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CALCULATION OF GROUP CROSS SECTIONS FOR HOT MONOATOMIC
MODERATOR WITH VARIABLE FLUX WEIGHTING WITHIN GROUPS
704 Code 521/RE 145

by

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ABSTRACT

This code finds inelastic cross-section matrix elements (transfer matrix) for hot monoatomic moderator for multigroup calculations by numeric-analytic double integration of Cohen's formula. Several approximations to the actual neutron density can be used as weight functions over the velocities of the initial groups. Modified and supplemented results are presented on binary cards and/or tape for direct input into the Argonne Transport Theory Codes or the SNG Code, or for off-line output.

ANALYTICAL CONSIDERATIONS

In case of very small absorption and for a moderator of infinite extent, the energy spectrum of neutrons approaches a Maxwellian distribution. When the absorption is not negligible and when there is a temperature variation in the reactor, the assumption of a Maxwellian spectrum is not adequate. A more detailed consideration of the neutron distribution, both spatially and energy-wise in the thermal region, is then desirable. The rate of neutron scattering has been sought for various moderators by numerous investigators (an early account of their work has been given by Cohen⁽¹⁾). In the case of a molecular or crystalline moderator their results apply mostly either for limited regions of temperature and neutron energy or are given in graphical form for special cases. For a monoatomic gaseous moderator the rate of neutron scattering can be given in a closed analytical form.^(2,1) Although the resulting transfer matrix is quite different from that for crystalline moderators, gross features of the resulting neutron spectrum are nearly the same,⁽³⁾ because for all kinds of moderators the transfer matrix has to satisfy conditions of detailed balance and give a direct coupling of neutrons of different thermal energies.

When the scattering cross section (σ_0) does not depend on relative neutron-nucleus velocity Cohen's formula⁽¹⁾ gives the inelastic scattering cross section in the form

$$\begin{aligned}\sigma_0 G(x \rightarrow y) &= \sigma_0 [M(y)/M(x)]^{\frac{1}{2}} S(x, y) \\ &= \sigma_0 \theta^2(y/x) \left\{ \exp(x^2 - y^2) \operatorname{erf}(\theta x - \zeta y) + \operatorname{erf}(\theta y - \zeta x) \right. \\ &\quad \left. \pm [\exp(x^2 - y^2) \operatorname{erf}(\theta x + \zeta y) - \operatorname{erf}(\theta y + \zeta x)] \right\}, \quad (1)\end{aligned}$$

where the upper sign (+) has to be used for $y > x$, and the lower sign (-) for $y < x$. The symbols x and y represent the initial and final neutron velocities, respectively, expressed in units of most probable initial and final velocity of thermal neutrons:

$$\begin{cases} x = v_i / \sqrt{2kT} = \sqrt{E_i/kT} \\ y = v_f / \sqrt{2kT} = \sqrt{E_f/kT} \end{cases}, \quad (2)$$

and

$$\theta = (m + 1)/2\sqrt{m}, \quad \zeta = (m - 1)/2\sqrt{m}, \quad (3)$$

where m is mass of the atom in multiples of neutron mass.

To find the inelastic cross-section matrix elements for multigroup calculations one has to average over initial velocities and integrate over final velocities in each energy group. Upon examination of the transport (or diffusion) equations one sees that a proper way of averaging would be given by the equation

$$\sigma_{i \rightarrow j} = \frac{\int N(x) dx \int \sigma_0 G(x \rightarrow y) dy}{\int x N(x) dx}, \quad (4)$$

where integration over y is carried out in the velocity group j , and x varies over the velocities of (initial) group i . Here $N(x)$ is the actual neutron density. Equation (1) permits integration over y in closed form through integration by parts. Integration of the first term and subsequent simplification using (3) gives

$$\begin{aligned} & \int_0^y y e^{-y^2} \cdot \operatorname{erf}(\theta x - \zeta y) dy \\ &= -\frac{1}{2} [e^{-y^2} \operatorname{erf}(\theta x - \zeta y) - \operatorname{erf}(\theta x)] \\ &+ \frac{1}{2} \int_0^y e^{-y^2} \frac{2}{\sqrt{\pi}} e^{-(\theta x - \zeta y)^2} (-\zeta dy) \\ &= -\frac{1}{2} e^{-y^2} \operatorname{erf}(\theta x - \zeta y) + \frac{1}{2} \operatorname{erf}(\theta x) \\ &- \frac{1}{2} \frac{\zeta}{\theta} e^{-x^2} [\operatorname{erf}(\theta y - \zeta x) + \operatorname{erf}(\zeta x)] \end{aligned}$$

where

$$\operatorname{erf}(x) = \frac{2}{\pi} \int_0^x e^{-u^2} du$$

Application of similar procedures to the other terms of equation (1) yields

$$\int_{y^1}^{y^2} G(x \rightarrow y) dy = [I_a(y) \mp I_b(y)]_{y^1}^{y^2}, \quad (5)$$

where the upper sign is used for $y > x$, the lower sign for $y < x$. The function $I_b(y)$ is chosen so that it vanishes for $y = x$. The functions $I_a(y)$ and $I_b(y)$ are, respectively,

$$\begin{aligned} I_a(y) = (\theta^2/2x) & \left\{ -\exp(x^2 - y^2) \operatorname{erf}(\theta x - \zeta y) \right. \\ & + \left[y^2 - \left(\frac{m-1}{m+1} \right)^2 x^2 + \frac{2}{(m+1)^2} - 1 \right] \operatorname{erf}(\theta y - \zeta x) \\ & \left. + \frac{1}{\sqrt{\pi}} \frac{1}{\theta^2} (\theta y + \zeta x) \exp - (\theta y - \zeta x)^2 \right\} \end{aligned} \quad (5a)$$

$$\begin{aligned} I_b(y) = (\theta^2/2x) & \left\{ \exp(x^2 - y^2) \operatorname{erf}(\theta x + \zeta y) \right. \\ & + \left[y^2 - \left(\frac{m-1}{m+1} \right)^2 x^2 + \frac{2}{(m+1)^2} - 1 \right] \operatorname{erf}(\theta y + \zeta x) \\ & \left. + \frac{1}{\sqrt{\pi}} \frac{1}{\theta^2} (\theta y - \zeta x) \exp - (\theta y + \zeta x)^2 - D \right\} \end{aligned}$$

with

$$\begin{aligned} D = & \left[\frac{x^2}{\theta^2} + \frac{2}{(m+1)^2} \right] \operatorname{erf}(\sqrt{m} x) \\ & + \frac{1}{\sqrt{\pi}} \frac{1}{\theta^2} \frac{x}{\sqrt{m}} \exp(-m x^2) \end{aligned} \quad (5b)$$

An attempt at analytical integration of (5) over x has been made, assuming $N(x) = \text{const}$. However, it has been frustrated by terms of type $\int \operatorname{erf} x e^{-x^2} x^{-1} dx$. Thus it has been decided to integrate over x numerically.

A code that performs a numerical double integration (trapezoidal rule) on Equation (1) has been developed by J. Griffin at Los Alamos (code GTM). The use of formula (5) saves one numerical integration, thereby reducing machine time and avoiding some errors in the numerical procedure [particularly because of sharpness of $G(x,y)$]. However, as in Griffin's

method, corresponding terms (in 5a and 5b) have an occasional tendency to cancel out. Through proper arrangement of the critical terms, this effect can be minimized.

The code 521/RE 145 integrates equations (5) simultaneously twice by Simpson's rule, the first time with four intervals per energy group, the second time with eight intervals per energy group. The ratios of the final results of corresponding integrations are printed in a separate column in the output. Their deviation from 1.0000000 gives a good indication of the accuracy of the integration. The function D is computed only for the diagonal elements. The explicit formulas for the entire computation are given in the following section.

For very critical cases, a more sophisticated code was devised for the GEORGE computer, using variable Gaussian integration and built-in checks for accuracy and loss of significant figures (Code 436/RE 116; Bareiss, Jankus, Strecok). However, this code was never necessary to solve actual engineering problems.

Computation of sample problems indicated that Code 521/RE 145 is considerably faster than GTM and CSX run in succession.

DESCRIPTION OF IBM-704 CODE 521/RE 145

SUMMARY:

To find inelastic cross-section matrix elements for multigroup calculations by numeric-analytic double integration of Cohen's formula with proper weight (i.e., the actual neutron density) over the velocities of the initial groups.

To present the results in accordance with CSX-024452 for direct input in the Argonne Transport Theory codes, the SNG code, or off-line output.

Original version contains two options for the neutron-density function. Provision is made for inserting up to seven additional neutron-density functions at any given time.

Code written in FORTRAN

Input: on-line

Output: optional on-line or off-line

Timing: depends on number of energy groups and on different output options. With off-line output, about 5 minutes is required.

Needs an 8K or more machine.

Given: $m, T, \sigma_0, h, c, \bar{\mu}, \nu \sigma_f(g), \sigma_g^{(a)}, E_i, n_g, \bar{\sigma}_{11}, \bar{\sigma}_{21},$

The program calculates:

$x = \sqrt{E_i/kT}, y = \sqrt{E_f/kT}$, where $k = 8.6164 \times 10^{-5}$, and E_f are same values as E_i

$$E_i > E_{i+1}, x_j > x_{j+1}, y_g > y_{g+1},$$

$$\theta = (m+1)/2\sqrt{m}, \quad \zeta = (m-1)/2\sqrt{m},$$

$$x_{j,\ell} = x_j - \frac{x_j - x_{j+1}}{8} \ell, \quad \ell = 0, 1, \dots, 8,$$

$$J(x_j, y_g) = I(x_j, y_g) - I(x_j, y_{g+1}) \quad \text{for off-diagonal elements}$$

$$= I(x_j, y_g) - I(x_j, y_{g+1}) + 2D(x_j) \quad \text{for on-diagonal elements}$$

where

$$I(x,y) = (\theta^2/2x) \cdot \{K(x,y) + L(x,y) + M(x,y)\},$$

$$K(x,y) = \exp(x^2 - y^2) \cdot [-\operatorname{erf}(\theta x - \zeta y) \mp \operatorname{erf}(\theta x + \zeta y)],$$

$$L(x,y) = [y^2 - \left(\frac{m-1}{m+1}\right)^2 x^2 + \frac{2}{(m+1)^2} - 1] \cdot [\operatorname{erf}(\theta y - \zeta x) \mp \operatorname{erf}(\theta y + \zeta x)],$$

$$M(x,y) = \frac{1}{\sqrt{\pi} \theta^2} \left[(\theta y + \zeta x) \exp\left\{-\frac{(\theta y - \zeta x)^2}{2}\right\} \mp (\theta y - \zeta x) \exp\left\{-\frac{(\theta y + \zeta x)^2}{2}\right\} \right],$$

$$\operatorname{erf}(z) = \frac{2}{\sqrt{\pi}} \int_0^z e^{-u^2} du \quad (\text{uneven fct.}),$$

$$D(x) = [\theta^2/2x] \cdot \left\{ [x^2/\theta^2 + 2/(m+1)^2] \operatorname{erf}(\sqrt{m}x) + (x/\theta^2 \sqrt{\pi} \sqrt{m}) \exp(-mx^2) \right\}$$

Use $\begin{cases} - & \text{for } y > x \\ + & \text{for } y < x \end{cases}$ where $\mp$. For diagonal elements see diagram.

$$x_i > x_{i+1}$$

$$y_g > y_{g+1}$$

Density functions $N(x)$, with two options provided initially,

$$(a) \quad N(x) = x^2 e^{-cx^2}, \quad \text{and}$$

$$(b) \quad N(x) = x^{n_g};$$

Up to seven additional options can be inserted in the code at any one time. These additional options can be any function of x , c , n_g .

$$S_j(F(x)) = F_{j,0} + 4F_{j,2} + 2F_{j,4} + 4F_{j,6} + F_{j,8},$$

$$T_j(F(x)) = F_{j,0} + 4F_{j,1} + 2F_{j,2} + 4F_{j,3} + 2F_{j,4} + 4F_{j,5} + 2F_{j,6} + 4F_{j,7} + F_{j,8},$$

where

$$F_{j,\ell}^{(1)} = N(x_{j,\ell}) \cdot J(x_{j,\ell}, y_g),$$

$$F_{j,\ell}^{(2)} = x_{j,\ell} N(x_{j,\ell});$$

$$\sigma_{jg}^{(1)} = \sigma_0 \cdot S_j^{(1)} / S_j^{(2)}, \quad \sigma_{jg}^{(2)} = \sigma_0 \cdot T_j^{(1)} / T_j^{(2)},$$

If $\sigma_{jg} < 0$ (through rounding errors), the machine sets $\sigma_{jg} = 0$

$$R_{jg} = \sigma_{jg}^{(1)} / \sigma_{jg}^{(2)}.$$

This ratio indicates the accuracy of the numerical integration. σ_{jg}^2 and R_{jg} are available as output.

If CSX-024452 type output is desired, the following additional calculations are performed:

$$\bar{\sigma}_{j,g} = (1 - \bar{\mu}) \sigma_{jg}, \quad \text{for } j - h < g < j + h$$

$$\bar{\sigma}_{j,j+h} = (1 - \bar{\mu}) \sum_{g=j+h}^G \sigma_{jg}, \quad \text{for } g = j + h$$

$$\bar{\sigma}_{j,j-h} = (1 - \bar{\mu}) \sum_{g=1}^{j-h} \sigma_{jg}, \quad \text{for } g = j - h$$

$$\bar{\sigma}_{tr,g} = \bar{\sigma}_g^{(a)} + \sum_{j=g-h}^{g+h} \bar{\sigma}_{jg},$$

$$\nu \bar{\sigma}_f = \nu \sigma_f,$$

where

$$\sigma_{jg} = 0 \text{ for } j, g < 2$$

$$j, g > G$$

$\bar{\sigma}_{11}$, $\bar{\sigma}_{21}$ are given as input,

$$h \leq 10, G \leq 24.$$

INPUT:

The input to the problem is through the on-line card reader. The actual number of cards for each case will depend on the number of energy groups G . For g groups there should be $(2g + 9)$ cards. The following are the 5 different card formats needed:

1. Identification card.

A five-or-less digit number ≤ 32767 , in card columns 1-5, closed up to the right (i.e., the number 22 would be punched in columns 4 and 5); leading zeros in the number will be suppressed in the output. Any punches to the right of column 5 will be ignored.

2. $m, T, \sigma_0, \bar{\mu}, c, \bar{\sigma}_{11}, \bar{\sigma}_{21}$.

Seven cards giving, in the above order, the values of the seven parameters of the problem. The code expects to find these values in columns 1 - 14 of the cards, closed up to the right, in standard floating point notation, with the power of ten expressed by a sign and one or two digits immediately following the number.

Up to eight significant digits can be read.

3. Problem specifications.

The ninth input card bears two two-digit numbers in columns 1-4. Columns 1 and 2 carry G , the number of energy groups, while h appears in columns 3 and 4. Leading zeros need not be punched. The tenth card specifies the type or types of output desired. A "0" or "1" in columns 2, 4, 6 and 8 will either suppress or result in giving the four different types of output. These four outputs are:

"1" in column 2 - GTM - type output	} on-line or
"1" in column 4 - CSX - type output	
"1" in column 6 - card output	} for ANL
"1" in column 8 - tape output	
	} transport codes

The program will come to a recognizable stop if all four options were read in as "0".

4. Density option cards.

The next $g - 1$ cards have, in column 2, one digit for the density function for the individual groups g , where $g = 2, 3, \dots, G$. Group 1 is the fast group and no density function applies here. If density function 2 is selected, n_g must be punched into 3-14, in fixed point notation, closed up to the right. Density function 1 does not use n_g ; hence all columns to the right of column 2 can be left blank.

Any future density functions added to the program can get the necessary information from columns 3-14 of these cards.

5. Group data.

The last g cards, one for each energy group, have three fields of 14 columns each. The first field (columns 1-14) has the final energy (in ev) of each individual energy group. Thus, the initial energy of the first group (fast neutrons) will never appear as input data. The initial energy for each group is, therefore, the energy punched in the previous card.

In order to avoid division by zero and possible underflow, the lowest energy must be greater than or equal to 10^{-10} . Practical experience has indicated that $E_{\text{lowest}} = 3 \times 10^{-6}$ is adequate in all cases.

The second field on the cards (columns 15-28) and the third field (columns 29-42) contain $\sigma(a)$ and $\nu\sigma_f$ for each group. All data on these cards are in standard floating point form, closed up to the right within each field.

OUTPUT:

Four different kinds of output are available and they are selected for each case by punching "1's" into the appropriate columns of the tenth input card. Any combination of these four output options can be selected, but it is impossible to run the problem without selecting at least one of them.

A "1" in column 2 will result in a GTM-type output, one page for each energy group except the fast group. The first page lists m , T , σ_0 , c , the energy option codes. All pages list the identification, i , the density option for the group, n if the option is 2, y_i , y_{i+1} , x_j ($j = 2, G$), $\sigma_{jg}^{(2)}$, and R_{jg} .

The σ_{jg} 's are set to zero by the routine if they ever become negative. The program tests both the $\sigma_{jg}^{(1)}$ and $\sigma_{jg}^{(2)}$ before calculating R_{jg} and, if either of the two is equal to zero, plants the following values for R_{jg} :

$\sigma_{jg}^{(1)}$	$\sigma_{jg}^{(2)}$	R_{jg}
= 0	= 0	1
= 0	> 0	0
> 0	= 0	-1

A "1" in column 4 will yield the CSX-type output, one page for 13 or less groups, two pages for more. The first page lists the identification number, m , T , σ_0 , c , $\bar{\mu}$, h , and an explanation of the density option codes. The body of the table consists of up to eleven columns with their headings. The first column is the final energy group (g), the next one lists either the density option code for the group if $\neq 2$, or n_g if option 2 was selected. The next three columns list, respectively, the absorption cross section, ν times σ -fission, and the transport cross section for each group. The remaining columns list the scattering cross sections $\bar{\sigma}_{gj}$ ($j = g+h, g+h-1, \dots, g+1, g, g-1, \dots, g-h+1, g-h$), with scattering from j into g . These are listed in up to six columns per line, with as many lines as are necessary for each group.

Both of these types of output will be on logical tape 3 if sense switch 1 is up, on-line if sense switch 1 is down. As sense switch 2 down will stop the machine after the GTM-type output is written, it is possible to get one of these two outputs on-line and the other off-line.

If the output is on tape 3, an end-of-file is written after each output. Tape 3 should be printed under program control.

The third possible output ("1" in column 6) is a deck of cards punched on-line, giving essentially the same type of data as the CSX-type output. The first two cards are for identification, listing m , t , σ_0 , c , $\bar{\mu}$, and h . These are followed by two or more cards for each energy group, the first card containing $\sigma_g^{(a)}$, $\nu \sigma_{f,g}$, $\bar{\sigma}_{tr,g}$, the successive cards the scattering cross sections $\bar{\sigma}_{gj}$.

The fourth possible output ("1" in column 8) will write on logical tape 2 the same information as was punched under the third option, in the same format, except that the first two records are omitted. An end of file is written after each case.

CODING INFORMATION:

The loader and the current code occupy locations $0 - 7607_8$ ($0 - 3972_{10}$); data are located in $73247_8 - 77777_8$ ($30375_{10} - 32767_{10}$).

In addition to the above locations (all modulo the size of the machine), the program uses locations $73000_8 - 73246_8$ ($30208_{10} - 30374_{10}$) for temporary storage purposes.

ADDITIONAL DENSITY OPTIONS:

The original program contains provisions for computing two possible density functions, namely,

Option 1 - $N(x) = x^2 \exp(-cx^2)$

2 - $N(x) = x^n$, with n specified for each energy group.

Provision is made for adding up to seven more density functions, labeled 3-9. These additional functions will have available to them

x at location 73205_8 ,
 c at location 73206_8 , and
 n_g at location 73207_8 .

The transfers to the new density functions can be made by changing the address part of the TSX instructions leading to them. These TSX's are located at

location	1461_8	for option 3
	1475_8	for option 4
	1511_8	for option 5
	1525_8	for option 6
	1541_8	for option 7
	1555_8	for option 8
	1571_8	for option 9

The address change can be made by means of a correction card which will overwrite the TSX to dummy address with TSX to actual start of function calculation. The routines used to calculate the new density functions must be located between locations

7610₈ and 72777₈ (3973₁₀ - 30207₁₀) and must return with a TRA 1, 4 instruction with the result in the accumulator. The routines themselves should be on absolute binary cards, which will be loaded by the main program loader.

OPERATING INSTRUCTIONS

SENSE SWITCHES

- 1 up - normal - GTM and CSX - type outputs on tape 3
- 1 down - output on-line
- 2 up - normal
- 2 down - stop (HPR 3770 at 2044) after GTM-type calculations (and output if selected)
- 3 - 6 are ignored

TAPE UNITS:

- 2 if output option 4 is selected ("1" in column 8 of card 10)
- 3 if output options 1 and/or 2 are selected ("1's" in columns 2 and/or 4 of card 10) and if sense switch 1 is up.

PRINTER BOARD

Share 2 if sense switch 1 is down.

LOAD

Code deck, followed by data decks for any number of cases, 2 blank cards.

Note: No blank cards between successive data decks.

OUTPUT

Depending on output options, tape 3 will contain (if any) one or two files per case, tape 2 one file. If output option 3 was used ("1" in column 6 of card 10) a deck of cards will be punched. The first two of these identify the case and give some input information.

Tape 3, if used, should be printed under program control. Tape 2, if used, can be printed on single or double-space, and should be saved as input to the ANL transport codes (e.g., 480/AMD107, which is the FORTRAN SNG-Code; 539/AMD112, which is a multi-polynomial approximation; etc.).

STOPS:

HPR 1005 at 312 - Output option card (data card 10) asks for no output. Correct card, ready this card in reader, push START

HPR 3770 at 2044 - End of GTM-type calculations (and output if selected). Occurs if sense switch 2 is down. Permits change of setting of sense switch 1. Push START to proceed.

HPR 77777 at 2533 - End of case. Push START to read data for next case.

For other stops of HPR type see FORTRAN Operator's Manual under "Error Stops in Object Program," page 3.

If a stop occurs while reading data for a case, the case can be restarted, or the next one can be started, by readying the cards in the reader, transferring manually to 140₈, and pushing START.

RUNNING TIME:

Depends on the number of energy groups and the types of output selected. With tape output, somewhere around 5 minutes.

UNDERFLOW ELIMINATOR:

Off.

LIST OF FORTRAN STATEMENTS

```

C      521 RF 145      CALCULATION OF MICROSCOPIC CROSS SECTIONS      ANXSECOO
C      WITH ARBITRARY LAWS OF NEUTRON DISTRIBUTION
C      FOR DIRECT INPUT IN TRANSPORT THEORY CODES
C
      DIMENSION E(25),Y(2),X(9),FK(9,2),FL(9,2),FM(9,2),FI(9,2),D(9), XSEC0001
X      FJ(9),NDOPT(25),FNX(9),F1X(9),F2X(9),SF1X(25),SF2X(25), XSEC0002
X      SIGMA(25),TF1X(25),TF2X(25),SIGMB(25,25),R(25,25), XSEC0003
X      XX(26),CK(25),ENUSIG(25),SIGABS(25),SIGBAR(25,25), XSEC0004
X      SIGTRA(25),SIGRAB(21),ZERO(11) XSEC0005
4000 ETAF(A,B)=THETA*A+ZETA*B XSEC0006
4001 EXJLF(A,B,C)=A-((A-B)/8.0)*C XSEC0007
4002 DENSAF(C)=XSQ*EXPF(-C*XSQ) XSEC0008
4003 DENSBF(X,A)=X**A XSEC0009
4004 DENSCEF(X,A,B)=X*A/B XSEC0010
4005 SFXF(A,B,C,D,E)=A+E+2.0*(C+2.0*(B+D)) XSEC0011
4006 TFXF(R,S,T,U,V,W,X,Y,Z)=R+Z+2.0*(T+V+X+2.0*(S+U+W+Y)) XSEC0012
      1 FORMAT (E14.7) XSEC0013
      5 FORMAT (4I2) XSEC0014
      10 FORMAT (I2,F12.7) XSEC0015
      15 FORMAT (3E14.7) XSEC0016
      20 FORMAT (I5) XSEC0017
4200 READ 20,IDNO XSEC0018
4205 READ 1,EM,T,SIG,EMU,CC,SIGIN1,SIGIN2 XSEC0019
4210 READ 5,IMAX,IH XSEC0020
4215 READ 5,KOUT,LOUT,MOUT,NOUT XSEC0021
4220 READ 10,(NDOPT(I),CK(I),I=2,IMAX) XSEC0022
4225 READ 15,(E(I),SIGABS(I),ENUSIG(I),I=1,IMAX) XSEC0023
C
C      PREVENT NO OUTPUT AND SET UP PROBLEM PARAMETERS
C
      1000 IF (KOUT+LOUT+MOUT+NOUT) 1005,1005,1020 XSEC0024
      1005 PAUSE 1005 XSEC0025
      1010 READ 5,KOUT,LOUT,MOUT,NOUT XSEC0026
      1015 GO TO 1000 XSEC0027
      1020 T0=SQRTF(EM) XSEC0028
      1025 THETA=(EM+1.0)/(2.0*T0) XSEC0029
      1030 THTSQ=THETA**2 XSEC0030
      1035 ZETA=(EM-1.0)/(2.0*T0) XSEC0031
      1040 EMPSQ=(EM+1.0)**2 XSEC0032
      1045 EMMSQ=(EM-1.0)**2 XSEC0033
      1050 EMRSQ=EMMSQ/EMPSQ XSEC0034
      1055 T1=2.0/EMPSQ XSEC0035
      1060 T2=T1-1.0 XSEC0036
      1065 T3=1.0/(1.7724539*THTSQ) XSEC0037
      1070 T4=(8.6164E-05)*T XSEC0038
C
C      WRITE HEADING FOR GTM TYPE OUTPUT
C
      1075 IF (KOUT) 2000,2000,1080 XSEC0039
      1080 IF (SFNSE SWITCH 1) 1085,1095 XSEC0040
      1085 PRINT 600,IDNO,EM,T,SIG,CC XSEC0041

```

LIST OF FORTRAN STATEMENTS (Cont'd.)

```

1090 GO TO 2000
1095 WRITE OUTPUT TAPE 3,600, IDNO, EM, T, SIG, CC
600 FORMAT (47H1521 RE 145 INELASTIC MATRIX ELEMENTS I5//
X 3HOM=F6.3,5H T=1PE10.3,12H SIGMA(0)=0PF6.3,5H C=F8.5/XSEC0042
X 45H0 2 2 N/ XSEC0043
X 55H DENSITY OPTION CODES 1=X *EXP(-CX ), 2=X /XSEC0044
X 55H XSEC0045
XSEC0046
XSEC0047
XSEC0049

C
C START ENERGY GROUP LOOPS
C
2000 K=2 XSEC0050
2005 DO 3360 I=2, IMAX XSEC0051
2010 Y(1)=SQRTF(E(I-1)/T4) XSEC0052
2015 Y(2)=SQRTF(E(I)/T4) XSEC0053
2020 DO 3345 J=2, IMAX XSEC0054
2025 X(1)=SQRTF(E(J-1)/T4) XSEC0055
2030 X(9)=SQRTF(E(J)/T4) XSEC0056
2035 EL=1.0 XSEC0057
2040 DO 2050 IJ=2, 8 XSEC0058
2045 X(IJ)=EXJLF(X(1), X(9), EL) XSEC0059
2050 EL=EL+1.0 XSEC0060

C
C START LOOPS WITHIN INDIVIDUAL ELEMENTS
C
2055 DO 3206 N=1, 2 XSEC0061
2060 YSQ=Y(N)**2 XSEC0062
2065 DO 3206 M=1, 9 XSEC0063
2070 XSQ=X(M)**2 XSEC0064
2075 T5=ETAF(X(M), -Y(N)) XSEC0065
2080 T6=ETAF(X(M), Y(N)) XSEC0066
2085 T7=ETAF(Y(N), -X(M)) XSEC0067
2090 T8=ETAF(Y(N), X(M)) XSEC0068
2095 TK1=EXP(XSQ-YSQ) XSEC0069
3000 TK2=ERRORF(T5) XSEC0070
3005 TK3=ERRORF(T6) XSEC0071
3010 TL1=YSQ-EMRSQ*XSQ+T2 XSEC0072
3015 TL2=ERRORF(T7) XSEC0073
3020 TL3=ERRORF(T8) XSEC0074
3025 IF ACCUMULATOR OVERFLOW 3030, 3035 XSEC0075
3030 CONTINUE XSEC0076
3035 TM2=T8*EXP(-T7**2) XSEC0077
3040 IF ACCUMULATOR OVERFLOW 3045, 3050 XSEC0078
3045 TM2=0.0 XSEC0079
3050 TM3=T7*EXP(-T8**2) XSEC0080
3055 IF ACCUMULATOR OVERFLOW 3060, 3065 XSEC0081
3060 TM3=0.0 XSEC0082
3065 IF (J-K) 3156, 3070, 3180 XSEC0083

C
C DIAGONAL ELEMENT
C
3070 IF ACCUMULATOR OVERFLOW 3072, 3074 XSEC0084
3072 CONTINUE XSEC0085

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LIST OF FORTRAN STATEMENTS (Cont'd.)

3074 GO TO (3076,3100),N	XSEC0086
3076 FK(M,1)=-TK1*(TK2+TK3)	XSEC0087
3078 IF ACCUMULATOR OVERFLOW 3080,3082	XSEC0088
3080 FK(M,1)=0.0	XSEC0089
3082 FL(M,1)=TL1*(TL2-TL3)	XSEC0090
3084 IF ACCUMULATOR OVERFLOW 3086,3088	XSEC0091
3086 FL(M,1)=0.0	XSEC0092
3088 FM(M,1)=T3*(TM2-TM3)	XSEC0093
3090 IF ACCUMULATOR OVERFLOW 3092,3094	XSEC0094
3092 FM(M,1)=0.0	XSEC0095
3094 FI(M,1)=(THTSQ/(2.0*X(M)))*(FK(M,1)+FL(M,1)+FM(M,1))	XSEC0096
3096 GO TO 3206	XSEC0097
3100 FK(M,2)=TK1*(-TK2+TK3)	XSEC0098
3102 IF ACCUMULATOR OVERFLOW 3104,3106	XSEC0099
3104 FK(M,2)=0.0	XSEC0100
3106 FL(M,2)=TL1*(TL2+TL3)	XSEC0101
3108 IF ACCUMULATOR OVERFLOW 3110,3112	XSEC0102
3110 FL(M,2)=0.0	XSEC0103
3112 FM(M,2)=T3*(TM2+TM3)	XSEC0104
3114 IF ACCUMULATOR OVERFLOW 3116,3118	XSEC0105
3116 FM(M,2)=0.0	XSEC0106
3118 T9=THTSQ/(2.0*X(M))	XSEC0107
3120 FI(M,2)=T9*(FK(M,2)+FL(M,2)+FM(M,2))	XSEC0108
3122 IF ACCUMULATOR OVERFLOW 3124,3126	XSEC0109
3124 FI(M,2)=0.0	XSEC0110
3126 TD=T3*EXP(-EM*XSQ)	XSEC0111
3128 IF ACCUMULATOR OVERFLOW 3130,3132	XSEC0112
3130 TD=0.0	XSEC0113
3132 TD=TD*X(M)	XSEC0114
3134 IF ACCUMULATOR OVERFLOW 3136,3138	XSEC0115
3136 TD=0.0	XSEC0116
3138 IF QUOTIENT OVERFLOW 3140,3142	XSEC0117
3140 CONTINUE	XSEC0118
3142 TD=TD/T0	XSEC0119
3144 IF QUOTIENT OVERFLOW 3146,3148	XSEC0120
3146 TD=0.0	XSEC0121
3148 TD=ERRORF(T0*X(M))+TD	XSEC0122
3150 D(M)=T9*((XSQ/THTSQ+T1)*TD)	XSEC0123
3152 FJ(M)=FI(M,1)-FI(M,2)+2.0*D(M)	XSEC0124
3154 GO TO 3206	XSEC0125
C	
C OFF-DIAGONAL ELEMENTS	
C	
3156 IF ACCUMULATOR OVERFLOW 3158,3160	XSEC0126
3158 CONTINUE	XSEC0127
3160 FK(M,N)=TK1*(-TK2+TK3)	XSEC0128
3162 IF ACCUMULATOR OVERFLOW 3164,3166	XSEC0129
3164 FK(M,N)=0.0	XSEC0130
3166 FL(M,N)=TL1*(TL2+TL3)	XSEC0131
3168 IF ACCUMULATOR OVERFLOW 3170,3172	XSEC0132
3170 FL(M,N)=0.0	XSEC0133
3172 FM(M,N)=T3*(TM2+TM3)	XSEC0134

LIST OF FORTRAN STATEMENTS (Cont'd.)

3174 GO TO 3198	XSEC0135
3180 IF ACCUMULATOR OVERFLOW 3182,3184	XSEC0136
3182 CONTINUE	XSEC0137
3184 FK(M,N)=-TK1*(TK2+TK3)	XSEC0138
3186 IF ACCUMULATOR OVERFLOW 3188,3190	XSEC0139
3188 FK(M,N)=0.0	XSEC0140
3190 FL(M,N)=TL1*(TL2-TL3)	XSEC0141
3192 IF ACCUMULATOR OVERFLOW 3194,3196	XSEC0142
3194 FL(M,N)=0.0	XSEC0143
3196 FM(M,N)=T3*(TM2-TM3)	XSEC0144
3198 IF ACCUMULATOR OVERFLOW 3200,3202	XSEC0145
3200 FM(M,N)=0.0	XSEC0146
3202 FI(M,N)=THTSQ/(2.0*X(M))*(FK(M,N)+FL(M,N)+FM(M,N))	XSEC0147
3204 FJ(M)=FI(M,1)-FI(M,2)	XSEC0148
3206 CONTINUE	XSEC0149
C	
C SELECT PROPER NEUTRON DENSITY FUNCTION	
C OPTIONS 3-9 (DENSFC) ARE DUMMY FUNCTIONS	
C TO ALLOW FUTURE OPTIONS	
C	
3208 KK=NDOPT(J)	XSEC0150
3210 DO 3276 M=1,9	XSEC0151
3212 IF ACCUMULATOR OVERFLOW 3214,3216	XSEC0152
3214 CONTINUE	XSEC0153
3216 GO TO (3218,3228,3238,3242,3246,3250,3254,3258,3262),KK	XSEC0154
3218 XSQ=X(M)**2	XSEC0155
3220 FNX(M)=DENSFC(CC)	XSEC0156
3222 IF ACCUMULATOR OVERFLOW 3224,3264	XSEC0157
3224 FNX(M)=0.0	XSEC0158
3226 GO TO 3264	XSEC0159
3228 IF (CK(J))3234,3230,3234	XSEC0160
3230 FNX(M)=1.0	XSEC0161
3232 GO TO 3264	XSEC0162
3234 FNX(M)=DENSBF(X(M),CK(J))	XSEC0163
3236 GO TO 3264	XSEC0164
3238 FNX(M)=DENSFC(X(M),CC,CK(J))	XSEC0165
3240 GO TO 3264	XSEC0166
3242 FNX(M)=DENSFC(X(M),CC,CK(J))	XSEC0167
3244 GO TO 3264	XSEC0168
3246 FNX(M)=DENSFC(X(M),CC,CK(J))	XSEC0169
3248 GO TO 3264	XSEC0170
3250 FNX(M)=DENSFC(X(M),CC,CK(J))	XSEC0171
3252 GO TO 3264	XSEC0172
3254 FNX(M)=DENSFC(X(M),CC,CK(J))	XSEC0173
3256 GO TO 3264	XSEC0174
3258 FNX(M)=DENSFC(X(M),CC,CK(J))	XSEC0175
3260 GO TO 3264	XSEC0176
3262 FNX(M)=DENSFC(X(M),CC,CK(J))	XSEC0177
3264 F1X(M)=FNX(M)*FJ(M)	XSEC0178
3266 IF ACCUMULATOR OVERFLOW 3268,3270	XSEC0179
3268 F1X(M)=0.0	XSEC0180
3270 F2X(M)=FNX(M)*X(M)	XSEC0181

LIST OF FORTRAN STATEMENTS (Cont'd.)

5555 IF (J-14) 5565,5560,5565	XSEC0323
5560 PRINT 705	XSEC0324
5565 IF (NDOPT(J)-2) 5570,5580,5570	XSEC0325
5570 PRINT 710,J,NDOPT(J),SIGABS(J),ENUSIG(J),SIGTRA(J),	XSEC0326
X (SIGRAB(I2),I2=1,I3)	XSEC0327
5575 GO TO 3492	XSEC0328
5580 PRINT 715,J,CK(J),SIGABS(J),ENUSIG(J),SIGTRA(J),	XSEC0329
X (SIGRAB(I2),I2=1,I3)	XSEC0330
5585 GO TO 3492	XSEC0331
5600 IF (J-14) 5610,5605,5610	XSEC0332
5605 WRITE OUTPUT TAPE 3,705	XSEC0333
5610 IF(NDOPT(J)-2) 5615,5625,5615	XSEC0334
5615 WRITE OUTPUT TAPE 3,710,J,NDOPT(J),SIGABS(J),ENUSIG(J),	XSEC0335
X SIGTRA(J),(SIGRAB(I2),I2=1,I3)	XSEC0336
5620 GO TO 3492	XSEC0337
5625 WRITE OUTPUT TAPE 3,715,J,CK(J),SIGABS(J),ENUSIG(J),	XSEC0338
X SIGTRA(J),(SIGRAB(I2),I2=1,I3)	XSEC0339
5630 GO TO 3492	XSEC0340
5700 IF (SFENSE SWITCH 1) 5705,5750	XSEC0341
5705 IF (J-14) 5715,5710,5715	XSEC0342
5710 PRINT 705	XSEC0343
5715 IF (NDOPT(J)-2) 5720,5730,5720	XSEC0344
5720 PRINT 710,J,NDOPT(J),SIGABS(J),ENUSIG(J),SIGTRA(J),	XSEC0345
X (ZERO(I4),I4=1,I5),(SIGRAB(I2),I2=1,I3)	XSEC0346
5725 GO TO 3512	XSEC0347
5730 PRINT 715,J,CK(J),SIGABS(J),ENUSIG(J),SIGTRA(J),	XSEC0348
X (ZERO(I4),I4=1,I5),(SIGRAB(I2),I2=1,I3)	XSEC0349
5735 GO TO 3512	XSEC0350
5750 IF (J-14) 5760,5755,5760	XSEC0351
5755 WRITE OUTPUT TAPE 3,705	XSEC0352
5760 IF (NDOPT(J)-2) 5765,5775,5765	XSEC0353
5765 WRITE OUTPUT TAPE 3,710,J,NDOPT(J),SIGABS(J),ENUSIG(J),	XSEC0354
X SIGTRA(J),(ZERO(I4),I4=1,I5),(SIGRAB(I2),I2=1,I3)	XSEC0355
5770 GO TO 3512	XSEC0356
5775 WRITE OUTPUT TAPE 3,715,J,CK(J),SIGABS(J),ENUSIG(J),	XSEC0357
X SIGTRA(J),(ZERO(I4),I4=1,I5),(SIGRAB(I2),I2=1,I3)	XSEC0358
5780 GO TO 3512	XSEC0359
700 FORMAT (81H1521 RE 145 MICROSCOPIC CROSS SECTIONS	XSEC0360
X I5//3HOM=F6.3,5H T=1PE10.3,12H SIGMAXSEC0361	
X(0)=0PF6.3,5H C=F8.5,9H MUBAR=F7.4,5H H=I2/	XSEC0362
X45H0 2 2 N/64H DENSITY OPTIOXSEC0363	
XN CODES 1=X *EXP(-CX), 2=X //113H0 G DENS.XSEC0364	
X ARSORP. NU TIMES TRANSPORT SCATTERING SIGMA(G,J), J=XSEC0365	
XG+H,G+H-1,...,G+1,G,G-1,...,G-H+1,G-H/93H OPT. SIGMA XSEC0366	
XSIG.FISS. SIGMA FROM GROUP J TO GROUPXSEC0367	
X G/9H OR N) XSEC0368	
705 FORMAT (13H1 I5,33H PAGE 2) XSEC0369	
710 FORMAT (1H0I2,I4,F15.7,2F12.7,F14.7,5F12.7/(1H F59.7,5F12.7)) XSEC0370	
715 FORMAT (1H0I2,F7.3,3F12.7,F14.7,5F12.7/(1H F59.7,5F12.7)) XSEC0371	

C
C CARDS FOR DIRECT INPUT TO ANL TRANSPORT CODES (MOUT POSITIVE)
C

LIST OF FORTRAN STATEMENTS (Cont'd.)

3406	JMH=J-IH	XSEC0222
3408	JPH=J+IH	XSEC0223
3410	IF (I-JPH) 3412,3418,3436	XSEC0224
3412	IF (I-JMH) 3436,3426,3414	XSEC0225
3414	SIGBAR(J,I)=SIGMB(J,I)	XSEC0226
3416	GO TO 3432	XSEC0227
3418	SIGBAR(J,I)=0.0	XSEC0228
3420	DO 3422 I1=JPH,IMAX	XSEC0229
3422	SIGBAR(J,I)=SIGBAR(J,I)+SIGMB(J,I1)	XSEC0230
3424	GO TO 3432	XSEC0231
3426	SIGBAR(J,I)=0.0	XSEC0232
3428	DO 3430 I1=2,JMH	XSEC0233
3430	SIGBAR(J,I)=SIGBAR(J,I)+SIGMB(J,I1)	XSEC0234
3432	SIGBAR(J,I)=TMU*SIGBAR(J,I)	XSEC0235
3434	GO TO 3438	XSEC0236
3436	SIGBAR(J,I)=0.0	XSEC0237
3438	CONTINUE	XSEC0238
3440	SIGBAR(1,1)=SIGIN1	XSEC0239
3442	SIGBAR(1,2)=SIGIN2	XSEC0240
3444	DO 3446 J=2,IMAX	XSEC0241
3446	SIGBAR(J,1)=0.0	XSEC0242
3448	DO 3450 I=3,IMAX	XSEC0243
3450	SIGBAR(1,I)=0.0	XSEC0244
3452	IF (LOUT) 3454,3454,5500	XSEC0245
3454	IH1=IH+1	XSEC0246
3456	IH2=IH+IH+1	XSEC0247
3458	DO 3466 I=1,IMAX	XSEC0248
3460	SIGTRA(I)=0.0	XSEC0249
3462	DO 3464 J=1,IMAX	XSEC0250
3464	SIGTRA(I)=SIGTRA(I)+SIGBAR(I,J)	XSEC0251
3466	SIGTRA(I)=SIGABS(I)+SIGTRA(I)	XSEC0252
3468	DO 3520 J=1,IMAX	XSEC0253
3470	IF (J+IH-IMAX) 3472,3472,3496	XSEC0254
3472	IF (J-IH) 3480,3480,3474	XSEC0255
3474	I1=J+IH1	XSEC0256
3476	I3=IH2	XSEC0257
3478	GO TO 3484	XSEC0258
3480	I1=J+IH1	XSEC0259
3482	I3=I1-1	XSEC0260
3484	DO 3488 I2=1,I3	XSEC0261
3486	I12=I1-I2	XSEC0262
3488	SIGRAR(I2)=SIGBAR(I12,J)	XSEC0263
3490	IF (LOUT) 3492,3492,5550	XSEC0264
3492	IF (MOUT) 3494,3494,6000	XSEC0265
3494	IF (NOUT) 3520,3520,6500	XSEC0266
3496	I3=IMAX+IH1-J	XSEC0267
3498	DO 3502 I2=1,I3	XSEC0268
3500	I12=IMAX-I2+1	XSEC0269
3502	SIGRAR(I2)=SIGBAR(I12,J)	XSEC0270
3504	I5=IH2-I3	XSEC0271
3506	DO 3508 I4=1,I5	XSEC0272
3508	ZERO(I4)=0.0	XSEC0273

LIST OF FORTRAN STATEMENTS (Cont'd.)

3510 IF (LQUT) 3512,3512,5700	XSEC0274
3512 IF (MQUT) 3514,3514,6050	XSEC0275
3514 IF (NQUT) 3520,3520,6520	XSEC0276
3520 CONTINUE	XSEC0277
3525 IF (LQUT) 3540,3540,3530	XSEC0278
3530 IF (SFNSE SWITCH 1) 3540,3535	XSEC0279
3535 END FILE 3	XSEC0280
3540 IF (NQUT) 3550,3550,3545	XSEC0281
3545 END FILE 2	XSEC0282
3550 PAUSE 77777	XSEC0283
3555 GO TO 4200	XSEC0284
C	
C GTM TYPE OUTPUT (KOUT POSITIVE)	
C	
5000 IF (K-2) 5005,5005,5100	XSEC0288
5005 IF (SFNSE SWITCH 1) 5010,5040	XSEC0289
5010 PRINT 605,I,NDOPT(I)	XSEC0290
5015 IF (NDOPT(I)-2) 5025,5020,5020	XSEC0291
5020 PRINT 610,CK(I)	XSEC0292
5025 PRINT 620,Y(1),Y(2),IMAX,(XX(J),SIGMB(J,I),R(J,I),J=2,IMAX)	XSEC0293
5030 PRINT 625,XX(IMAX+1)	XSEC0294
5035 GO TO 3360	XSEC0295
5040 WRITE OUTPUT TAPE 3,605,I,NDOPT(I)	XSEC0296
5045 IF (NDOPT(I)-2) 5055,5050,5050	XSEC0297
5050 WRITE OUTPUT TAPE 3,610,CK(I)	XSEC0298
5055 WRITE OUTPUT TAPE 3,620,Y(1),Y(2),IMAX,(XX(J),SIGMB(J,I),	XSEC0299
X R(J,I),J=2,IMAX)	XSEC0300
5060 WRITE OUTPUT TAPE 3,625,XX(IMAX+1)	XSEC0301
5065 GO TO 3360	XSEC0302
5100 IPAGE=K-1	XSEC0303
5105 IF (SFNSE SWITCH 1) 5110,5120	XSEC0304
5110 PRINT 650,IDNO,IPAGE	XSEC0305
5115 GO TO 5010	XSEC0306
5120 WRITE OUTPUT TAPE 3,650,IDNO,IPAGE	XSEC0307
5125 GO TO 5040	XSEC0308
605 FORMAT (19H ENERGY GROUP(I),I=12,19H DENSITY OPTION 11)	XSEC0309
610 FORMAT (45H+ (N=F6.3,1H))	XSEC0310
620 FORMAT (25H0 Y(I)=F10.7,12H Y(I+1)=F10.7/	XSEC0311
X15H0 X(J),J=2,12,31H SIGMA(J,I) R(J,I) //	XSEC0312
X(1H F15.7/1H F37.7,F12.7))	XSEC0313
625 FORMAT (1H F15.7)	XSEC0314
650 FORMAT (11H1 I5,43H	XSEC0315
XPAGE 12/1H0)	XSEC0316
C	
C CSX TYPE OUTPUT (LOUT POSITIVE)	
C	
5500 IF (SFNSE SWITCH 1) 5505,5515	XSEC0317
5505 PRINT 700,IDNO,EM,T,SIG,CC,EMU,IH	XSEC0318
5510 GO TO 3454	XSEC0319
5515 WRITE OUTPUT TAPE 3,700,IDNO,EM,T,SIG,CC,EMU,IH	XSEC0320
5520 GO TO 3454	XSEC0321
5550 IF (SFNSE SWITCH 1) 5555,5600	XSEC0322

LIST OF FORTRAN STATEMENTS (Cont'd.)

3272 IF ACCUMULATOR OVERFLOW 3274,3276	XSEC0182
3274 F2X(M)=0.0	XSEC0183
3276 CONTINUE	XSEC0184
C	
C INTEGRATION OVER X	
C	
3300 SF1X(J)=SFXF(F1X(1),F1X(3),F1X(5),F1X(7),F1X(9))	XSEC0185
3302 SF2X(J)=SFXF(F2X(1),F2X(3),F2X(5),F2X(7),F2X(9))	XSEC0186
3304 SIGMA(J)=SIG*SF1X(J)/SF2X(J)	XSEC0187
3306 IF (SIGMA(J)) 3308,3308,3310	XSEC0188
3308 SIGMA(J)=0.0	XSEC0189
3310 TF1X(J)=TFXF(F1X(1),F1X(2),F1X(3),F1X(4),F1X(5),F1X(6),F1X(7),	XSEC0190
X F1X(8),F1X(9))	XSEC0191
3312 TF2X(J)=TFXF(F2X(1),F2X(2),F2X(3),F2X(4),F2X(5),F2X(6),F2X(7),	XSEC0192
X F2X(8),F2X(9))	XSEC0193
3314 SIGMB(J,I)=SIG*TF1X(J)/TF2X(J)	XSEC0194
3316 IF (SIGMB(J,I)) 3318,3318,3320	XSEC0195
3318 SIGMB(J,I)=0.0	XSEC0196
3320 IF (SIGMA(J)) 3322,3322,3332	XSEC0197
3322 IF (SIGMB(J,I)) 3324,3324,3328	XSEC0198
3324 R(J,I)=1.0	XSEC0199
3326 GO TO 3340	XSEC0200
3328 R(J,I)=0.0	XSEC0201
3330 GO TO 3340	XSEC0202
3332 IF (SIGMB(J,I)) 3334,3334,3338	XSEC0203
3334 R(J,I)=-1.0	XSEC0204
3336 GO TO 3340	XSEC0205
3338 R(J,I)=SIGMA(J)/SIGMB(J,I)	XSEC0206
3340 XX(J)=X(1)	XSEC0207
3342 XX(J+1)=X(9)	XSEC0208
3345 CONTINUE	XSEC0209
3350 IF (KOUT) 3360,3360,5000	XSEC0210
3360 K=K+1	XSEC0211
3362 IF (KOUT) 3368,3368,3364	XSEC0212
3364 IF (SFNSE SWITCH 1) 3368,3366	XSEC0213
3366 END FILE 3	XSEC0214
3368 IF (SFNSE SWITCH 2) 3370,3372	XSEC0215
3370 PAUSE 3370	XSEC0216
C	
C END OF ENERGY GROUP LOOPS	
C GO TO GTM TYPE OUTPUT IF WANTED	
C PAUSE IF SS2 DOWN	
C GO TO CSX CALCULATIONS OR READ DATA FOR NEXT CASE	
C	
3372 IF (LOUT+MOUT+NOUT) 3374,3374,3400	XSEC0217
3374 GO TO 4200	XSEC0218
C	
C TRANSPORT AND SCATTERING CROSS SECTIONS	
C	
3400 TMU=1.0-EMU	XSEC0219
3402 DO 3438 I=2,IMAX	XSEC0220
3404 DO 3438 J=2,IMAX	XSEC0221

LIST OF FORTRAN STATEMENTS (Cont'd.)

6000 IF (J-1) 6005,6005,6010	XSEC0372
6005 PUNCH 800,IDNO,EM,T,SIG,CC,EMU,IH	XSEC0373
6010 PUNCH 805,SIGABS(J),ENUSIG(J),SIGTRA(J),(SIGRAB(I2),I2=1,I3)	XSEC0374
6015 GO TO 3494	XSEC0375
6050 IF (J-1) 6055,6055,6060	XSEC0376
6055 PUNCH 800,IDNO,EM,T,SIG,CC,EMU,IH	XSEC0377
6060 PUNCH 805,SIGABS(J),ENUSIG(J),SIGTRA(J),(ZERO(I4),I4=1,I5),	XSEC0378
X (SIGRAB(I2),I2=1,I3)	XSEC0379
6065 GO TO 3514	XSEC0380
800 FORMAT (I5,28H MICROSCOPIC CROSS SECTIONS/2HM=F6.3,4H T=1PE10.3,	XSEC0381
X11H SIGMA(0)=OPF6.3,4H C=F8.5,8H MUBAR=F7.4,4H H=I2)	XSEC0382
805 FORMAT (3F12.7/(6F12.7))	XSEC0383
C	
C WRITE CROSS SECTIONS ON TAPE 2 TO GIVE DIRECT INPUT	
C TO ANL TRANSPORT CODES (NOUT POSITIVE)	
C	
6500 WRITE OUTPUT TAPE 2,805,SIGABS(J),ENUSIG(J),SIGTRA(J),	XSEC0384
X (SIGRAB(I2),I2=1,I3)	XSEC0385
6505 GO TO 3520	XSEC0386
6520 WRITE OUTPUT TAPE 2,805,SIGABS(J),ENUSIG(J),SIGTRA(J),	XSEC0387
X (ZERO(I4),I4=1,I5),(SIGRAB(I2),I2=1,I3)	XSEC0388
6525 GO TO 3520	XSEC0389

STORAGE MAP

STORAGE FOR VARIABLES APPEARING IN DIMENSION OR EQUIVALENCE SENTENCES

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
FNX	32688	77660		FM	32342	77126		FL	32360	77150		FK	32378	77172
FI	32324	77104		F2X	32670	77636		F1X	32679	77647		E	32767	77777
D	32731	77733		CK	32510	77376		NDOP1	32713	77711		R	31681	75701
SF2X	32636	77574		SIGABS	32460	77314		SIGBAR	31056	74520		SIGMA	32611	77543
SIGRAB	32410	77232		SIGTRA	32435	77263		TF1X	32586	77512		TF2X	32561	77461
XX	32536	77430		Y	32742	77746		ZERO	32389	77205		X	32740	77744

STORAGE FOR VARIABLES WHICH DO NOT APPEAR IN DIMENSION OR EQUIVALENCE SENTENCES

[illegible]

NAMES OF FORTRAN FUNCTIONS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

IFN	LOC	IFN	LOC	IFN	LOC	IFN	LOC	IFN	LOC
ETA	2 03723	EXJL	3 03732	DENSA	4 03741	DENSB	5 03753	DENSC	6 03761
SFX	7 03765	TFX	8 04001						

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
4000	2	03723	4001	3	03732	4002	4	03741	4003	5	03753	4004	6	03761
4005	7	03765	4006	8	04001	1	9	00000	5	10	00000	10	11	00000
15	12	00000	20	13	00000	4200	14	00001	4200	16	00013	4205	17	00015
4205	19	00035	4210	20	00037	4210	22	00054	4215	23	00056	4215	25	00073
4220	26	00075	4220	31	00116	4225	32	00120	4225	37	00142	1000	38	00144
1005	39	00152	1010	40	00153	1010	42	00170	1015	43	00172	1020	44	00173
1025	45	00200	1030	46	00207	1035	47	00212	1040	48	00221	1045	49	00227
1050	50	00235	1055	51	00240	1060	52	00243	1065	53	00246	1070	54	00254
1075	55	00257	1080	56	00263	1085	57	00265	1085	59	00303	1090	60	00305
1095	61	00306	1095	63	00324	600	64	00000	2000	65	00326	2005	66	00330
2010	67	00344	2015	68	00352	2020	69	00360	2025	70	00367	2030	71	00375
2035	72	00403	2040	73	00405	2045	74	00406	2050	75	00420	2055	76	00425
2060	77	00433	2065	78	00436	2070	79	00441	2075	80	00445	2080	81	00457
2085	82	00467	2090	83	00501	2095	84	00511	3000	85	00517	3005	86	00524
3010	87	00531	3015	88	00537	3020	89	00544	3025	90	00551	3030	91	00553
3035	92	00553	3040	93	00565	3045	94	00567	3050	95	00571	3055	96	00603

STORAGE MAP

3060	97	00605	3065	98	00607	3070	99	00614	3072	100	00616
3076	102	00620	3078	103	00630	3080	104	00634	3082	105	00636
3086	107	00646	3088	108	00653	3090	109	00661	3092	110	00663
3096	112	00703	3100	113	00704	3102	114	00713	3104	115	00715
3108	117	00730	3110	118	00732	3112	119	00737	3114	120	00745
3118	122	00754	3120	123	00762	3122	124	00771	3124	125	00773
3128	127	01012	3130	128	01016	3132	129	01020	3134	130	01023
3138	132	01032	3140	133	01036	3142	134	01036	3144	135	01041
3148	137	01047	3150	138	01056	3152	139	01072	3154	140	01077
3158	142	01102	3160	143	01102	3162	144	01110	3164	145	01112
3168	147	01122	3170	148	01124	3172	149	01126	3174	150	01134
3187	152	01137	3184	153	01137	3186	154	01146	3188	155	01150
3192	157	01160	3194	158	01162	3196	159	01164	3198	160	01172
3202	162	01176	3204	163	01212	3206	164	01215	3208	165	01226
3212	167	01237	3214	168	01241	3216	169	01241	3218	170	01253
3222	172	01264	3224	173	01266	3226	174	01270	3228	175	01272
3232	177	01300	3234	178	01301	3236	179	01311	3238	180	01312
3247	182	01326	3244	183	01340	3246	184	01342	3248	185	01354
3252	187	01370	3254	188	01372	3256	189	01404	3258	190	01406
3262	192	01422	3264	193	01434	3266	194	01437	3268	195	01441
3277	197	01446	3274	198	01450	3276	199	01452	3280	200	01454
3304	202	01510	3306	203	01514	3308	204	01517	3310	205	01521
3314	207	01575	3316	208	01602	3318	209	01605	3320	210	01607
3324	212	01615	3326	213	01617	3328	214	01620	3330	215	01622
3334	217	01626	3336	218	01630	3338	219	01631	3340	220	01634
3345	222	01640	3350	223	01647	3360	224	01661	3362	225	01672
3366	227	01701	3366	227	01701	3368	228	01702	3370	229	01704
3374	231	01712	3400	232	01713	3412	233	01716	3404	234	01734
3408	236	01746	3410	237	01751	3422	238	01755	3414	239	01763
3418	241	01770	3420	242	01772	3422	243	02012	3424	244	02020
3428	246	02024	3430	247	02037	3432	248	02045	3434	249	02050
3438	251	02055	3440	252	02070	3442	253	02072	3444	254	02074
3448	256	02103	3450	257	02110	3452	258	02114	3454	259	02117
3458	261	02126	3460	262	02142	3462	263	02144	3464	264	02144
3468	266	02160	3470	267	02170	3472	268	02175	3474	269	02202
3478	271	02207	3480	272	02210	3482	273	02213	3484	274	02216
3488	276	02231	3490	277	02236	3492	278	02245	3494	279	02255
3498	281	02270	3500	282	02275	3502	283	02303	3504	284	02310
3508	286	02316	3510	287	02322	3512	288	02331	3514	289	02340
3525	291	02356	3530	292	02362	3535	293	02365	3535	293	02365
3545	295	02372	3545	295	02372	3550	296	02373	3555	297	02374
5005	299	02401	5010	300	02403	5010	302	02416	5015	303	02420
5020	306	02437	5025	307	02441	5025	313	02502	5030	314	02504
5035	317	02521	5040	318	02522	5040	320	02535	5045	321	02537
5050	324	02566	5055	325	02560	5055	331	02621	5060	332	02633
5065	335	02640	5100	336	02641	5105	337	02644	5110	338	02646
5115	341	02663	5120	342	02664	5120	344	02677	5125	345	02701
610	347	01620	620	348	00200	625	349	00330	650	350	00150
5505	352	02704	5505	354	02724	5510	355	02726	5515	356	02727
5520	359	02751	5550	360	02752	5555	361	02754	5560	362	02761
5565	364	02773	5570	365	02776	5570	371	03025	5575	372	03027
5580	373	03030	5580	373	03030	5580	373	03030	5580	373	03030

STORAGE MAP

5610	384	03101	5615	385	03104	5615	391	03133	5620	392	03135	5625	393	03136
5625	399	03165	5630	400	03167	5700	401	03170	5705	402	03172	5710	403	03177
5710	404	03206	5715	405	03211	5720	406	03214	5720	415	03253	5725	416	03255
5730	417	03256	5730	426	03315	5735	427	03317	5750	428	03320	5755	429	03325
5755	430	03334	5760	431	03337	5765	432	03342	5765	441	03401	5770	442	03403
5775	443	03404	5775	452	03443	5780	453	03445	700	454	03230	705	455	03160
710	456	03110	715	457	03160	6000	458	03446	6005	459	03452	6005	461	03472
6010	462	03474	6010	468	03522	6015	469	03524	6050	470	03525	6055	471	03531
6055	473	03551	6060	474	03553	6060	483	03611	6065	484	03613	800	485	04340
805	486	02170	6500	487	03614	6500	493	03642	6505	494	03644	6520	495	03645
6520	504	03703	6525	505	03705									

SUBROUTINES OBTAINED FROM LIBRARY

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
(DBC)	2362	04472	(CSH)	2879	05477	(BDC)	2960	05620	(FIL)	2990	05656	(LEV)	3003	05673
(RTN)	3030	05726	(SCH)	3454	06576	(SPH)	3600	07020	(STH)	3696	07160	EXP(3)	3704	07170
EXP	3712	07200	SQRT	3817	07351	ERROR	3839	07377						

SAMPLE PROBLEM

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FORM I

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AMD-8 (8-58)

704 INPUT DATA
FORM I

PROBLEM 521/RE 145

ORIGINATOR

DATA I.D. 02302

DATE _____

PAGE 3 OF 3

[illegible]

LISTING OF INPUT CARDS FOR SAMPLE PROBLEM

02302				1
	4.3+1			2
	3.0+2			3
	4.7+0			4
	5.6-2			5
	1.3333+0			6
	4.416343+0			7
	3.3657-2			8
20 4				9
1 1 1 1				10
2	-2.0			11
2	-2.0			12
2	-2.0			13
2	-2.0			14
2	-2.0			15
2	-2.0			16
2	-2.0			17
2	-2.0			18
2	-2.0			19
2	-2.0			20
2	-2.7			21
1	0.0			22
1	0.0			23
1	0.0			24
1	0.0			25
1	0.0			26
1	0.0			27
1	0.0			28
1	0.0			29
	2.0+0	4.81-5	0.0+0	30
	1.5+0	4.213-4	0.0+0	31
	1.0+0	5.116-4	0.0+0	32
	8.0-1	5.685-4	0.0+0	33
	6.0-1	6.497-4	0.0+0	34
	5.0-1	7.072-4	0.0+0	35
	4.0-1	7.815-4	0.0+0	36
	3.5-1	8.353-4	0.0+0	37
	3.0-1	9.282-4	0.0+0	38
	2.5-1	1.0089-3	0.0+0	39
	2.0-1	1.1206-3	0.0+0	40
	1.5-1	1.2821-3	0.0+0	41
	1.0-1	1.5291-3	0.0+0	42
	7.0-2	1.8292-3	0.0+0	43
	5.0-2	2.1635-3	0.0+0	44
	4.0-2	2.4722-3	0.0+0	45
	3.0-2	2.8162-3	0.0+0	46
	2.0-2	3.3456-3	0.0+0	47
	1.0-2	4.3148-3	0.0+0	48
	3.0-6	7.1876-3	0.0+0	49

LISTING OF GTM-TYPE OUTPUT

521 RE 145 INELASTIC MATRIX ELEMENTS 2302

M=43.000 T= 3.000E 02 SIGMA(0)= 4.700 C= 1.33330

DENSITY OPTION CODES $1=X^2 * \exp(-CX^2)$, $2=X^N$

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PAGE 2

ENERGY GROUP(I),I= 2 DENSITY OPTION 2 (N=-2.000)

ENERGY GROUP(I),I= 3 DENSITY OPTION 2 (N=-2.000)

Y(I)= 8.7961260 Y(I+1)= 7.6176686

X(J),J=2,20	SIGMA(J,I)	R(J,I)
8.7961260	3.9051646	0.9967171
7.6176686	0.0349827	1.6531868
6.2198004	0.	1.0000000
5.5631586	0.	1.0000000
4.8178366	0.	1.0000000
4.3980630	0.	1.0000000
3.9337471	0.	1.0000000
3.6796835	0.	1.0000000
3.4067250	0.	1.0000000
3.1099002	0.	1.0000000
2.7815793	0.	1.0000000
2.4089183	0.	1.0000000
1.9668736	0.	1.0000000
1.6456045	0.	1.0000000
1.3907896	0.	1.0000000
1.2439601	0.	1.0000000
1.0773010	0.	1.0000000
0.8796126	0.	1.0000000
0.6219800	0.	1.0000000
0.0107730	0.	1.0000000

Y(I)= 7.6176686 Y(I+1)= 6.2198004

X(J),J=2,20	SIGMA(J,I)	R(J,I)
8.7961260	0.7652030	0.9930707
7.6176686	4.1085322	0.9958152
6.2198004	0.0975768	1.0839787
5.5631586	0.0000006	1.3194975
4.8178366	0.	1.0000000
4.3980630	0.	1.0000000
3.9337471	0.	1.0000000
3.6796835	0.	1.0000000
3.4067250	0.	1.0000000
3.1099002	0.	1.0000000
2.7815793	0.	1.0000000
2.4089183	0.	1.0000000
1.9668736	0.	1.0000000
1.6456045	0.	1.0000000
1.3907896	0.	1.0000000
1.2439601	0.	1.0000000
1.0773010	0.	1.0000000
0.8796126	0.	1.0000000
0.6219800	0.	1.0000000
0.0107730	0.	1.0000000

LISTING OF GTM-TYPE OUTPUT (Cont'd.)

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ENERGY GROUP(I),I= 4 DENSITY OPTION 2 (N=-2.000)

Y(I)= 6.2198004 Y(I+1)= 5.5631586

X(J),J=2,20	SIGMA(J,I)	R(J,I)
8.7961260	0.	1.0000000
7.6176686	0.5561445	0.9886902
6.2198004	3.5724399	0.9978141
5.5631586	0.1013264	1.1003435
4.8178366	0.0000003	1.1672416
4.3980630	0.	1.0000000
3.9337471	0.	1.0000000
3.6796835	0.	1.0000000
3.4067250	0.	1.0000000
3.1099002	0.	1.0000000
2.7815793	0.	1.0000000
2.4089183	0.	1.0000000
1.9668736	0.	1.0000000
1.6456045	0.	1.0000000
1.3907896	0.	1.0000000
1.2439601	0.	1.0000000
1.0773010	0.	1.0000000
0.8796126	0.	1.0000000
0.6219800	0.	1.0000000
0.0107730	0.	1.0000000

ENERGY GROUP(I),I= 5 DENSITY OPTION 2 (N=-2.000)

Y(I)= 5.5631586 Y(I+1)= 4.8178366

X(J),J=2,20	SIGMA(J,I)	R(J,I)
8.7961260	0.0000000	1.9729930
7.6176686	0.0015017	1.4217305
6.2198004	1.0310979	0.9995428
5.5631586	3.7729991	0.9973715
4.8178366	0.2237355	1.0099390
4.3980630	0.0003205	1.0528524
3.9337471	0.0000000	1.6341757
3.6796835	0.	1.0000000
3.4067250	0.	1.0000000
3.1099002	0.	1.0000000
2.7815793	0.	1.0000000
2.4089183	0.	1.0000000
1.9668736	0.	1.0000000
1.6456045	0.	1.0000000
1.3907896	0.	1.0000000
1.2439601	0.	1.0000000
1.0773010	0.	1.0000000
0.8796126	0.	1.0000000
0.6219800	0.	1.0000000
0.0107730	0.	1.0000000

LISTING OF GTM-TYPE OUTPUT (Cont'd.)

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PAGE 6

ENERGY GROUP(I),I= 6 DENSITY OPTION 2 (N=-2.000)

Y(I)= 4.8178366 Y(I+1)= 4.3980630

X(J),J=2,20	SIGMA(J,I)	R(J,I)
8.7961260	0.0000000	1.9974117
7.6176686	0.	1.0000000
6.2198004	0.0004687	1.1838747
5.5631586	0.8034952	0.9985701
4.8178366	3.1789124	0.9993375
4.3980630	0.2244190	1.0118375
3.9337471	0.0003611	1.0060863
3.6796835	0.0000026	1.0112448
3.4067250	0.	1.0000000
3.1099002	0.	1.0000000
2.7815793	0.	1.0000000
2.4089183	0.	1.0000000
1.9668736	0.	1.0000000
1.6456045	0.	1.0000000
1.3907896	0.	1.0000000
1.2439601	0.	1.0000000
1.0773010	0.	1.0000000
0.8796126	0.	1.0000000
0.6219800	0.	1.0000000
0.0107730	0.	1.0000000

ENERGY GROUP(I),I= 7 DENSITY OPTION 2 (N=-2.000)

Y(I)= 4.3980630 Y(I+1)= 3.9337471

X(J),J=2,20	SIGMA(J,I)	R(J,I)
8.7961260	0.	1.0000000
7.6176686	0.0000000	1.9832323
6.2198004	0.	1.0000000
5.5631586	0.0242035	1.0374153
4.8178366	1.2797298	0.9998145
4.3980630	3.3652951	0.9992185
3.9337471	0.4591551	1.0008526
3.6796835	0.0148905	1.0030906
3.4067250	0.0001404	1.0124173
3.1099002	0.0000005	0.9127025
2.7815793	0.	1.0000000
2.4089183	0.	1.0000000
1.9668736	0.	1.0000000
1.6456045	0.	1.0000000
1.3907896	0.	1.0000000
1.2439601	0.	1.0000000
1.0773010	0.	1.0000000
0.8796126	0.	1.0000000
0.6219800	0.	1.0000000
0.0107730	0.	1.0000000

LISTING OF GTM-TYPE OUTPUT (Cont'd.)

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PAGE 8

ENERGY GROUP(I),I= 8 DENSITY OPTION 2 (N=-2.000)

Y(I)= 3.9337471 Y(I+1)= 3.6796835

X(J),J=2,20	SIGMA(J,I)	R(J,I)
8.7961260	0.	1.0000000
7.6176686	0.0000000	1.9970414
6.2198004	0.0000000	1.5366410
5.5631586	0.0000219	0.6867809
4.8178366	0.0196760	1.0063725
4.3980630	0.9634151	0.9996168
3.9337471	2.5664422	0.9998560
3.6796835	0.4446157	1.0009128
3.4067250	0.0117672	1.0041208
3.1099002	0.0000701	1.0195888
2.7815793	0.0000001	1.1178636
2.4089183	0.	1.0000000
1.9668736	0.	1.0000000
1.6456045	0.	1.0000000
1.3907896	0.	1.0000000
1.2439601	0.	1.0000000
1.0773010	0.	1.0000000
0.8796126	0.	1.0000000
0.6219800	0.	1.0000000
0.0107730	0.	1.0000000

ENERGY GROUP(I),I= 9 DENSITY OPTION 2 (N=-2.000)

Y(I)= 3.6796835 Y(I+1)= 3.4067250

X(J),J=2,20	SIGMA(J,I)	R(J,I)
8.7961260	0.	1.0000000
7.6176686	0.0000000	1.9988576
6.2198004	0.0000000	1.6705947
5.5631586	0.	1.0000000
4.8178366	0.0005415	0.9776756
4.3980630	0.1433775	1.0015837
3.9337471	1.4854525	0.9999573
3.6796835	2.7051868	0.9998398
3.4067250	0.4439873	1.0010832
3.1099002	0.0087424	1.0061105
2.7815793	0.0000267	1.0308114
2.4089183	0.	1.0000000
1.9668736	0.	1.0000000
1.6456045	0.	1.0000000
1.3907896	0.	1.0000000
1.2439601	0.	1.0000000
1.0773010	0.	1.0000000
0.8796126	0.	1.0000000
0.6219800	0.	1.0000000
0.0107730	0.	1.0000000

LISTING OF GTM-TYPE OUTPUT (Cont'd.)

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ENERGY GROUP(I),I=10 DENSITY OPTION 2 (N=-2.000)

Y(I)= 3.4067250

Y(I+1)= 3.1099002

X(J),J=2,20	SIGMA(J,I)	R(J,I)
8.7961260	0.	1.0000000
7.6176686	0.0000000	1.9995886
6.2198004	0.0000000	1.7802023
5.5631586	0.0000000	0.
4.8178366	0.	1.0000000
4.3980630	0.0062868	1.0154718
3.9337471	0.1871939	1.0001560
3.6796835	1.4112070	0.9999475
3.4067250	2.8620091	0.9998145
3.1099002	0.4379644	1.0013487
2.7815793	0.0055444	1.0094565
2.4089183	0.0000034	1.0255475
1.9668736	0.	1.0000000
1.6456045	0.	1.0000000
1.3907896	0.	1.0000000
1.2439601	0.	1.0000000
1.0773010	0.	1.0000000
0.8796126	0.	1.0000000
0.6219800	0.	1.0000000
0.0107730	0.	1.0000000

ENERGY GROUP(I),I=11 DENSITY OPTION 2 (N=-2.000)

Y(I)= 3.1099002

Y(I+1)= 2.7815793

X(J),J=2,20	SIGMA(J,I)	R(J,I)
8.7961260	0.	1.0000000
7.6176686	0.	1.0000000
6.2198004	0.0000000	1.8626940
5.5631586	0.0000000	1.7048301
4.8178366	0.	1.0000000
4.3980630	0.0000520	1.0271458
3.9337471	0.0051579	1.0028414
3.6796835	0.1267162	1.0003873
3.4067250	1.3123569	0.9999447
3.1099002	3.0416209	0.9997705
2.7815793	0.4112992	1.0015757
2.4089183	0.0014047	1.0024562
1.9668736	0.0000015	0.9662113
1.6456045	0.	1.0000000
1.3907896	0.	1.0000000
1.2439601	0.	1.0000000
1.0773010	0.	1.0000000
0.8796126	0.	1.0000000
0.6219800	0.	1.0000000
0.0107730	0.	1.0000000

LISTING OF GTM-TYPE OUTPUT (Cont'd.)

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PAGE 12

ENERGY GROUP(I),I=12 DENSITY OPTION 2 (N=-2.700)

Y(I)= 2.7815793 Y(I+1)= 2.4089183

X(J),J=2,20	SIGMA(J,I)	R(J,I)
8.7961260	0.	1.0000000
7.6176686	0.	1.0000000
6.2198004	0.0000000	1.9203044
5.5631586	0.0000000	1.8332647
4.8178366	0.0000000	1.2258197
4.3980630	0.	1.0000000
3.9337471	0.0000155	0.7160647
3.6796835	0.0017476	1.0031911
3.4067250	0.0745302	1.0009371
3.1099002	1.1833209	0.9999743
2.7815793	3.2412726	0.9996839
2.4089183	0.2128084	0.9994259
1.9668736	0.0014189	1.0020737
1.6456045	0.0000087	1.0028925
1.3907896	0.0000000	5.4904972
1.2439601	0.	1.0000000
1.0773010	0.	1.0000000
0.8796126	0.	1.0000000
0.6219800	0.	1.0000000
0.0107730	0.	1.0000000

ENERGY GROUP(I),I=13 DENSITY OPTION 1

Y(I)= 2.4089183 Y(I+1)= 1.9668736

X(J),J=2,20	SIGMA(J,I)	R(J,I)
8.7961260	0.	1.0000000
7.6176686	0.	1.0000000
6.2198004	0.	1.0000000
5.5631586	0.0000000	1.9167583
4.8178366	0.0000000	1.3768700
4.3980630	0.0000000	1.2580882
3.9337471	0.0000000	0.
3.6796835	0.	1.0000000
3.4067250	0.0003751	1.0070356
3.1099002	0.0345782	1.0023963
2.7815793	1.0397532	1.0002322
2.4089183	3.3378843	0.9980790
1.9668736	0.5020780	0.9998319
1.6456045	0.0180722	1.0003668
1.3907896	0.0006715	1.0001354
1.2439601	0.0000488	1.0011769
1.0773010	0.0000035	1.0126132
0.8796126	0.	1.0000000
0.6219800	0.	1.0000000
0.0107730	0.	1.0000000

LISTING OF GTM-TYPE OUTPUT (Cont'd.)

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PAGE 14

ENERGY GROUP(I),I=14 DENSITY OPTION 1

Y(I)= 1.9668736 Y(I+1)= 1.6456045

X(J),J=2,20	SIGMA(J,I)	R(J,I)
8.7961260	0.	1.0000000
7.6176686	0.	1.0000000
6.2198004	0.	1.0000000
5.5631586	0.0000000	1.9645831
4.8178366	0.0000000	1.5507189
4.3980630	0.0000000	1.4577921
3.9337471	0.0000000	1.0683273
3.6796835	0.0000000	1.0481785
3.4067250	0.	1.0000000
3.1099002	0.0000343	1.0097407
2.7815793	0.0102524	1.0078913
2.4089183	1.1101654	1.0048073
1.9668736	3.0776055	0.9996680
1.6456045	0.7654501	0.9999214
1.3907896	0.0899521	1.0000161
1.2439601	0.0127555	1.0001886
1.0773010	0.0009312	1.0012417
0.8796126	0.0000324	1.0067312
0.6219800	0.0000003	0.
0.0107730		

ENERGY GROUP(I),I=15 DENSITY OPTION 1

Y(I)= 1.6456045 Y(I+1)= 1.3907896

X(J),J=2,20	SIGMA(J,I)	R(J,I)
8.7961260	0.	1.0000000
7.6176686	0.	1.0000000
6.2198004	0.	1.0000000
5.5631586	0.	1.0000000
4.8178366	0.0000000	1.6586239
4.3980630	0.0000000	1.5907347
3.9337471	0.0000000	1.1200333
3.6796835	0.0000000	1.0964518
3.4067250	0.0000000	1.0700261
3.1099002	0.	1.0000000
2.7815793	0.0000563	1.0117437
2.4089183	0.0487102	1.0229921
1.9668736	1.0411735	1.0006906
1.6456045	2.7934434	0.9999377
1.3907896	1.2180548	0.9999899
1.2439601	0.3095560	0.9999984
1.0773010	0.0456654	1.0002350
0.8796126	0.0028342	1.0033446
0.6219800	0.0000550	1.1721920
0.0107730		

LISTING OF GTM-TYPE OUTPUT (Cont'd.)

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PAGE 16

ENERGY GROUP(I),I=16 DENSITY OPTION 1

Y(I)= 1.3907896 Y(I+1)= 1.2439601

X(J),J=2,20	SIGMA(J,I)	R(J,I)
8.7961260	0.	1.0000000
7.6176686	0.	1.0000000
6.2198004	0.	1.0000000
5.5631586	0.	1.0000000
4.8178366	0.	1.0000000
4.3980630	0.0000000	1.6804772
3.9337471	0.0000000	1.1703624
3.6796835	0.0000000	1.1464503
3.4067250	0.0000000	1.1180720
3.1099002	0.0000000	1.0843388
2.7815793	0.	1.0000000
2.4089183	0.0011786	1.0582749
1.9668736	0.0807461	1.0033204
1.6456045	0.8541894	1.0000617
1.3907896	1.9821847	1.0000006
1.2439601	0.9756904	0.9999797
1.0773010	0.2198439	1.0000115
0.8796126	0.0230057	1.0012920
0.6219800	0.0006743	1.1534631
0.0107730		

ENERGY GROUP(I),I=17 DENSITY OPTION 1

Y(I)= 1.2439601 Y(I+1)= 1.0773010

X(J),J=2,20	SIGMA(J,I)	R(J,I)
8.7961260	0.	1.0000000
7.6176686	0.	1.0000000
6.2198004	0.	1.0000000
5.5631586	0.	1.0000000
4.8178366	0.	1.0000000
4.3980630	0.0000000	1.7251496
3.9337471	0.0000000	1.2023690
3.6796835	0.0000000	1.1792292
3.4067250	0.0000000	1.1511502
3.1099002	0.0000000	1.1165624
2.7815793	0.	1.0000000
2.4089183	0.0000957	1.0765082
1.9668736	0.0132892	1.0074951
1.6456045	0.2513866	1.0004199
1.3907896	1.1428065	0.9999966
1.2439601	2.1762672	1.0000083
1.0773010	1.0161590	0.9999679
0.8796126	0.1738204	1.0003062
0.6219800	0.0100939	1.0862113
0.0107730		

LISTING OF GTM-TYPE OUTPUT (Cont'd.)

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PAGE 18

ENERGY GROUP(I),I=18 DENSITY OPTION 1

Y(I)= 1.0773010

Y(I+1)= 0.8796126

X(J),J=2,20	SIGMA(J,I)	R(J,I)
8.7961260	0.	1.0000000
7.6176686	0.	1.0000000
6.2198004	0.	1.0000000
5.5631586	0.	1.0000000
4.8178366	0.	1.0000000
4.3980630	0.0000000	1.7658186
3.9337471	0.0000000	1.2407014
3.6796835	0.0000000	1.2191332
3.4067250	0.0000000	1.1924354
3.1099002	0.0000000	1.1585113
2.7815793	0.0000000	1.1178596
2.4089183	0.0000036	1.2580724
1.9668736	0.0010383	1.0157794
1.6456045	0.0394705	1.0015110
1.3907896	0.2723951	1.0000322
1.2439601	1.0957536	0.9999894
1.0773010	2.4463364	1.0000194
0.8796126	1.0727815	0.9999588
0.6219800	0.1292115	1.0370912
0.0107730		

ENERGY GROUP(I),I=19 DENSITY OPTION 1

Y(I)= 0.8796126

Y(I+1)= 0.6219800

X(J),J=2,20	SIGMA(J,I)	R(J,I)
8.7961260	0.	1.0000000
7.6176686	0.	1.0000000
6.2198004	0.	1.0000000
5.5631586	0.	1.0000000
4.8178366	0.	1.0000000
4.3980630	0.	1.0000000
3.9337471	0.0000000	1.2883808
3.6796835	0.0000000	1.2692313
3.4067250	0.0000000	1.2453911
3.1099002	0.0000000	1.2142522
2.7815793	0.0000000	1.1759104
2.4089183	0.	1.0000000
1.9668736	0.0000303	1.0269532
1.6456045	0.0021863	1.0043002
1.3907896	0.0252710	1.0001782
1.2439601	0.1662654	1.0000561
1.0773010	0.9731156	0.9999616
0.8796126	2.8640561	1.0000158
0.6219800	1.3518354	1.0078088
0.0107730		

LISTING OF GTM-TYPE OUTPUT (Cont'd.)

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ENERGY GROUP(I),I=20 DENSITY OPTION 1

	Y(I)= 0.6219800	Y(I+1)= 0.0107730
X(J),J=2,20	SIGMA(J,I)	R(J,I)
8.7961260	0.	1.0000000
7.6176686	0.	1.0000000
6.2198004	0.	1.0000000
5.5631586	0.	1.0000000
4.8178366	0.	1.0000000
4.3980630	0.	1.0000000
3.9337471	0.	1.0000000
3.6796835	0.0000000	1.3372428
3.4067250	0.0000000	1.3184365
3.1099002	0.0000000	1.2934234
2.7815793	0.0000000	1.2625177
2.4089183	0.0000000	1.2646883
1.9668736	0.	1.0000000
1.6456045	0.0000199	1.0114438
1.3907896	0.0003585	1.0005763
1.2439601	0.0045251	1.0004575
1.0773010	0.0554363	1.0001380
0.8796126	0.6604138	0.9998569
0.6219800	3.4887454	0.9946956
0.0107730		

LISTING OF CSX-TYPE OUTPUT

521 RE 145 MICROSCOPIC CROSS SECTIONS

2302

M=43.000 T= 3.000E 02 SIGMA(0)= 4.700 C= 1.33330 MUBAR= 0.0560 H= 4

DENSITY OPTION CODES $1=X^2 \cdot \exp(-CX)$, $2=X^N$

G	DENS. OPT. OR N	ABSORP. SIGMA	NU TIMES SIG.FISS.	TRANSPORT SIGMA	SCATTERING	SIGMA(G,J), FROM GROUP J TO GROUP G	J=G+H,G+H-1,...,G+1,G,G-1,...,G-H+1,G-H	
1	0	0.0000481	0.	4.4500480	0.	0.	0.	4.4163430
2	-2.000	0.0004213	0.	4.4092484	0.	0.	0.0330237	3.6864754 0.0336570
3	-2.000	0.0005116	0.	4.4384076	0. 0.	0.	0.0000005 0.0921125	3.8784544 0.7223517
4	-2.000	0.0005685	0.	4.4388630	0. 0.	0.	0.0000003 0.0956521	3.3723833 0.5250004
5	-2.000	0.0006497	0.	4.4393816	0. 0.0014176	0.0000000 0.0000000	0.0003025 0.2112063	3.5617112 0.9733564
6	-2.000	0.0007072	0.	4.4399573	0. 0.0004425	0.0000025 0.0000000	0.0003409 0.2118516	3.0008933 0.7584995
7	-2.000	0.0007815	0.	4.4405699	0.0000004 0.0228481	0.0001325 0.	0.0140567 0.0000000	0.4334424 3.1768386 1.2080650
8	-2.000	0.0008353	0.	4.4412017	0.0000001 0.0185741	0.0000662 0.0000207	0.0111082 0.0000000	0.4197173 2.4227214 0.9094639
9	-2.000	0.0009282	0.	4.4418501	0. 0.1353483	0.0000252 0.0005112	0.0082528 0.0000000	0.4191240 2.5536964 1.4022672
10	-2.000	0.0010089	0.	4.4426856	0. 0.1767110	0.0000032 0.0059347	0.0052339 0.0000000	0.4134384 2.7017366 1.3321794
11	-2.000	0.0011206	0.	4.4438974	0. 0.1196201	0.0000015 0.0048691	0.0013260 0.0000490	0.3882665 2.8712901 1.2388649
12	-2.700	0.0012821	0.	4.4458274	0.0000000 0.0703565	0.0000082 0.0016497	0.0013394 0.0000146	0.2008912 3.0597613 1.1170549
13	1	0.0015291	0.	4.4498971	0.0000461 0.0326418	0.0006339 0.0003541	0.0170601 0.0000000	0.4739616 3.1509628 0.9815270
14	1	0.0018292	0.	4.4550369	0.0008824 0.0096783	0.0120412 0.0000323	0.0849148 0.0000000	0.7225849 2.9052596 1.0479961
15	1	0.0021635	0.	4.4618336	0.0027061 0.0459824	0.0431082 0.0000531	0.2922208 0.0000000	1.1498437 2.6370106 0.9828678
16	1	0.0024722	0.	4.4691914	0.0006887 0.0762243	0.0217174 0.0011126	0.2075327 0.0000000	0.9210517 1.8711824 0.8063548
17	1	0.0028162	0.	4.4781898	0. 0.2373089	0.0095287 0.0125450	0.1640865 0.0000937	0.9592541 2.0543963 1.0788093
18	1	0.0033456	0.	4.4944174	0. 0.2571410	0. 0.0372601	0.1219756 0.0010087	1.0127057 2.3093415 1.0343914
19	1	0.0043148	0.	4.5326301	0. 0.1569546	0. 0.0238558	0. 0.0020826	1.2761326 2.7036690 0.9186211
20	1	0.0071876	0.	4.7088888	0. 0.0523319	0. 0.0042717	0. 0.0003384	0. 3.2933756 0.6234307

LISTING OF CARD OUTPUT

2302 MICROSCOPIC CROSS SECTIONS

M=43.000 T= 3.000E 02 SIGMA(0)= 4.700 C= 1.33330 MUBAR= 0.0560 H= 4
 0.0000481 0. 4.4500480
 0. 0. 0. 0. 4.4163430
 0.0004213 0. 4.4092484
 0. 0. 0. 0.0330237 3.6864754 0.0336570
 0.0005116 0. 4.4384076
 0. 0. 0.0000005 0.0921125 3.8784544 0.7223517
 0. 0. 4.4388630
 0. 0. 0.0000003 0.0956521 3.3723833 0.5250004
 0. 0. 4.4393816
 0.0006497 0. 4.4393816
 0. 0.0000000 0.0003025 0.2112063 3.5617112 0.9733564
 0.0014176 0.0000000 0.
 0.0007072 0. 4.4399573
 0. 0.0000025 0.0003409 0.2118516 3.0008933 0.7584995
 0.0004425 0. 0.0000000
 0.0007815 0. 4.4405699
 0.0000004 0.0001325 0.0140567 0.4334424 3.1768386 1.2080650
 0.0228481 0. 0.0000000
 0.0008353 0. 4.4412017
 0.0000001 0.0000662 0.0111082 0.4197173 2.4227214 0.9094639
 0.0185741 0.0000207 0.0000000
 0.0009282 0. 4.4418501
 0. 0.0000252 0.0082528 0.4191240 2.5536964 1.4022672
 0.1353483 0.0005112 0.0000000
 0.0010089 0. 4.4426856
 0. 0.0000032 0.0052339 0.4134384 2.7017366 1.3321794
 0.1767110 0.0059347 0.0000000
 0.0011206 0. 4.4438974
 0. 0.0000015 0.0013260 0.3882665 2.8712901 1.2388649
 0.1196201 0.0048691 0.0000490
 0.0012821 0. 4.4458274
 0.0000000 0.0000082 0.0013394 0.2008912 3.0597613 1.1170549
 0.0703565 0.0016497 0.0000146
 0.0015291 0. 4.4498971
 0.0000461 0.0006339 0.0170601 0.4739616 3.1509628 0.9815270
 0.0326418 0.0003541 0.0000000
 0.0018292 0. 4.4550369
 0.0008824 0.0120412 0.0849148 0.7225849 2.9052596 1.0479961
 0.0096783 0.0000323 0.0000000
 0.0021635 0. 4.4618336
 0.0027061 0.0431082 0.2922208 1.1498437 2.6370106 0.9828678
 0.0459824 0.0000531 0.0000000
 0.0024722 0. 4.4691914
 0.0006887 0.0217174 0.2075327 0.9210517 1.8711824 0.8063548
 0.0762243 0.0011126 0.0000000
 0.0028162 0. 4.4781898
 0. 0.0095287 0.1640865 0.9592541 2.0543963 1.0788093
 0.2373089 0.0125450 0.0000937
 0.0033456 0. 4.4944174
 0. 0. 0.1219756 1.0127057 2.3093415 1.0343914
 0.2571410 0.0372601 0.0010087
 0.0043148 0. 4.5326301
 0. 0. 0. 1.2761326 2.7036690 0.9186211
 0.1569546 0.0238558 0.0020826
 0.0071876 0. 4.7088888
 0. 0. 0. 0. 3.2933756 0.6234307
 0.0523319 0.0042717 0.0003384

LISTING OF OUTPUT ON TAPE 2

0.0000481	0.	4.4500480			
0.	0.	0.	0.	4.4163430	
0.0004213	0.	4.4092484			
0.	0.	0.	0.0330237	3.6864754	0.0336570
0.0005116	0.	4.4384076			
0.	0.	0.0000005	0.0921125	3.8784544	0.7223517
0.					
0.0005685	0.	4.4388630			
0.	0.	0.0000003	0.0956521	3.3723833	0.5250004
0.	0.				
0.0006497	0.	4.4393816			
0.	0.0000000	0.0003025	0.2112063	3.5617112	0.9733564
0.0014176	0.0000000	0.			
0.0007072	0.	4.4399573			
0.	0.0000025	0.0003409	0.2118516	3.0008933	0.7584995
0.0004425	0.	0.0000000			
0.0007815	0.	4.4405699			
0.0000004	0.0001325	0.0140567	0.4334424	3.1768386	1.2080650
0.0228481	0.	0.0000000			
0.0008353	0.	4.4412017			
0.0000001	0.0000662	0.0111082	0.4197173	2.4227214	0.9094639
0.0185741	0.0000207	0.0000000			
0.0009282	0.	4.4418501			
0.	0.0000252	0.0082528	0.4191240	2.5536964	1.4022672
0.1353483	0.0005112	0.0000000			
0.0010089	0.	4.4426856			
0.	0.0000032	0.0052339	0.4134384	2.7017366	1.3321794
0.1767110	0.0059347	0.0000000			
0.0011206	0.	4.4438974			
0.	0.0000015	0.0013260	0.3882665	2.8712901	1.2388649
0.1196201	0.0048691	0.0000490			
0.0012821	0.	4.4458274			
0.0000000	0.0000082	0.0013394	0.2008912	3.0597613	1.1170549
0.0703565	0.0016497	0.0000146			
0.0015291	0.	4.4498971			
0.0000461	0.0006339	0.0170601	0.4739616	3.1509628	0.9815270
0.0326418	0.0003541	0.0000000			
0.0018292	0.	4.4550369			
0.0008824	0.0120412	0.0849148	0.7225849	2.9052596	1.0479961
0.0096783	0.0000323	0.0000000			
0.0021635	0.	4.4618336			
0.0027061	0.0431082	0.2922208	1.1498437	2.6370106	0.9828678
0.0459824	0.0000531	0.0000000			
0.0024722	0.	4.4691914			
0.0006887	0.0217174	0.2075327	0.9210517	1.8711824	0.8063548
0.0762243	0.0011126	0.0000000			
0.0028162	0.	4.4781898			
0.	0.0095287	0.1640865	0.9592541	2.0543963	1.0788093
0.2373089	0.0125450	0.0000937			
0.0033456	0.	4.4944174			
0.	0.	0.1219756	1.0127057	2.3093415	1.0343914
0.2571410	0.0372601	0.0010087			
0.0043148	0.	4.5326301			
0.	0.	0.	1.2761326	2.7036690	0.9186211
0.1569546	0.0238558	0.0020826			
0.0071876	0.	4.7088888			
0.	0.	0.	0.	3.2933756	0.6234307
0.0523319	0.0042717	0.0003384			

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