrow g}_{so}$, and a total cross section is formed such that

$$\sigma^g_{tot} = \sigma^a_g + \sigma^g_{coh} + \sum_{h=g}^{G} \sigma^{h\leftarrow g}_{so} \quad \text{(all in barns)} \tag{27}$$

Cross sections are then arranged in a table, printed, and punched. This process is repeated for all the elements, and then the n=1 Legendre component tables are prepared for all elements. For $n > 0$ absorption and coherent scattering, cross sections are not prepared. After group-to-group scattering, cross-section tables are prepared for all elements and all n, execution terminates.

The code listed in this report was written in Fortran IV for use on the IBM 7030 machine. Profligate use was made of storage, and the program as written will not load into a 32,000 word memory. This difficulty is simply remedied by rewriting the common statement, at the cost, however, of reducing the capability of the program. As written, the program will provide up to 100-group cross sections for up to six Legendre moments for each of an unlimited number of elements. Absorption, source, coherent scattering, and flux weighting data are each limited to a maximum of 1000 values at 1000 energies. Trapezoidal integration can be performed for up to 100 intervals in an energy range.

Code Input Preparation

The data necessary for input is defined and listed, in order of normal input, below. Integers are read according to a 14I5 format, and floating point numbers are read with a 1P6E12.5 format. All energies are input in Mev, beginning at the highest energy and proceeding to the lowest.

1. IG, N, NMAX, KØN

   IG = Number of groups plus one.

   N = Number of integration intervals/group.

   NMAX = Number of Legendre components to be prepared.

   KØN = Control Integer. KØN < 0, input flux weighting;

   KØN > 0, source weighting; and KØN = 0, no weighting.

2. (Optional) IF, then EFLUX(I), then FLUX(I)

   IF = Number of input fluxes.

   EFLUX(I) = Energies at which input flux is given.

   FLUX(I) = Input flux weighting function.

3. IS, then ES(I), then S(I)

   These are quantities analogous to 2. for an input source.

4. EG(I) = Group energy bounds.

5. IZ, then Z(I)

   IZ = Number of Elements.

   Z(I) = Atomic numbers of elements.

6. IA, IC, then SIGA(I), EA(I)

IA = Number of input absorption cross sections.

IC = Number of input coherent scattering cross sections.

SIGA(I) = Absorption cross section (barns) for the first element.

EA(I) = energies at which first element absorption cross sections are given.

7. (Optional) SIGCØH(I), then ECØH(I)

Data for coherent scattering analogous to absorption.

Inputs 6. and (possibly) 7. are repeated for each element.

Code Output Description

Cross section tables are printed in the format shown in the listing of the sample problem. For each group, the column entries are σ_a, $\nu\sigma_f$, σ_t, $\sigma_{g\leftarrow g}$, $\sigma_{g\leftarrow g+1}$, $\sigma_{g\leftarrow g+2}$, etc. The heading of each table identifies the element by its atomic number and the Legendre component by P_n, $n = 0, 1, \ldots, NMAX-1$. $n = 0$ corresponds to the isotropic transfer table.

Punched output begins with a header card identifying the element and Legendre moment. Following the header card, the applicable cross section, beginning with the first group, is punched sequentially. The format is that used for input to the Los Alamos transport codes DTF and DDF.

Code Listing and Sample Problem

A listing of the code, including subroutines, is given. Output from a typical problem is reproduced following the code listing. In the output of the cross section tables, a table size of G groups (columns) by G + 3 rows must be allowed even though the group energy structure is such that all rows may not be used. In the sample problem, the group structure allows down-scattering from group one to group nine, but not to group ten.

In the sample problem from which the output listing was extracted, six Legendre components were calculated for each of five elements. One hundred integration intervals were used in each of the thirteen groups. The entire problem required one minute and fifty-eight seconds of IBM 7030 (Stretch) computation time.

REFERENCES

1. G. W. Grodstein, "X-Ray Attenuation Coefficients From 10 kev to 100 Mev," National Bureau of Standards Circular 583 (1957).
2. H. Goldstein, Fundamental Aspects of Reactor Shielding, Addison-Wesley, Reading, Mass. (1959).

```
C  PROGRAM GAMLEG
C     GIVEN SOURCE AND ABSORPTION ENERGY DEPENDENCE CODE PROVIIDES
C     GROUP AVERAGED CROSS SECTIONS FOR INPUT TU THE DTF OR DDF
C     CODES. UP TO N (N LESS THAN 10) LEGENDRE TRANSFER SCATTERING CROSS
C     SECTIONS ARE PREPARED.
C
C     THREE WEIGHTING OPTIONS ARE AVAILABLE. (A)-UNWEIGHTED, (B)-SOURCE
C     ENERGY WEIGHTING, (C)-WEIGHTING WITH INPUT FLUX
C
C
      COMMON EG(101),ASG(100),SIGS(100),SIGC(100),DF(100),FG(100),
     1FLUX(1000),S(1000),ES(1000),IS,SIGA(1000),EA(1000),IA,SG(100),
     2SIGCOH(1000),ECOH(1000),IC,SIGMAT(103,103),TRANS(100,100),
     3FLUXS(100,201),EFLUX(1000),Z(50),SIGTOT(100)
C
C     DEFINITION OF VARIABLES
C     SIGA(I)=ABSORPTION C/S
C     EA(I)=ABSORPTION ENERGIES
C     S(I)=SOURCE
C     ES(I)=SOURCE ENERGIES
C     SIGCOH(I)=COHERENT SCATTERING CROSS SECTION
C     ECOH(I)=ENERGIES FOR ABOVE
C     EG(I)=GROUP ENERGIES
C     ASG(I)=GROUP AVG ABSORPTION CROSS SECTION
C     SIGS(I)=GROUP AVG SCATTERING CROSS SECTION
C     SIGC(I)=GROUP AVG COHERENT CROSS SECTION
C     FG(I)=GROUP AVG FLUX
C     SG(I)=GROUP AVG SOURCE
C     TRANS(I,J)=GROUP AVG TRANSFER CROSS SECTIONS
C
C     SIGMAT(I,J)=SCATTERING TRANSFER MATRIX
C
C
C
C     FLUXS(I)=WEIGHTING FUNCTION
C
C     IA=NO. ABSORPTION ENERGIES
C     IS=NO. SOURCE ENERGIES
C     IC=NO. COHERENT SCATTER ENERGIES
C     IG=NO. GROUP ENERGIES
C     N=NO. INTEGRATION PTS. PER GROUP
C     IF=NO. OF INPUT FLUXES
C     NMAX=NO. OF LEGENDRE COMPONENTS REQUESTED
C     Z(I)=ATOMIC NUMBERS
C
C                INPUT
C
      READ(10,501)IG,N,NMAX,KON
      WRITE(9,503)N,NMAX,KON
      IF(KON.GE.0)GOTO2
      READ(10,501)IF
      READ(10,502)(EFLUX(I),I=1,IF)
      READ(10,502)(FLUX(I),I=1,IF)
      WRITE(9,504)(I,EFLUX(I),FLUX(I),I=1,IF)
    2 READ(10,501)IS
      READ(10,502)(ES(I),I=1,IS)
      READ(10,502)(S(I),I=1,IS)
      READ(10,502)(EG(I),I=1,IG)
      WRITE(9,505)(I,ES(I),S(I),I=1,IS)
```

```
      WRITE(9,506)(I,EG(I),I=1,IG)
  501 FORMAT(14I5)
  502 FORMAT(1P6E12.5)
  503 FORMAT(1H1,I4,25H INTEGRATION POINTS/GROUP,/,I5,
     117H LEGENDRE MOMENTS,/,I5,38H CONTROL (-1/0/1) - (FLUX/NONE/SOURCE
     2),//)
  504 FORMAT(10H0          ,14H ENERGY (MEV) ,11H INPUT FLUX,/,(3X,I5,2X,
     12E14.7))
  505 FORMAT(10H0          ,14H ENERGY (MEV) ,7H SOURCE,/,(3X,I5,2X,2E14.
     17))
  506 FORMAT(10H0          ,20H GROUP ENERGY BOUNDS,/,(3X,I5,2X,E14.7))
C
C     CONTROL INTEGERS
      IGA=IG-1
      IM=N+1
      IMA=N+2
      IGB=IG+2
      IGD=IG-2
      FN=N
C
C     EXPRESS ENERGIES IN REST MASS UNITS
      ERM=1./.51099
      DO5I=1,IG
    5 EG(I)=ERM*EG(I)
      DO6I=1,IS
    6 ES(I)=ERM*ES(I)
      IF(KON.GE.0)GOTO9
      DO8I=1,IF
    8 EFLUX(I)=ERM*EFLUX(I)
C
C     INITIALIZE FLUX AND AVERAGE FLUX, SOURCE, AND SCATTERING CROSS
C     SECTION
    9 DO18K=1,IGA
      H=(EG(K)-EG(K+1))/FN
      ASIG=0.
      AFLU=0.
      ASOU=0.
      DO17I=1,IM
      AA=FLOAT(I-1)*H+EG(K+1)
      AB=AA
      IF(KON)10,11,12
   10 CALLAL(AB,FLUX,EFLUX,IF)
      GOTO13
   11 AB=1.0
      GOTO13
   12 CALLAL(AB,S,ES,IS)
   13 IF(I.EQ.1)GOTO15
      IF(I.NE.IM)GOTO16
   15 AB=AB*.5
   16 FLUXS(K,I)=AB
      AFLU=AFLU+AB
      ASIG=ASIG+AB*SIGMAS(AA)
      CALLAL(AA,S,ES,IS)
   17 ASOU=ASOU+AB*AA
      FG(K)=AFLU
      SIGS(K)=ASIG/FG(K)
   18 SG(K)=ASOU/FG(K)
      WRITE(9,181)(K,FG(K),SIGS(K),SG(K),K=1,IGA)
  181 FORMAT(6HOGROUP,14H   AVG FLUX   ,14H AVG SIGMA S
```

```
     112H  AVG SOURCE,//,(I4,2X,1P3E14.7))
C
C       CALCULATE LEGENDRE MOMENTS - FOR EACH ELEMENT
        MZ=0
        DO2000M=1,NMAX
        DO19I=1,IGB
        DO19J=1,IGA
   19   SIGMAT(I,J)=0.0
        DO37K=1,IGA
        DIF=0.
        HA=(EG(K)-EG(K+1))/FN
        DO27L=K,IGA
        AIN=0.
        DO25I=1,IM
        AX=EG(K)-FLOAT(I-1)*HA
        Q=AX/(1.+2.*AX)
        BU=AMIN1(AX,EG(L))
        BL=AMAX1(Q,EG(L+1))
        IF(L.EQ.IGA)BL=Q
        QQ=0.0
        IF(BL.LT.BU)QQ=FLUXS(K,I)*(SIGLEG(M,AX,BU)-SIGLEG(M,AX,BL))
   25   AIN=AIN+QQ
        TRANS(K,L)=AIN/FG(K)
        IF(M.EQ.1)DIF=DIF-TRANS(K,L)
   27   CONTINUE
        IF(M.NE.1)GOTO36
        DIFF=SIGS(K)+DIF
        WRITE(9,507)K,DIFF
  507   FORMAT(43HODIFFERENCE-GROUP AVG SCATTER CROSS SECTION,
       143H AND SUM OF GROUP AVERAGED TRANSFERS, GROUP,
       2I2,6H , IS=1PE12.5)
        DF(K)=DIF
   36   SIGTOT(K)=0.
        ASG(K)=0.
   37   CONTINUE
C
C       ELEMENT DEPENDENT PORTION
        IF(MZ.NE.0)GOTO101
        READ(10,501)IZ
        READ(10,502)(Z(I),I=1,IZ)
        MZ=1
        ZA=Z(MZ)*.249375
  101   IF(M.GT.1)GOTO3000
 1000   READ(10,501)IA,IC
        READ(10,502)(SIGA(I),I=1,IA)
        READ(10,502)(EA(I),I=1,IA)
        IF(IC.EQ.0)GOTO31
        READ(10,502)(SIGCOH(I),I=1,IC)
        READ(10,502)(ECOH(I),I=1,IC)
        WRITE(9,508)(I,ECOH(I),SIGCOH(I),I=1,IC)
  508   FORMAT(10HO          ,14H ENERGY (MEV) ,17H COHERENT SCATTER,/,(3X,
       1I5,2X,2E14.7))
        DO30I=1,IC
   30   ECOH(I)=ECOH(I)*ERM
        MZ=1
   31   WRITE(9,509)(I,EA(I),SIGA(I),I=1,IA)
  509   FORMAT(10HO          ,14H ENERGY (MEV) ,11H ABSORPTION,/,(3X,I5,2X,
       12E14.7))
        DO32I=1,IA
   32   EA(I)=EA(I)*ERM
```

```
      DO35J=1,IGA
      H=(EG(J)-EG(J+1))/FN
      AABS=0.
      ACOH=0.
      DO34I=1,IM
      AX=FLOAT(I-1)*H+EG(J+1)
      AB=AX
      CALLAL(AB,SIGA,EA,IA)
      AABS=AABS+FLUXS(J,I)*AB
      IF(IC.EQ.0)GOTO34
      CALLAL(AX,SIGCOH,ECOH,IC)
      ACOH=ACOH+FLUXS(J,I)*AX
   34 CONTINUE
      ASG(J)=AABS/FG(J)
   35 SIGC(J)=ACOH/FG(J)
      DO 102 K=1,IGA
      SIGTOT(K)=ASG(K)-DF(K)*ZA+SIGC(K)
  102 TRANS(K,K)=TRANS(K,K)+SIGC(K)/ZA
C
C     FORM CROSS SECTION TABLE
 3000 DO38J=1,IGA
      SIGMAT(1,J)=ASG(J)
      SIGMAT(2,J)=0.
   38 SIGMAT(3,J)=SIGTOT(J)
      DO39I=1,IGA
      IAB=I+3
      DO39J=I,IGA
      JA=J-I+1
   39 SIGMAT(IAB,J)=TRANS(JA,J)*ZA
C
C     PRINT AND PUNCH CROSS SECTION TABLE
      NAB=M-1
      WRITE(9,510)NAB,Z(MZ)
  510 FORMAT(2HOP,I2,20H CROSS SECTION TABLE,
     115H ATOMIC NUMBER=2PE11.3)
      PUNCH510,NAB,Z(MZ)
      MA=1
      MB=8
   40 MC=MINO(MB,IGA)
      WRITE(9,511)(J,J=MA,MC)
      WRITE(9,513)
      DO41I=1,IGB
   41 WRITE(9,512)I,(SIGMAT(I,J),J=MA,MC)
      MA=MA+8
      MB=MB+8
      IF(MA.LE.IGA)GOTO40
  511 FORMAT(7HO       , 8(8H  GROUP=I2,3X))
  512 FORMAT(I4,3X,1P8E13.6)
  513 FORMAT(1HO)
      PUNCH502,((SIGMAT(I,J),I=1,IGB),J=1,IGA)
      IF(MZ.EQ.IZ)GOTO42
      MZ=MZ+1
      ZA=Z(MZ)*.249375
      IF(M-1) 3000,1000,3000
   42 MZ=1
      ZA=Z(MZ)*.249375
 2000 CONTINUE
      CALLEXIT
      END
```

NO. BINARY CARDS 000086 - LENGTH (8)001563 WORDS (=(10)000883)

```
      SUBROUTINEAL(X,Y,XA,J)
C     LINEARLY INTERPOLATES FUNCTION Y TO GIVE VALUE AT X
      DIMENSION Y(J),XA(J)
      I=1
  100 A=X-XA(I)+.000001
      IF(A)1,6,5
    1 I=I+1
      IF(I.LE.J)GOTO100
      WRITE(9,4)
    4 FORMAT(36HOERROR-ENERGY LESS THAN ALL ENERGIES)
      CALLEXIT
    5 N=I
      IF(N.LE.1)GOTO6
      M=N-1
      X=Y(N)+(X-XA(N))*(Y(M)-Y(N))/(XA(M)-XA(N))
      RETURN
    6 X=Y(I)
      RETURN
      END
NO. BINARY CARDS 000012 - LENGTH (8)000143 WORDS (=(10)000099)


      FUNCTIONSIGMAS(E)
C     KLEIN NISHINA SCATTERING CROSS,SECTION
      A=1.+2.*E
      B=E*E
      C=E-2.-2./E
      SIGMAS=(ALOG(A)*C+4.+2.*B*(1.+E)/(A*A))/B
      RETURN
      END
NO. BINARY CARDS 000009 - LENGTH (8)000101 WORDS (=(10)000065)


      FUNCTIONSIGLEG(N,Y,X)
C     COMPUTES FIRST INTEGRAL IN LEGENDRE MOMENT AVERAGE
      DIMENSIONFA(10),UA(10)
      A3=1./3.
      A=1./Y
      F=Y-2.-2.*A
      G=(2.+A)*A
      H=1.+A
      C=A*A
      D=1./X
      E=ALOG(X)
      A6=1./6.
      FA(1)=-D+F*E+X*G+X*X*.5*A
      IF(N.LE.1)GOTO6
      P=D*D
      FA(2)=-.5*P-F*D+E*G+X*A
      IF(N.LE.2)GOTO6
      Q=D*P
      FA(3)=-A3*Q-F*.5*P-G*D+A*E
      WA=H*H
      IF(N.LE.3)GOTO6
      R=D*Q
```

```
      FA(4)=-.25*R-F*A3*Q-G*.5*P-A*D
      WB=H*WA
      IF(N.LE.4)GOTO6
      S=D*R
      FA(5)=-.2*S-.25*F*R-A3*G*Q-.5*A*P
      WC=H*WB
      IF(N.LE.5)GOTO6
      T=D*S
      FA(6)=-A6*T-.2*F*S-.25*G*R-A3*A*Q
      WD=H*WC
    6 GOTO(8,9,10,11,12,13),N
    8 UA(1)=1.
      GOTO14
    9 UA(1)=H
      UA(2)=-1.
      GOTO14
   10 UA(1)=1.5*WA-.5
      UA(2)=-3.*H
      UA(3)=1.5
      GOTO14
   11 UA(1)=2.5*WB-1.5*H
      UA(2)=1.5-7.5*WA
      UA(3)=7.5*H
      UA(4)=-2.5
      GOTO14
   12 UA(1)=4.375*WC-3.75*WA+.375
      UA(2)=7.5*H-17.5*WB
      UA(3)=26.25*WA-3.75
      UA(4)=-17.5*H
      UA(5)=4.375
      GOTO14
   13 UA(1)=7.875*WD-8.75*WB+H*1.875
      UA(2)=-39.375*WC+26.25*WA-1.875
      UA(3)=78.75*WB-26.25*H
      UA(4)=-78.75*WA+8.75
      UA(5)=39.375*H
      UA(6)=-7.875
   14 SS=0.
      DO15I=1,N
   15 SS=SS+UA(I)*FA(I)
      SIGLEG=SS*C
      RETURN
      END
NO. BINARY CARDS 000026 - LENGTH (8)000420 WORDS (=(10)000272)
```

```
 100 INTEGRATION POINTS/GROUP
   6 LEGENORE MOMENTS
   0 CONTROL (-1/0/1) - (FLUX/NONE/SOURCE)


          ENERGY (MEV)  SOURCE
      1    .2000000E+01  .1000000E+01
      2    .1990000E+01  .1000000E+01
      3    .1989900E+01  .0000000E 00
      4    .2000000E-01  .0000000E 00

          GROUP ENERGY BOUNDS
      1    .2000000E+01
      2    .1990000E+01
      3    .1750000E+01
      4    .1500000E+01
      5    .1250000E+01
      6    .1000000E+01
      7    .7500000E+00
      8    .5000000E+00
      9    .2500000E-00
     10    .2000000E-00
     11    .1500000E-00
     12    .1000000E-00
     13    .5000000E-01
     14    .2000000E-01

GROUP    AVG FLUX     AVG SIGMA S     AVG SOURCE

  1   1.0000000E+02 5.8751749E-01 1.0000000E+00
  2   1.0000000E+02 6.0972384E-01 5.0000000E-03
  3   1.0000000E+02 6.5911907E-01  .0000000E 00
  4   1.0000000E+02 7.2095414E-01  .0000000E 00
  5   1.0000000E+02 7.9962480E-01  .0000000E 00
  6   1.0000000E+02 9.0479751E-01  .0000000E 00
  7   1.0000000E+02 1.0570503E+00  .0000000E 00
  8   1.0000000E+02 1.3130185E+00  .0000000E 00
  9   1.0000000E+02 1.5686320E+00  .0000000E 00
 10   1.0000000E+02 1.7006147E+00  .0000000E 00
 11   1.0000000E+02 1.8717100E+00  .0000000E 00
 12   1.0000000E+02 2.1045798E+00  .0000000E 00
 13   1.0000000E+02 2.3591171E+00  .0000000E 00

DIFFERENCE-GROUP AVG SCATTER CROSS SECTION AND SUM OF GROUP AVERAGED TRANSFERS, GROUP 1 , IS= 2.48690E-14

DIFFERENCE-GROUP AVG SCATTER CROSS SECTION AND SUM OF GROUP AVERAGED TRANSFERS, GROUP 2 , IS= 1.77636E-14

DIFFERENCE-GROUP AVG SCATTER CROSS SECTION AND SUM OF GROUP AVERAGED TRANSFERS, GROUP 3 , IS= 1.77636E-14
```

OIFFERENCE-GROUP AVG SCATTER CROSS SECTION ANO SUM OF GROUP AVERAGED TRANSFERS, GROUP 4 , IS= 7.10543E-15

DIFFERENCE-GROUP AVG SCATTER CROSS SECTION AND SUM OF GROUP AVERAGEQ TRANSFERS, GROUP 5 , IS= 1.06581E-14

OIFFERENCE-GROUP AVG SCATTER CROSS SECTION AND SUM OF GROUP AVERAGED TRANSFERS, GROUP 6 , IS=-3.55271E-15

OIFFERENCE-GROUP AVG SCATTER CROSS SECTION AND SUM OF GROUP AVERAGED TRANSFERS, GROUP 7 , IS= 7.10543E-15

OIFFERENCE-GROUP AVG SCATTER CROSS SECTION ANO SUM OF GROUP AVERAGED TRANSFERS, GROUP 8 , IS=-4.97380E-14

DIFFERENCE-GROUP AVG SCATTER CROSS SECTION ANO SUM OF GROUP AVERAGED TRANSFERS, GROUP 9 , IS=-7.10543E-14

DIFFERENCE-GROUP AVG SCATTER CROSS SECTION ANO SUM OF GROUP AVERAGED TRANSFERS, GROUP10 , IS= 2.91323E-13

OIFFERENCE-GROUP AVG SCATTER CROSS SECTION AND SUM OF GROUP AVERAGED TRANSFERS, GROUP11 , IS=-1.70530E-13

OIFFERENCE-GROUP AVG SCATTER CROSS SECTION AND SUM OF GROUP AVERAGED TRANSFERS, GROUP12 , IS=-1.50635E-12

OIFFERENCE-GROUP AVG SCATTER CROSS SECTION ANO SUM OF GROUP AVERAGED TRANSFERS, GROUP13 , IS=-4.55032E-11

	ENERGY (MEV)	ABSORPTION
1	.1000000E+02	.1410000E+01
2	.9172760E+01	.1323140E+01
3	.8413950E+01	.1243460E+01
4	.7717910E+01	.1161920E+01
5	.7079460E+01	.1075730E+01
6	.6493810E+01	.9966650E+00
7	.5956620E+01	.9226250E+00
8	.5463860E+01	.8388570E+00
9	.5011870E+01	.7620180E+00
10	.4597270E+01	.6794530E+00
11	.4216960E+01	.6033920E+00
12	.3868120E+01	.5323050E+00
13	.3548130E+01	.4651080E-00
14	.3254620E+01	.4034690E-00
15	.2985380E+01	.3467840E-00
16	.2738420E+01	.2924520E-00
17	.2511880E+01	.2426140E-00
18	.2304090E+01	.1969000E-00
19	.2113490E+01	.1549670E-00
20	.1938650E+01	.1201840E-00
21	.1778280E+01	.9452430E-01
22	.1631170E+01	.7098720E-01
23	.1496230E+01	.4984940E-01
24	.1372460E+01	.4489840E-01
25	.1258920E+01	.4035690E-01
26	.1154780E+01	.3619120E-01
27	.1059250E+01	.3237000E-01
28	.9716260E+00	.3283770E-01
29	.8912490E+00	.4087540E-01

30	.8175220E+00	.4824820E-01
31	.7498930E+00	.6252690E-01
32	.6878590E+00	.7803550E-01
33	.6309560E+00	.9226130E-01
34	.5787610E+00	.1127440E-00
35	.5308830E+00	.1414710E-00
36	.4869670E-00	.1769440E-00
37	.4466830E-00	.2293130E-00
38	.4097310E-00	.2773500E-00
39	.3758370E-00	.3794050E-00
40	.3447460E-00	.4944410E-00
41	.3162270E-00	.5999610E+00
42	.2900670E-00	.8129640E+00
43	.2660720E-00	.1182500E+01
44	.2440610E-00	.1521460E+01
45	.2238720E-00	.1832380E+01
46	.2053520E-00	.2117580E+01
47	.1883640E-00	.2944690E+01
48	.1727820E-00	.3941950E+01
49	.1584890E-00	.4856720E+01
50	.1453780E-00	.6666440E+01
51	.1333520E-00	.9961640E+01
52	.1223200E-00	.1298420E+02
53	.1122020E-00	.1575680E+02
54	.1029200E-00	.1830000E+02
55	.9440580E-01	.2438660E+02
56	.8659620E-01	.3176670E+02
57	.7943260E-01	.3950400E+02
58	.7286160E-01	.5691870E+02
59	.6683420E-01	.7289290E+02
60	.6130540E-01	.8754560E+02
61	.5623390E-01	.1151070E+03
62	.5158200E-01	.1448770E+03
63	.4731500E-01	.1960830E+03
64	.4340090E-01	.2559700E+03
65	.3981060E-01	.3160180E+03
66	.3651730E-01	.4553240E+03
67	.3349640E-01	.5831050E+03
68	.3072550E-01	.7003160E+03
69	.2818370E-01	.1030520E+04
70	.2585220E-01	.1414980E+04
71	.2371360E-01	.1767640E+04
72	.2175200E-01	.2091130E+04
73	.1995250E-01	.2357280E+04
74	.1830200E-01	.1566200E+04
75	.1678800E-01	.8405710E+03
76	.1539920E-01	.1749660E+03
77	.1412530E-01	-.0000000E 00
78	.1295680E-01	-.0000000E 00
79	.1188500E-01	-.0000000E 00

80	.1090180E-01	-.0000000E 00
81	.9999950E-02	-.1656040E+02

P 0 CROSS SECTION TABLE ATOMIC NUMBER= 26.000E+00

	GROUP= 1	GROUP= 2	GROUP= 3	GROUP= 4	GROUP= 5	GROUP= 6	GROUP= 7	GROUP= 8
1	1.313944E-01	1.094138E-01	7.011533E-02	4.500376E-02	3.531846E-02	4.366640E-02	1.016086E-01	4.940899E-01
2	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00
3	3.940711E+00	4.062711E+00	4.343679E+00	4.719490E+00	5.219886E+00	5.910147E+00	6.955258E+00	9.007374E+00
4	8.307004E-03	2.163522E-01	2.952282E-01	4.070417E-01	5.962012E-01	9.534051E-01	1.749661E+00	4.118039E+00
5	.000000E 00	3.937949E-01	4.621335E-01	6.066808E-01	8.351973E-01	1.215808E+00	1.910242E+00	3.515806E+00
6	.000000E 00	.000000E 00	4.017480E-01	4.547428E-01	5.939008E-01	8.114471E-01	1.179944E+00	2.149823E+00
7	.000000E 00	.000000E 00	.000000E 00	4.006283E-01	4.612193E-01	6.112729E-01	8.764425E-01	1.666718E+00
8	.000000E 00	.000000E 00	.000000E 00	.000000E 00	4.132093E-01	4.969475E-01	7.129248E-01	1.391554E+00
9	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	4.543229E-01	6.108497E-01	1.202747E+00
10	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	5.704331E-01	1.064078E+00
11	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	1.004496E+00
12	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00
13	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00
14	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00
15	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00
16	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00

	GROUP= 9	GROUP=10	GROUP=11	GROUP=12	GROUP=13	GROUP=
1	1.824556E+00	3.874091E+00	1.231689E+01	6.228691E+01	7.713843E+02	
2	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	
3	1.199517E+01	1.490045E+01	2.445259E+01	7.593248E+01	7.866802E+02	
4	2.639000E+00	3.955529E+00	6.686486E+00	1.213210E+01	1.529593E+01	
5	1.847687E+00	4.247795E+00	6.852918E+00	5.449213E+00	1.513469E+00	
6	1.018013E+00	2.108151E+00	3.283823E+00	2.179132E-01	.000000E 00	
7	7.865229E-01	5.701696E-01	4.394068E-01	.000000E 00	.000000E 00	
8	5.258960E-01	6.648755E-02	.000000E 00	.000000E 00	.000000E 00	
9	3.528034E-01	.000000E 00	.000000E 00	.000000E 00	.000000E 00	
10	2.508087E-01	.000000E 00	.000000E 00	.000000E 00	.000000E 00	
11	1.869735E-01	.000000E 00	.000000E 00	.000000E 00	.000000E 00	
12	1.623769E-01	.000000E 00	.000000E 00	.000000E 00	.000000E 00	
13	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	
14	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	
15	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	
16	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	

	ENERGY (MEV)	ABSORPTION
1	.1000000E+02	.2700000E-00
2	.9172760E+01	.2493190E-00
3	.8413950E+01	.2303490E-00
4	.7717910E+01	.2129480E-00

5	.7079460E+01	.1969860E-00
6	.6493810E+01	.1823450E-00
7	.5956620E+01	.1687000E-00
8	.5463860E+01	.1539320E-00
9	.5011870E+01	.1403860E-00
10	.4597270E+01	.1239090E-00
11	.4216960E+01	.1086850E-00
12	.3868120E+01	.9512040E-01
13	.3548130E+01	.8328090E-01
14	.3254620E+01	.7242080E-01
15	.2985380E+01	.6238600E-01
16	.2738420E+01	.5201350E-01
17	.2511880E+01	.4249910E-01
18	.2304090E+01	.3377190E-01
19	.2113490E+01	.2576650E-01
20	.1938650E+01	.1903680E-01
21	.1778280E+01	.1390480E-01
22	.1631170E+01	.9197420E-02
23	.1496230E+01	.4962360E-02
24	.1372460E+01	.3724610E-02
25	.1258920E+01	.2589260E-02
26	.1154780E+01	.1547790E-02
27	.1059250E+01	.5925660E-03
28	.9716260E+00	.1418740E-03
29	.8912490E+00	.5439030E-03
30	.8175220E+00	.9124100E-03
31	.7498930E+00	.1250510E-02
32	.6878590E+00	.1560750E-02
33	.6309560E+00	.1845210E-02
34	.5787610E+00	.3762850E-02
35	.5308830E+00	.7736700E-02
36	.4869670E-00	.9739720E-02
37	.4466830E-00	.8007460E-02
38	.4097310E-00	.6418550E-02
39	.3758370E-00	.6966620E-02
40	.3447460E-00	.8210260E-02
41	.3162270E-00	.9351100E-02
42	.2900670E-00	.1297980E-01
43	.2660720E-00	.2017850E-01
44	.2440610E-00	.2678160E-01
45	.2238720E-00	.3283850E-01
46	.2053520E-00	.3839430E-01
47	.1883640E-00	.5163560E-01
48	.1727820E-00	.6721800E-01
49	.1584890E-00	.8151130E-01
50	.1453780E-00	.1131100E-00
51	.1333520E-00	.1732420E-00
52	.1223200E-00	.2283990E-00
53	.1122020E-00	.2789930E-00
54	.1029200E-00	.3254020E-00

P 1 CROSS SECTION TABLE ATOMIC NUMBER= 26.000E+00

	GROUP= 1	GROUP= 2	GROUP= 3	GROUP= 4	GROUP= 5	GROUP= 6	GROUP= 7	GROUP= 8
1	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00
2	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00
3	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00
4	8.303452E-03	2.138789E-01	2.905928E-01	3.981611E-01	5.769156E-01	9.030375E-01	1.572465E+00	2.996006E+00
5	.000000E 00	3.869357E-01	4.433991E-01	5.726791E-01	7.677341E-01	1.061805E+00	1.474084E+00	1.512361E+00
6	.000000E 00	.000000E 00	3.780913E-01	4.100545E-01	5.108690E-01	6.381858E-01	7.420800E-01	2.714598E-01
7	.000000E 00	.000000E 00	.000000E 00	3.539227E-01	3.772120E-01	4.444196E-01	4.734213E-01	-4.043519E-02
8	.000000E 00	.000000E 00	.000000E 00	.000000E 00	3.303896E-01	3.401253E-01	3.419587E-01	-1.581261E-01
9	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	3.026293E-01	2.666180E-01	-2.080639E-01
10	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	2.384627E-01	-2.284749E-01
11	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	-2.334056E-01
12	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00
13	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00
14	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00
15	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00
16	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00

	GROUP= 9	GROUP=10	GROUP=11	GROUP=12	GROUP=13	GROUP=
1	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	
2	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	
3	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	
4	2.239142E+00	3.008482E+00	3.589098E+00	1.846720E+00	7.440085E-01	
5	4.584600E-01	1.661501E+00	-9.141198E-01	-1.920442E+00	-5.761476E-01	
6	-4.703115E-01	-9.432517E-01	-1.869745E+00	-1.972085E-01	.000000E 00	
7	-5.530377E-01	-4.807833E-01	-3.534320E-01	.000000E 00	.000000E 00	
8	-4.156997E-01	-6.374432E-02	.000000E 00	.000000E 00	.000000E 00	
9	-2.939207E-01	.000000E 00	.000000E 00	.000000E 00	.000000E 00	
10	-2.163276E-01	.000000E 00	.000000E 00	.000000E 00	.000000E 00	
11	-1.652310E-01	.000000E 00	.000000E 00	.000000E 00	.000000E 00	
12	-1.449967E-01	.000000E 00	.000000E 00	.000000E 00	.000000E 00	
13	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	
14	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	
15	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	
16	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	

P 1 CROSS SECTION TABLE ATOMIC NUM8ER= 11.000E+00

	GROUP= 1	GROUP= 2	GROUP= 3	GROUP= 4	GROUP= 5	GROUP= 6	GROUP= 7	GROUP= 8
1	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00
2	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00
3	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00
4	3.512999E-03	9.048722E-02	1.229431E-01	1.684528E-01	2.440797E-01	3.820543E-01	6.652736E-01	1.267541E+00

P 5 CROSS SECTION TABLE ATOMIC NUMBER= 92.000E+00

	GROUP= 1	GROUP= 2	GROUP= 3	GROUP= 4	GROUP= 5	GROUP= 6	GROUP= 7	GROUP= 8
1	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00
2	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00
3	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00
4	2.920593E-02	6.420244E-01	8.184010E-01	1.020963E+00	1.249918E+00	1.369248E+00	8.263159E-01	1.891789E-01
5	.000000E 00	1.058073E+00	7.963076E-01	7.222974E-01	4.198748E-01	-4.031940E-01	-1.551928E+00	-4.108710E-01
6	.000000E 00	.000000E 00	4.165086E-01	-2.130944E-02	-4.588465E-01	-1.043264E+00	-7.941657E-01	2.951891E-01
7	.000000E 00	.000000E 00	.000000E 00	-1.800775E-01	-5.723712E-01	-8.021505E-01	-6.433764E-02	1.663721E-01
8	.000000E 00	.000000E 00	.000000E 00	.000000E 00	-5.606021E-01	-5.648164E-01	2.444472E-01	6.352018E-02
9	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	-4.672651E-01	3.664273E-01	1.648683E-02
10	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	3.968770E-01	-6.134872E-03
11	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	-1.381211E-02
12	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00
13	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00
14	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00
15	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00
16	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00

	GROUP= 9	GROUP=10	GROUP=11	GROUP=12	GROUP=13	GROUP=
1	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	
2	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	
3	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	
4	9.460875E-02	-1.031262E-01	-9.630091E-02	7.907040E-04	-8.531322E-02	
5	-7.866989E-02	3.310621E-01	2.433758E-01	1.093092E-01	2.968634E-03	
6	-2.577852E-01	-3.608770E-02	-3.794828E-01	-1.128635E-01	.000000E 00	
7	3.764016E-01	9.500122E-02	4.547891E-02	.000000E 00	.000000E 00	
8	2.460265E-01	-1.184265E-01	.000000E 00	.000000E 00	.000000E 00	
9	1.417101E-01	.000000E 00	.000000E 00	.000000E 00	.000000E 00	
10	5.457664E-02	.000000E 00	.000000E 00	.000000E 00	.000000E 00	
11	-1.880510E-03	.000000E 00	.000000E 00	.000000E 00	.000000E 00	
12	-2.225069E-02	.000000E 00	.000000E 00	.000000E 00	.000000E 00	
13	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	
14	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	
15	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	
16	.000000E 00	.000000E 00	.000000E 00	.000000E 00	.000000E 00	

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