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ORNL-RSIC-31
(Vol. I)

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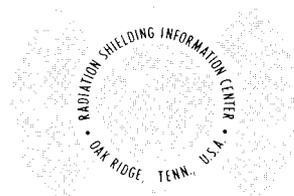
ABSTRACTS OF PERIPHERAL SHIELDING CODE PACKAGES ASSEMBLED BY THE RADIATION SHIELDING INFORMATION CENTER

Betty F. Maskewitz

Note:

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RADIATION SHIELDING INFORMATION CENTER



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PREFACE

This book of abstracts describes computer code packages considered to be useful tools in doing shielding research. In order to distinguish between complex radiation transport programs designated by CCC (Computer Code Collection) numbers, these codes are designated as Peripheral to Shielding Routines (PSR's). In the CCC abstracts (ORNL-RSIC-13), when such a code is useful to a given code package, we have used the name "Auxiliary Routine." Where we cannot tie the stand-alone program to a specific CCC package, we package alone as a PSR-designation.

The main purpose of the abstracts is to give to a potential code user several criteria for deciding whether or not he wishes to use the code. In many cases, there may be significant gaps in the information given. The abstracts will be revised or updated as needed. The reader is urged to bring errors or omissions to our attention.

The abstracts included in the initial distribution were written and edited by members of the RSIC staff. In a few instances, the contributor supplied an abstract which was very useful. Ideally, the abstract should be written by individuals at the contributing installation, leaving only the job of editing to the RSIC staff. A copy of the RSIC format is included to be used as a guide for this purpose.

The loose-leaf notebook covers were chosen for practical reasons. From time to time, new abstracts will be issued, and existing ones will be updated, corrected, modified or deleted. The code contributor, or any other volunteer, is invited to write to RSIC suggesting any desired change. Such changes, if coming from any other source, will be cleared with the contributor of the code.

The RSIC staff is particularly anxious to note our contributors properly and to give credit, whenever merited. It is hoped that any lapse will be called to the attention of the RSIC Coordinator.

When a code is to be placed in the RSIC collection, the contributor is asked to designate an individual familiar with the programming, operation, and data preparation to be available to answer questions. If the code is very complex, or if several codes are being placed in the

collection at a given time, RSIC requests that a briefing be given to members of the staff. This is ideally in the form of an informal workshop held at the contributing installation.

When codes are received by RSIC, they are put into the RSIC routine checking process. When fully processed, the codes are packaged, assigned a package number and an abstract is written. The distribution of an abstract indicates that in the code package described the codes are operable, the sample problems having been run by the RSIC staff.

The RSIC collection may include computer codes which, for various reasons, have restricted distribution. The restriction will be explained in item (12) of the RSIC abstract and the code package will be handled in whatever manner required because of the restriction.

With the encouragement of the USAEC, RSIC cooperates closely with the Argonne Code Center and the NEA Computer Programme Library (NEA-CPL) serving other OECD countries from Ispra, Italy. The European shielding scientist will find it more expedient to make his request for a code to NEA-CPL when it is available there. This cooperative agreement existing between the code centers was brought about in an effort to serve the scientific community more efficiently. It does not eliminate the need for open lines of communication between the individual shielding scientist and the information center. The overall RSIC program requires the stocking of the information store as well as retrieving from it. Members of the RSIC staff are always available for consultation in connection with the shielding code packages.

The collection and dissemination of the information contained in this book of abstracts represent the work of many people. We are grateful to the code contributors, without whom there would be no computer code collection; to the report authors, who tried very hard to put into words all the information necessary to the understanding and successful use of a complicated tool; to the USAEC, to NASA, and to DNA, for their encouragement and their financial support in the RSIC programs.

It is a pleasure to acknowledge the contributions of other members of the RSIC staff. The writing of the code package abstracts is a

continuing effort, and at some point each staff member makes a contribution. Hemma E. Comolander, Henrietta R. Hendrickson, and Juanita B. Wright of the RSIC Codes Section staff verify the accuracy and completeness of that part of the abstract which describes the hardware, the software, and the contents of the code package. R. W. Roussin, D. K. Trubey, and W. Zobel advise on the nature of the problem solved and the method of solution. We are especially indebted to Vivian Z. Jacobs for coordinating this publishing effort and to Virginia Glidewell who prepares the camera-ready manuscript.

Betty F. Maskewitz
RSIC Coordinator



RSIC ABSTRACT FORMAT - SHIELDING COMPUTER CODE PACKAGE

Pagination

In upper right corner give the number assigned to the package and the page number. Example: the four pages of code package PSR-1 would be numbered 1.1, 1.2, 1.3, and 1.4.

Heading

RSIC CODE PACKAGE PSR-xx, where xx is the number assigned by the Center when the code is packaged and ready for distribution.

Descriptive Headings and Contents: Items 1 through 13

1. NAME AND TITLE OF CODE

- a. Name given to main code.
- b. Give a descriptive title. This title should tell something of the nature of the code: calculational method, geometry, or any feature that distinguishes this shielding code from another.

AUXILIARY ROUTINES

Name and descriptive title of auxiliary codes used in preparing data or in processing output.

Give any useful background information or history of the primary code or the auxiliary codes. Such information should include the name of a code that might have been superseded or extended into this version, establish credit for original work, explain a code name that has been changed, or give a specific meaning if there is one to the name selected.

2. CONTRIBUTORS

- a. Give name and location of installation where code was developed.
- b. If more than one installation is involved in the code development, give name and location of installation with whom credit is to be shared.

- c. If an additional contribution is made to the code package by an installation other than that listed in (a) or (b), give name and location of installation and itemize the addition.

3. CODING LANGUAGE AND COMPUTER

Make a brief statement, as "FORTRAN; IBM 360."

4. NATURE OF PROBLEM SOLVED

Give a brief description of the physical problem, including any basic physics approximations contained in the problem formulation.

5. METHOD OF SOLUTION

Make a short summary of the mathematical and numerical techniques used in the calculation.

6. RESTRICTIONS OR LIMITATIONS

Include restrictions suggested by storage allocation and implied argument range restrictions due to approximations, etc.

7. TYPICAL RUNNING TIME

Give enough detail to enable the potential user to estimate the running time for a given choice of program parameters.

8. COMPUTER HARDWARE REQUIREMENTS

- a. Designed for what machine configuration? Size?
- b. Upon what other machines is it operable?
- c. What auxiliary storage (such as tapes, discs, etc.) is needed?
- d. What is the channel configuration?
- e. What auxiliary equipment (such as punch, printer, plotter) is needed?
- f. Is clock sampled?

9. COMPUTER SOFTWARE REQUIREMENTS

- a. Under Programmer Control

If routines included in the package have been coded in mixed languages, indicate extent of each. If a certain class of routines

is in the assembly rather than compiler language (input-output, random number generator, etc.), this should be stated.

b. Operating System or Monitor

With the operating system or monitor and associated sub-routine library distributed by the computer manufacturer defined as "standard," note all deviations from this standard pertinent to the operation of the program. The following questions should be answered.

- (1) Monitor or other system?
- (2) Is an interpreter or manager or executive routine required?
- (3) Are nonstandard library routines used?
- (4) Are there variations in channel assignments? Is a special I-O table required?

10. REFERENCES

List (by report author, title, number, and date) documentation available for describing the code and its utilization.

11. CONTENTS OF CODE PACKAGE

Name items in the package, as

- a. documentation: listed references and any additional available material,
- b. codes, including main program and any auxiliary programs, relating in what form they are being distributed,
- c. software being distributed with the code package,
- d. sample problem input and output,
- e. libraries available for use with the codes.

12. HOW TO OBTAIN PACKAGE

- a. Where inquiries may be addressed.
- b. If transmitted on tape, how many tapes are required?
- c. Where are tapes to be sent?

13. DATE OF ABSTRACT

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LIST OF RSIC
PERIPHERAL SHIELDING ROUTINES,
TITLES, CONTRIBUTORS, AND
PRIMARY REFERENCES



- PSR-1: MAX-XTREME
GENERALIZED SEVERAL-CONSTRAINT LAGRANGE MULTIPLIER, contributed by Neutron Physics Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee.
FORTRAN 63; CDC 1604
(References: ORNL-3742, ORNL-3846)
- PSR-2: CHAD
DIFFERENTIAL ANGULAR DATA TRANSFORMATION ROUTINE, contributed by Atomics International, Canoga Park, California.
FORTRAN IV, MAP; IBM 7094
(Reference: NAA-SR-11231)
- PSR-3: ELIESE
ANALYSES OF ELASTIC AND INELASTIC SCATTERING CROSS SECTIONS, contributed by the Japanese Nuclear Data Committee, Japan Atomic Energy Research Institute.
FORTRAN IV; IBM 7090
(Reference: JAERI 1096)
- PSR-4: HEITLER
CROSS SECTION GENERATOR, contributed by UKAEA Atomic Energy Research Establishment, Harwell, England.
FORTRAN IV; IBM 7090 and 7030
(Reference: AERE-M-1956)
- PSR-5: AGN-SIGMA
GENERATOR OF THE LEGENDRE COMPONENTS OF THE MULTIGROUP MATRICES, contributed by Aerojet-General Nucleonics, San Ramon, California.
FORTRAN II; IBM 7090
(Reference: AN-1447)
- PSR-6: EDISN
ENERGY DISTRIBUTION OF INELASTICALLY SCATTERED NEUTRON CALCULATIONS, contributed by Teledyne Brown Engineering Company, Huntsville, Alabama.
FORTRAN IV; IBM 360 and 1130
(Reference: RL-SSL-200)
- PSR-7: MUG
MULTIGROUP PHOTON CROSS SECTION GENERATOR, contributed by Computing Technology Center, Union Carbide Nuclear Division, Oak Ridge, Tennessee.
FORTRAN IV; IBM 360
(Reference: CTC-17)

PSR-8: AUTOJOM-JOMREAD

COMPUTER PROGRAMS TO GENERATE OR CHECK COEFFICIENTS FOR QUADRATIC EQUATIONS DESCRIBING 3D GEOMETRIES, contributed by Research and Technology Division, Air Force Weapons Laboratory, Kirtland Air Force Base, New Mexico.
FORTRAN IV; CDC 6600
(References: AFWL-TR-67-60, AFWL-TR-67-36)

PSR-9: CSP

NEUTRON CROSS SECTION AVERAGING CODE, contributed by Neutron Physics Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee.
FORTRAN IV; IBM 360
(Reference: ORNL-4130)

PSR-10: EVAP

CALCULATION OF PARTICLE EVAPORATION FROM EXCITED COMPOUND NUCLEI, contributed by Neutron Physics Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee.
FORTRAN IV; IBM 360
(References: ORNL-TM-3119, ORNL-4379)

PSR-11: POPOP4

CONVERTER OF GAMMA-RAY SPECTRA TO SECONDARY GAMMA-RAY PRODUCTION CROSS SECTIONS, contributed by Computing Technology Center and Oak Ridge National Laboratory, Union Carbide Nuclear Division, Oak Ridge, Tennessee.
FORTRAN IV; IBM 360
(References: CTC-12, CTC-20, CTC-42)

PSR-12: GGC

MULTIGROUP CROSS SECTION CODE SYSTEM FOR USE IN DIFFUSION AND TRANSPORT CODES, contributed by Gulf General Atomic, San Diego, California.
FORTRAN IV; UNIVAC 1108 and IBM 360
(References: GA-7156, GA-7157, GA-7158, GA-9021)

PSR-13: SUPERTO G III

DATA GENERATOR - FINE GROUP CONSTANTS AND P_n SCATTERING MATRICES FROM ENDF/B, contributed by Oak Ridge National Laboratory, Oak Ridge, Tennessee.
FORTRAN IV; CDC 6400
(Reference: ORNL-TM-2679)

- PSR-14: 05S
RESPONSE FUNCTION GENERATOR - A MODIFIED O5R MONTE CARLO CODE FOR CALCULATING PULSE HEIGHT DISTRIBUTIONS DUE TO MONOENERGETIC NEUTRONS INCIDENT ON ORGANIC SCINTILLATORS, contributed by Computing Technology Center and Oak Ridge National Laboratory, Union Carbide Nuclear Division, Oak Ridge, Tennessee, and NASA Lewis Research Center, Cleveland, Ohio.
PSR-14A: FORTRAN 63 and CODAP; IBM 360
PSR-14B: FORTRAN IV; IBM 360
PSR-14C: FORTRAN IV and MAP; IBM 7090
(Reference: ORNL-4160)
- PSR-15: UKE
CROSS SECTION FORMAT TRANSLATOR - UKAEA-NDL TO ENDF/B, contributed by Computing Technology Center and Oak Ridge National Laboratory, Union Carbide Nuclear Division, Oak Ridge, Tennessee.
FORTRAN IV; IBM 360
(Reference: ORNL-TM-2880)
- PSR-16: RANGE
RANGE-ENERGY RELATION CODE - CHARGED PARTICLES IN CHEMICAL ELEMENTS, contributed by Virginia Polytechnic Institute, Blacksburg, Virginia, and Lawrence Radiation Laboratory, Berkeley, California.
FORTRAN IV; IBM 7090
(Reference:
- PSR-17: FERDOR-COOLC
SPECTRA UNFOLDING CODES, contributed by Neutron Physics Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee, and Intelcom Radiation Technology, San Diego, California.
FORTRAN IV; IBM 7090, UNIVAC 1108, and IBM 360
(References: TPR-0145, ORNL-TM-2225, Nucl. Sci. Eng. 27, 299-307, Communications of the ACM, Vol. 9, No. 5, 381-385, N.I.M. 52, 181-192, TID-7594, 147-158, ORNL-3360, GA-9751, Vol. II, GA-9882, ORNL-3743, N.I.M. 85, 69-76)
- PSR-18: PLOTFB I
ENDF/B DATA PLOTTING CODE, contributed by National Neutron Cross Section Center, Brookhaven National Laboratory, Upton, New York and Mathematics Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee.
FORTRAN IV; IBM 360
(References: ORNL-4800, p. 51 and BNL-13582)
- PSR-19: AGN-GAM
FLUX SPECTRA AND MULTIGROUP CONSTANT GENERATOR, contributed by Aerojet-General Nucleonics, San Ramon, California.
FORTRAN II and FAP; IBM 7090
(Reference: AGN TM-407)

PSR-20: LAPHANO

P₀ MULTIGROUP PHOTON PRODUCTION MATRIX AND SOURCE VECTOR CODE FOR ENDF DATA, contributed by Theoretical Division, Los Alamos Scientific Laboratory, Los Alamos, New Mexico.
FORTRAN IV; CDC 6600, CDC 7600, IBM 360 and UNIVAC 1108
(References: LA-4337, LA-4750-MS, BNL-13582, LA-4739)

PSR-21: PHOX

CODE TO CHECK SYNTAX AND PHYSICAL REALISM OF PHOTON PRODUCTION DATA, contributed by Los Alamos Scientific Laboratory, Los Alamos, New Mexico.
FORTRAN IV; CDC 6600, IBM 360, B 5500
(References: LA-4506-MS, DASA 2379)

PSR-22: RICE

CALCULATION OF PRIMARY RECOIL ATOM SPECTRA FROM ENDF/B DATA, contributed by Reactor Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee.
FORTRAN IV; IBM 360
(Reference: ORNL-TM-2706)

PSR-23: SPECTER

CALCULATION OF ENERGY DISTRIBUTION OF NUCLEAR REACTION PRODUCTS, contributed by Teledyne Brown Engineering Company, Huntsville, Alabama.
FORTRAN IV; IBM 360 and 7094
(Reference: SMSD-SSL-1100)

PSR-24: IER

INTEGRAL EVALUATION ROUTINES, contributed by University of Tulsa and Warren Research Foundation, Tulsa, Oklahoma, and Oak Ridge National Laboratory, Oak Ridge, Tennessee.
FORTRAN; IBM 360
(References: Informal Notes, MR 34 #8606, pp. 228 and 1000)

PSR-25: DUCAL

NEUTRON-CAPTURE GAMMA-RAY CASCADE MODEL, contributed by Neutron Physics Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee.
FORTRAN IV and Assembler Language; IBM 360
(References: Nucl. Sci. Eng. 32, 62-75 [1968], unpublished Memo)

PSR-26: NEVEMOR

MULTIGROUP-MULTIREGION CALCULATION OF FLUX SPECTRA AND ENERGY DEPOSITION FOR FAST NEUTRONS, contributed by AECL Whiteshell Nuclear Research Establishment, Pinewa, Manitoba, Canada.
FORTRAN IV; IBM 360
(Reference: AECL-3433)

- PSR-27: GIRD
SHUFFLE-DWELL GAMMA-RAY IRRADIATOR DESIGN CODE, contributed by
Brookhaven National Laboratory, Upton, New York.
FORTRAN IV; CDC 6600
(Reference: BNL 50148)
- PSR-28: AMUSE
GAMMA-RAY SPECTRA UNFOLDING CODE, contributed by Los Alamos
Scientific Laboratory, Los Alamos, New Mexico.
FORTRAN 63; CDC 6600
(Reference: LA-4030)
- PSR-29: SCANS
SPECTRA CALCULATION FROM ACTIVATED NUCLIDE SETS, contributed by
Idaho Nuclear Corporation, Idaho Falls, Idaho.
FORTRAN IV; IBM 360
(Reference: IN-1446)
- PSR-30: VIXEN
A CODE TO CHECK PHYSICAL CONSISTENCY OF PHOTON-PRODUCTION DATA IN
REVISED ENDF FORMAT, contributed by Los Alamos Scientific Labora-
tory, Los Alamos, New Mexico.
FORTRAN IV; CDC 6600 and 7600, IBM 360
(Reference: LA-4739)
- PSR-31: SWIFT
MONTE CARLO NEUTRON SPECTRA UNFOLDING CODE, contributed by USAEC
Health and Safety Laboratory, New York, New York.
FORTRAN IV; CDC 6600
(Reference: HASL-244, Nucl. Instr. Meth. 91, 573-577 [1971])
- PSR-32: CUPED
SCINTILLATION SPECTROMETER POLYENERGETIC GAMMA PHOTON EXPERIMENTAL
DISTRIBUTIONS UNFOLDING CODE, contributed by NUS Corporation,
Röckville, Maryland.
FORTRAN IV; IBM 360
(Reference: NUS-557)
- PSR-33: GAROL
CALCULATION OF RESONANCE NEUTRON ABSORPTION IN TWO-REGION PROBLEMS,
contributed by Gulf General Atomic, San Diego, California.
FORTRAN IV; IBM 7090, 7094
(Reference: GA-6637)

PSR-34: EVP XIX

ANALYTICAL MODEL OF THE EVAPORATION STEP IN SPALLATION REACTIONS, contributed by 'The Swedish Research Councils' Laboratory, Studsvik, Nyköping, Sweden, and the CERN Computer Science Library, Geneva, Switzerland.

FORTTRAN IV; CDC 6600 and IBM 360

(Reference: Nucl. Phys. A126, 401-427 [1969])

PSR-35: EDITOR

ENDF FORMAT DATA PROCESSOR, contributed by Oak Ridge National Laboratory, Oak Ridge, Tennessee.

FORTTRAN IV; IBM 360 and CDC 6600

(Reference: ORNL-TM-3266)

PSR-36: CONVERT

AN IBM-TO-CDC PROGRAM CONVERSION CODE, contributed by Los Alamos Scientific Laboratory and Aerospace Research Applications Center, Bloomington, Indiana.

FORTTRAN IV; CDC 6600

(Reference: LA-4555)

PSR-37: SASSI

CALCULATION OF NUCLEON SCATTERING FROM A SPHERICAL OPTICAL POTENTIAL, contributed by CNEN Centro di Calcolo, Bologna, Italy.

FORTTRAN IV; IBM 7094 and IBM 360

(Reference: CNEN-CEC[68]-18)

PSR-38: PHROG

GENERATOR OF FAST NEUTRON SPECTRA AND AVERAGE MULTIGROUP CONSTANTS, contributed by Idaho Nuclear Corporation, Idaho Falls, Idaho.

FORTTRAN IV; IBM 360

(Reference: IN-1435)

PSR-39: DEM

MONTE CARLO CALCULATION OF PHOTOPeAK EFFICIENCY, PHOTOFRACTION AND RESPONSE FUNCTION, AND TOTAL DETECTION EFFICIENCY FOR A THICK DISK SOURCE, contributed by Department of Nuclear Engineering, Kyoto University, Japan.

FORTTRAN IV; FACOM 230-60

(Reference: Nucl. Instr. Meth. 68, 163-168 [1970])

PSR-40: GENRD

FREE FORMAT CARD INPUT PROCESSOR, contributed by Los Alamos Scientific Laboratory, Los Alamos, New Mexico

FORTTRAN IV; CDC 6600, IBM 360 and GE 635

(Reference: LA-4793)

- PSR-41: MAZE
SPECTRA UNFOLDING CODE, contributed by Science Applications, Inc.,
La Jolla, California.
FORTRAN IV; UNIVAC 1108
(Reference: SAI-72-574-LJ)
- PSR-42: DUFOLD
DERIVATIVE UNFOLDING CODE - DETERMINATION OF NEUTRON SPECTRA FROM
NE-213 PULSE HEIGHT DATA, contributed by Kansas State University,
Manhattan, Kansas.
FORTRAN IV; IBM 360
(Reference: COO-2049-7)
- PSR-43: FLUSH
SPECTRAL UNFOLDING CODE - STEPWISE REGRESSION OF SYSTEM RESPONSE
FUNCTIONS, contributed by EG&G, Los Alamos, New Mexico.
FORTRAN IV; CDC 6600
(Reference: EGG-1183-5000)
- PSR-44: BRMSTK
CSEWG INTEGRAL DATA TESTING SHIELDING EXPERIMENT CODE PACKAGE,
contributed by Neutron Physics Division, Oak Ridge National Labora-
tory, Oak Ridge, Tennessee, and Los Alamos Scientific Laboratory,
Los Alamos, New Mexico.
FORTRAN IV; IBM 360 and CDC 6600
(References: ORNL-TM-3867, -3868, -3869, -3870, -3871, -3957,
and -3974)
- PSR-45: GAUSS V
ANALYSIS CODE FOR GAMMA-RAY SPECTRA FROM GE(Li) SPECTROMETERS,
contributed by Aerojet Nuclear Company, Idaho Falls, Idaho.
FORTRAN IV; IBM 360
(Reference: ANCR-1043)
- PSR-46: XLACS
PROGRAM TO PRODUCE WEIGHTED MULTIGROUP NEUTRON CROSS SECTIONS
FROM ENDF/B FOR USE IN XSDRN, contributed by Oak Ridge National
Laboratory, Oak Ridge, Tennessee.
FORTRAN IV; IBM 360
(Reference: ORNL-TM-3646 [AMPX-2])
- PSR-47: ENLOSS
CALCULATION OF ENERGY LOSS OF CHARGED PARTICLES, contributed by
Crocker Nuclear Laboratory, University of California, Davis,
California.
FORTRAN IV; CDC 6600
(Reference: AERE R-7072)

PSR-48: ALC 1

CROSS SECTION LIBRARY MANAGEMENT ROUTINE FOR ANISN (CCC-82), DOT (CCC-89) AND DISCRETE ORDINATES CODES ANISN, DOT, AND DTF SERIES, contributed by Oak Ridge National Laboratory, Oak Ridge, Tennessee. FORTRAN IV; IBM 360
(Reference: ORNL-TM-4015)

PSR-49: DINT

MULTIGROUP COHERENT-INCOHERENT CROSS SECTION DATA GENERATOR FOR PHOTON TRANSPORT CALCULATIONS, contributed by Sandia Laboratories, Albuquerque, New Mexico. FORTRAN IV; CDC 6600
(Reference: SC-RR-72-0684)

RSIC CODE PACKAGE PSR-1

1. NAME AND TITLE OF CODE

MAX-XTREME: Generalized Several-Constraint LaGrange Multiplier.

2. CONTRIBUTOR

Neutron Physics Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

3. CODING LANGUAGE AND COMPUTER

FORTRAN 63; CDC 1604.

4. NATURE OF PROBLEM SOLVED

MAX was written to solve the one-constraint LaGrange multiplier problem; XTREME is MAX expanded to solve the problem with several constraints.

The method of LaGrange multipliers seeks to find a stationary value for some function $W = W(\alpha_1, \alpha_2, \dots, \alpha_J)$, subject to constraints which take the form of equality conditions.

5. METHOD OF SOLUTION

Numerical methods are used to solve the LaGrange multiplier problem. XTREME deals with up to 25 independent variables. It finds an extreme value for an object function subject to a number of equality constraints, at most one less than the number of independent variables. All second derivatives of the object function must exist everywhere in the domain of computation.

6. RESTRICTIONS OR LIMITATIONS

There are no unusual restrictions or limitations.

7. TYPICAL RUNNING TIME

No study has been made by RSIC as to typical running time.

8. COMPUTER HARDWARE REQUIREMENTS

The code was designed for the CDC 1604 computer.

9. COMPUTER SOFTWARE REQUIREMENTS

Written in FORTRAN 63 to run on the COOP Monitor System.

10. REFERENCES

F. H. S. Clark and F. B. K. Kam, "A Generalized One-Constraint LaGrange Multiplier Numerical Formulation," ORNL-3742 (March 1965).

Francis B. K. Kam and Francis H. S. Clark, "Numerical Solution of the LaGrange Multiplier Problem with Several Constraints," ORNL-3846 (December 1965).

11. CONTENTS OF CODE PACKAGE

The package contains the following items:

- a. the referenced documents,
- b. a reel of magnetic tape on which is written in 1 file: the BCD source card decks.

12. HOW TO OBTAIN PACKAGE

Inquiries or requests for the code package may be mailed to

CODES COORDINATOR
Radiation Shielding Information Center
Oak Ridge National Laboratory
P. O. Box X
Oak Ridge, Tennessee 37830

or telephoned to

Area Code 615; 483-8611, extension 3-6944, or to
FTS xx-615-483-6944.

Persons requesting the code package should send a reel of magnetic tape to the above address.

13. DATE OF ABSTRACT

November 1972.

RSIC CODE PACKAGE PSR-2

1. NAME AND TITLE OF CODE

CHAD: Differential Angular Data Transformation Routine.

CHAD is also packaged in the Argonne Code Center, Abstract 215.

2. CONTRIBUTOR

Atomics International, Canoga Park, California.

3. CODING LANGUAGE AND COMPUTER

FORTRAN IV and MAP; IBM 7094.

4. NATURE OF PROBLEM SOLVED

CHAD is designed to facilitate analysis and handling of differential neutron scattering data. It produces Legendre scattering coefficients from angular distribution data tabulated in many different formats. It can transform angular distribution data into Legendre scattering coefficients in either the laboratory or the center-of-mass frame of reference. It calculates the average cosine of the scattering angle in the laboratory system and the average logarithmic energy decrement per elastic collision.

5. METHOD OF SOLUTION

A recursive method is used for calculating the transformation matrices which convert Legendre coefficients from one frame of reference to another. The Legendre scattering coefficients, the average cosine of the scattering angle in the laboratory system, and the average logarithmic energy decrement per elastic collision are obtained analytically from differential scattering at a specified neutron energy, assuming that the differential cross section is a linear function between points. These input data may be either the laboratory or the center-of-mass system.

6. RESTRICTIONS OR LIMITATIONS

Atomic mass greater than 1; no more than 30 Legendre coefficients; and no more than 100 values of the cosine of the scattering angle.

7. TYPICAL RUNNING TIME

No study of typical running time has been made by RSIC.

8. COMPUTER HARDWARE REQUIREMENTS

The code was designed for and is operable on the IBM 7094.

9. COMPUTER SOFTWARE REQUIREMENTS

The packaged code was run on the IBM 7090 IBSYS Operating System. The plotting options were not used.

10. REFERENCE

R. F. Berland, "CHAD - Code to Handle Angular Data," NAA-SR-11231 (December 1965).

11. CONTENTS OF CODE PACKAGE

The package contains the following items:

- a. the referenced document,
- b. a reel of magnetic tape on which is written in 5 files: the BCD source card decks and BCD input and output for a sample problem.

12. HOW TO OBTAIN PACKAGE

Inquiries or requests for the code package may be mailed to

CODES COORDINATOR
Radiation Shielding Information Center
Oak Ridge National Laboratory
P. O. Box X
Oak Ridge, Tennessee 37830

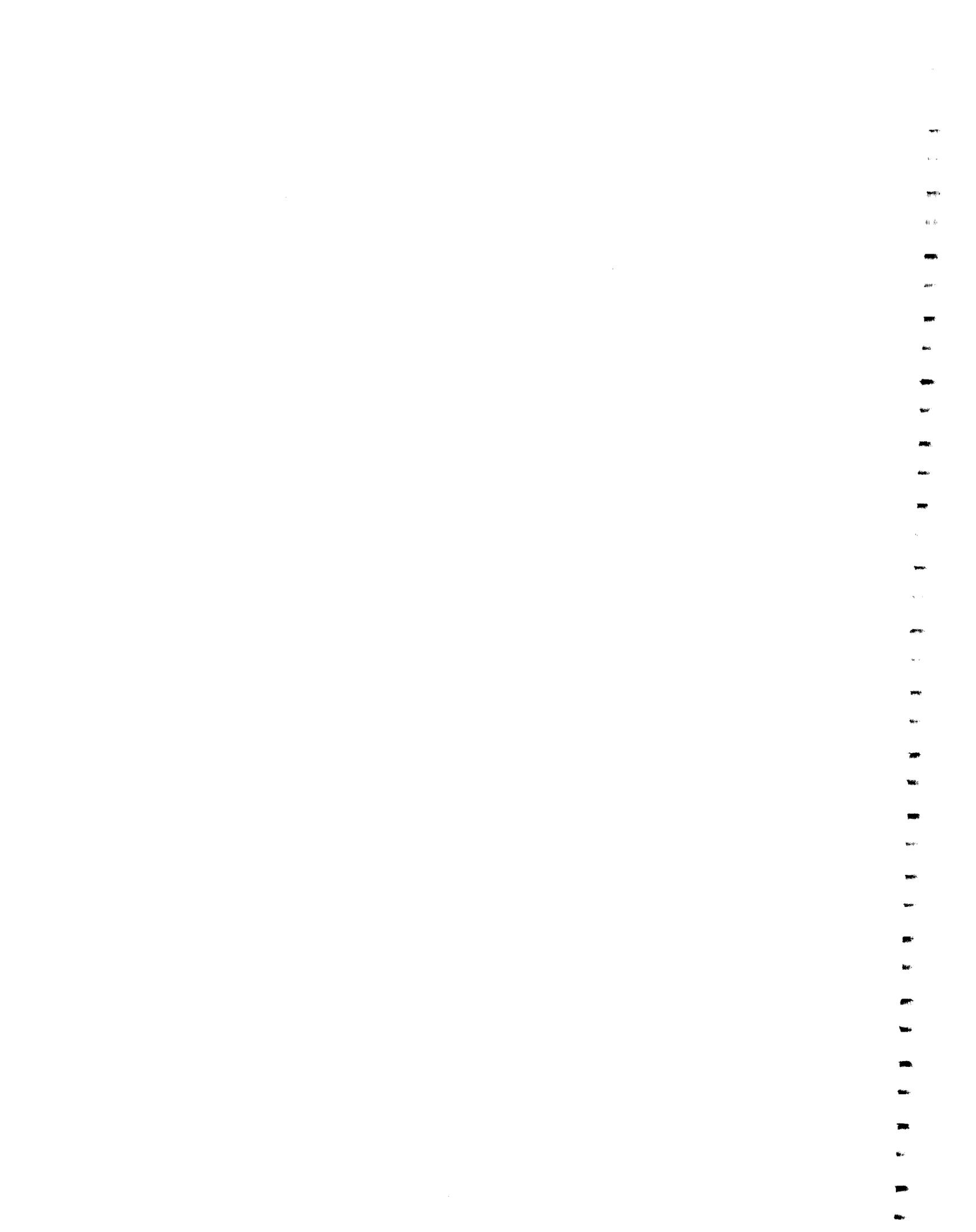
or telephoned to

Area Code 615; 483-8611, extension 3-6944, or to
FTS xx-615-483-6944.

Persons requesting the code package should send a reel of magnetic
tape to the above address.

13. DATE OF ABSTRACT

November 1972.



RSIC CODE PACKAGE PSR-3

1. NAME AND TITLE OF CODE

ELIESE: Analyses of Elastic and Inelastic Scattering Cross Sections.

The code is packaged in the NEA Computer Program Library as ELIESE 1, Abstract 123.

2. CONTRIBUTOR

Japanese Nuclear Data Committee, Japan Atomic Energy Research Institute through the NEA Computer Programme Library, Ispra (Varese), Italy.

3. CODING LANGUAGE AND COMPUTER

FORTRAN II; IBM 7090.

4. NATURE OF PROBLEM SOLVED

ELIESE is designed to calculate any kind of cross sections for elastic and inelastic scatterings of neutrons, protons, and alpha particles.

5. METHOD OF SOLUTION

The optical model is used for elastic scattering and the Hauser-Feshbach method of treating the compound nuclear process is used for nonelastic scattering.

6. RESTRICTIONS OR LIMITATIONS

The maximum number of energy levels is 30.

7. TYPICAL RUNNING TIME

No study of typical running time has been made by RSIC.

8. COMPUTER HARDWARE REQUIREMENTS

The code was designed for and is operable on the IBM 7090 computer.

9. COMPUTER SOFTWARE REQUIREMENTS

The FORTRAN II Monitor System may be used.

10. REFERENCE

Japanese Nuclear Data Committee, "Program ELIESE-1, FORTRAN II Program for Analyses of Elastic and Inelastic Scattering Cross Sections," JAERI 1096 (November 1965).

11. CONTENTS OF CODE PACKAGE

The package contains the following items:

- a. the referenced document,
- b. a reel of magnetic tape on which is written in 4 files: the source card decks, input for a sample problem and BCD output from the problem.

12. HOW TO OBTAIN PACKAGE

Inquiries or requests for the code package may be mailed to

CODES COORDINATOR
Radiation Shielding Information Center
Oak Ridge National Laboratory
Post Office Box X
Oak Ridge, Tennessee 37830

or telephoned to

Area Code 615; 483-8611, extension 3-6944, or to
FTS xx-615-483-6944.

Persons requesting the code package should send a reel of magnetic tape to the above address.

13. DATE OF ABSTRACT

November 1972.

RSIC CODE PACKAGE PSR-4

1. NAME AND TITLE OF CODE

HEITLER: Cross Section Generator.

2. CONTRIBUTOR

UKAEA Atomic Energy Research Establishment, Harwell, England,
through the NEA Computer Programme Library, Ispra (Varese), Italy.

3. CODING LANGUAGE AND COMPUTER

FORTRAN IV; IBM 7090 and 7030.

4. NATURE OF PROBLEM SOLVED

HEITLER computes the Compton, photoelectric, pair-production, and total microscopic cross sections for any element in the range of atomic numbers from 1 to 94 inclusive, for any photon energy in the range of 10 keV to 20 MeV inclusive. It also computes either the Compton absorption cross section or the Klein-Nishina differential scattering cross section as desired.

5. METHOD OF SOLUTION

The Compton cross sections are computed analytically. The photoelectric and pair-production cross sections are obtained by suitable interpolation in atomic number and energy using a compilation of 25 sets of measured cross sections.

6. RESTRICTIONS OR LIMITATIONS

There are none noted.

7. TYPICAL RUNNING TIME

No study of typical running time has been made by RSIC.

8. COMPUTER HARDWARE REQUIREMENTS

The code was designed for the IBM 7030 and is also operable on the IBM 7090 computer.

9. COMPUTER SOFTWARE REQUIREMENTS

HEITLER was written in basic FORTRAN in order to minimize conversion problems. It has been compiled on the IBM 7030 S2 System and on the IBM 7090 IBSYS Operating System.

10. REFERENCE

A. Foderaro, "Subroutine HEITLER," AERE-M 1956 (September 1967).

11. CONTENTS OF CODE PACKAGE

The package contains the following items:

- a. the referenced document,
- b. a reel of magnetic tape on which is written in 1 file: the BCD source card decks and BCD input for a sample problem.

12. HOW TO OBTAIN PACKAGE

Inquiries or requests for the code package may be mailed to

CODES COORDINATOR
Radiation Shielding Information Center
Oak Ridge National Laboratory
Post Office Box X
Oak Ridge, Tennessee 37830

or telephoned to

Area Code 615; 483-8611, extension 3-6944, or to
FTS xx-615-483-6944.

Persons requesting the code package should send a reel of magnetic tape to the above address.

13. DATE OF ABSTRACT

November 1972.

RSIC CODE PACKAGE PSR-5

1. NAME AND TITLE OF CODE

AGN-SIGMA: Generator of the Legendre Components of the Multi-group Transfer Matrices.

The code is also carried in the Argonne Code Center, Abstract 243.

2. CONTRIBUTOR

Aerojet-General Nucleonics, San Ramon, California.

3. CODING LANGUAGE AND COMPUTER

FORTRAN II; IBM 7090.

4. NATURE OF PROBLEM SOLVED

The AGN-SIGMA code is used to calculate the Legendre components of the multigroup transfer matrices, $\sigma_{\ell}^{g \rightarrow g+n}$, up through the fifth degree for fast neutrons. Reactions considered are elastic scattering, inelastic scattering (level excitation and the evaporation model) and the (n,2n) reaction (five decay modes). The code is also used to calculate group averaged cross sections as well as to manipulate, e.g., add, multiply, etc., the output matrices. The neutron spectrum may be a combination of fission and 1/E or arbitrary input data.

5. METHOD OF SOLUTION

All integrations are performed by an iterative Simpson's Rule. The transfer cross sections for all values of ℓ are calculated concurrently by series-parallel passing through the integration scheme.

6. RESTRICTIONS OR LIMITATIONS

The calculation is limited to 100 groups and 50 groups down-scatter.

7. TYPICAL RUNNING TIME

No study of typical running time has been made by RSIC.

8. COMPUTER HARDWARE REQUIREMENTS

The code was designed for and is operable on the IBM 7090 and 7094. From 4 to 11 tape units may be used, dependent on the problem being run.

9. COMPUTER SOFTWARE REQUIREMENTS

The standard IBM FORTRAN II Monitor System may be used.

10. REFERENCE

S. T. Perkins, D. W. Thompson, and P. J. DuBois, "User's Manual for AGN-SIGMA: A Code to Calculate the Legendre Components of the Multigroup Transfer Matrices and the Group Cross Sections," AN-1447 (October 1965).

11. CONTENTS OF CODE PACKAGE

The package contains the following items:

- a. the referenced document,
- b. a reel of magnetic tape on which is written in 4 files: the BCD source card decks, BCD input for a sample problem, and the output listing from the problem.

12. HOW TO OBTAIN PACKAGE

Inquiries or requests for the code package may be mailed to

CODES COORDINATOR
Radiation Shielding Information Center
Oak Ridge National Laboratory
P. O. Box X
Oak Ridge, Tennessee 37830

or telephoned to

Area Code 615; 483-8611, extension 3-6944, or to
FTS xx-615-483-6944.

Persons requesting the code package should send a reel of magnetic tape to the above address.

13. DATE OF ABSTRACT

November 1972.



RSIC CODE PACKAGE PSR-6

1. NAME AND TITLE OF CODE

EDISN: Energy Distribution of Inelastically Scattered Neutron Calculations.

2. CONTRIBUTOR

Teledyne Brown Engineering Company, Huntsville, Alabama.

3. CODING LANGUAGE AND COMPUTER

FORTRAN IV; IBM 360 and 1130.

4. NATURE OF PROBLEM SOLVED

EDISN is designed to calculate the energy spectrum of inelastically scattered and evaporated neutrons. Calculated energy distributions of neutrons from (n,n') and $(n,2n)$ reactions in the Fe^{56} region are included.

5. METHOD OF SOLUTION

Given a nucleus (N,Z) bombarded by a neutron of energy E , EDISN requires as input appropriate parameters specifying the level densities of (N,Z) and $(N-1,Z)$ and the binding energy of the last neutron in (N,Z) . Employing the Weisskopf-Ewing formula, with cross sections for compound nucleus formation being determined by the continuum theory of nuclear reactions, the code calculates the energy spectra of the inelastically scattered "first" neutrons and the subsequently evaporated "second" neutrons.

Simpson's method is used for all numerical integrations. Included as options: the Feld approximation, the Troubetzkoy approximation, and the exact calculation.

For the purpose of making the code self-contained, subroutines for calculating cross sections for compound-nucleus formation and nuclear level densities have been incorporated. The former

calculation is based on the continuum theory, and the latter employs the familiar energy dependence of the level density as derived from the Fermi gas model. A more sophisticated treatment of these quantities would simply require the replacement of these routines by others that have a more detailed theoretical basis. For instance, the former subroutine could be replaced by one of several available programs for determining the compound-nucleus formation cross sections by the optical model.

6. RESTRICTIONS OR LIMITATIONS

The code is applicable to situations in which the compound-nucleus reaction mechanism predominates and the nonelastic processes other than (n,n') and $(n,2n)$ are negligible. In addition, it is required that the levels of the compound and residual nuclei be representable by continuous level densities.

7. TYPICAL RUNNING TIME

Running time increases rapidly as the number of increments used in the numerical integrations is raised. Typical times on the IBM 360 for 30 increments, which yield a high degree of accuracy, are ~ 3 min.

8. COMPUTER HARDWARE REQUIREMENTS

The code was designed for the IBM 1130 and is also operable on the IBM 360 computer. 8K of memory is adequate.

9. COMPUTER SOFTWARE REQUIREMENTS

Standard IBM 360 software may be used for the packaged version. For IBM 1130 use, it should be noted that EDISN was written under Version 1 Modification Level 7 of the 1130 Disk Monitor System.

10. REFERENCE

R. Snow and M. C. George, "A Computer Code for Calculating the Energy Distribution of Inelastically Scattered Neutrons," RL-SSL-200 (July 1968).

BACKGROUND REFERENCES

D. H. Ewing and V. F. Weisskopf, Phys. Rev. 57, 472, 935 (1940)
(not packaged).

J. M. Blatt and V. F. Weisskopf, Theoretical Nuclear Physics,
pp. 345-358, John Wiley and Sons, New York and London (1952) (not
packaged).

11. CONTENTS OF PACKAGE

The package contains the following items:

- a. the referenced document,
- b. a reel of magnetic tape on which is written in 2 files: The
EBCDIC source card deck, BCD input for a sample problem and an
output listing from the problem.

12. HOW TO OBTAIN PACKAGE

Inquiries or requests for the code package may be mailed to

CODES COORDINATOR
Radiation Shielding Information Center
Oak Ridge National Laboratory
Post Office Box X
Oak Ridge, Tennessee 37830

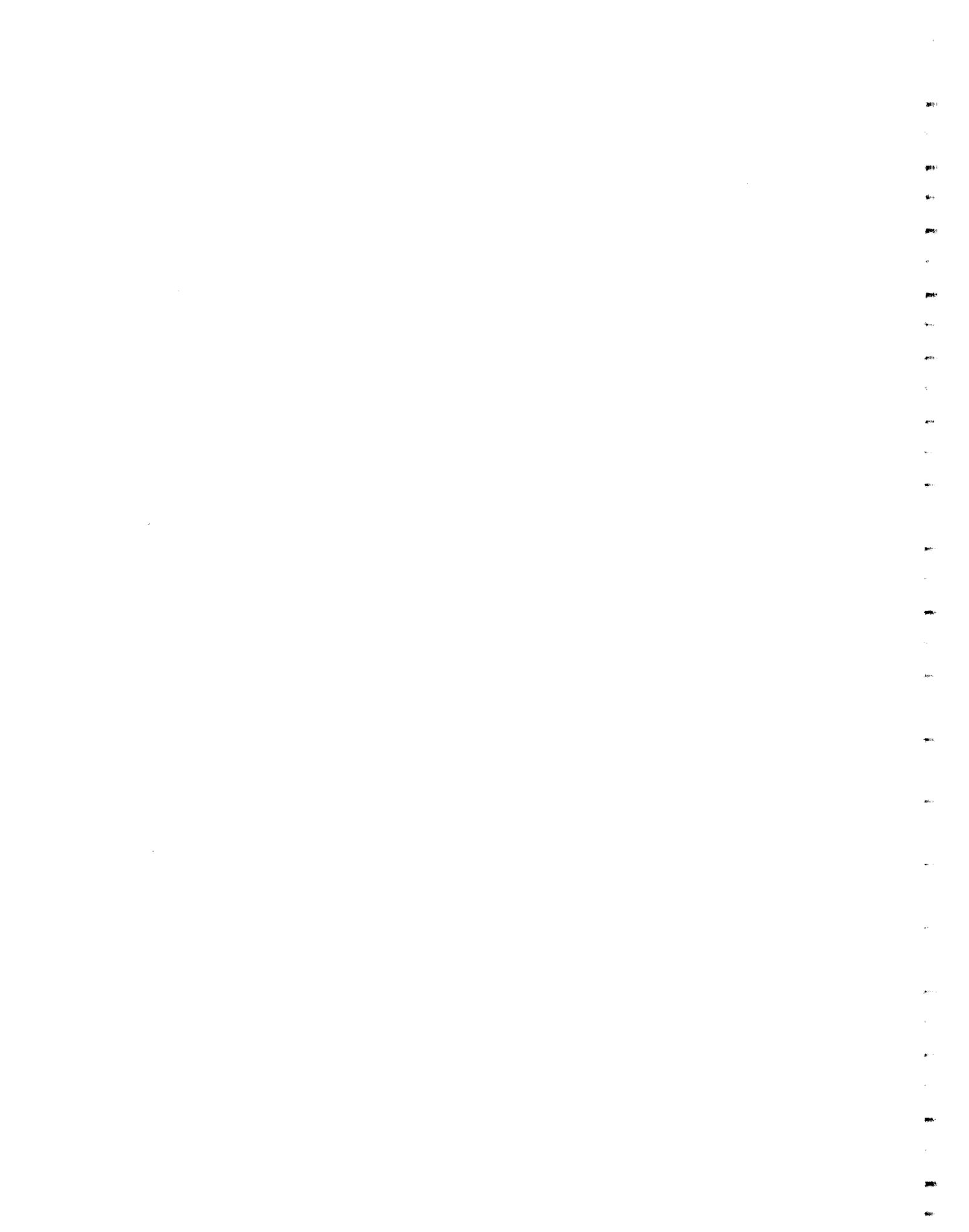
or telephoned to

Area Code 615; 483-8611, extension, 3-6944, or to
FTS xx-615-483-6944.

Persons requesting the code package should send a reel of magnetic
tape to the above address.

13. DATE OF ABSTRACT

November 1972.



RSIC CODE PACKAGE PSR-7

1. NAME AND TITLE OF CODE

MUG: Multigroup Photon Cross Section Generator.

MUG is a revision of PROGRAM GAMMA, XDC-59-3-80 (January 1959) by M. J. Stanley.

2. CONTRIBUTOR

Computing Technology Center, Union Carbide Nuclear Division,
Oak Ridge, Tennessee.

3. CODING LANGUAGE AND COMPUTER

FORTRAN IV; IBM 360.

4. NATURE OF PROBLEM SOLVED

MUG generates multigroup photon cross sections suitable for use in discrete ordinates or other transport codes.

Although not used in transport codes, MUG also produces kerma factors (absorption cross sections).

5. METHOD OF SOLUTION

MUG reads tabulated photoelectric and pair production cross sections, combines these with analytic Compton data to produce scattering and total cross sections for an arbitrary energy group structure. Pair production is treated as a type of scattering, i.e., annihilation produces two 0.51-MeV photons. The Klein-Nishina formula is integrated to produce angular distribution coefficients up to P_{12} . Flat flux or input flux values may be used as energy weighting functions.

5. RESTRICTIONS OR LIMITATIONS

- \leq 100 groups
- \leq P₁₂ expansion
- \leq 20 elements per problem.

7. TYPICAL RUNNING TIME

No study of typical running time has been made by RSIC.

8. COMPUTER HARDWARE REQUIREMENTS

The code was designed for and is operable on the IBM 360.

9. COMPUTER SOFTWARE REQUIREMENTS

Standard FORTRAN IV compilers may be used. MUG reads the ENDF/B cross sections distributed by the National Neutron Cross Section Center (NNCSC), Brookhaven National Laboratory, Upton, New York.

10. REFERENCE

J. R. Knight and F. R. Mynatt, "MUG - A Program for Generating Multigroup Photon Cross Sections," CTC-17 (January 1970).

11. CONTENTS OF CODE PACKAGE

The package contains the following items:

- a. the referenced document,
- b. a reel of magnetic tape on which is written in several files: the BCD source card deck, BCD input for a sample problem and an output listing from the problem.

12. HOW TO OBTAIN PACKAGE

Inquiries or requests for the code package may be mailed to

CODES COORDINATOR
Radiation Shielding Information Center
Oak Ridge National Laboratory
Post Office Box X
Oak Ridge, Tennessee 37830

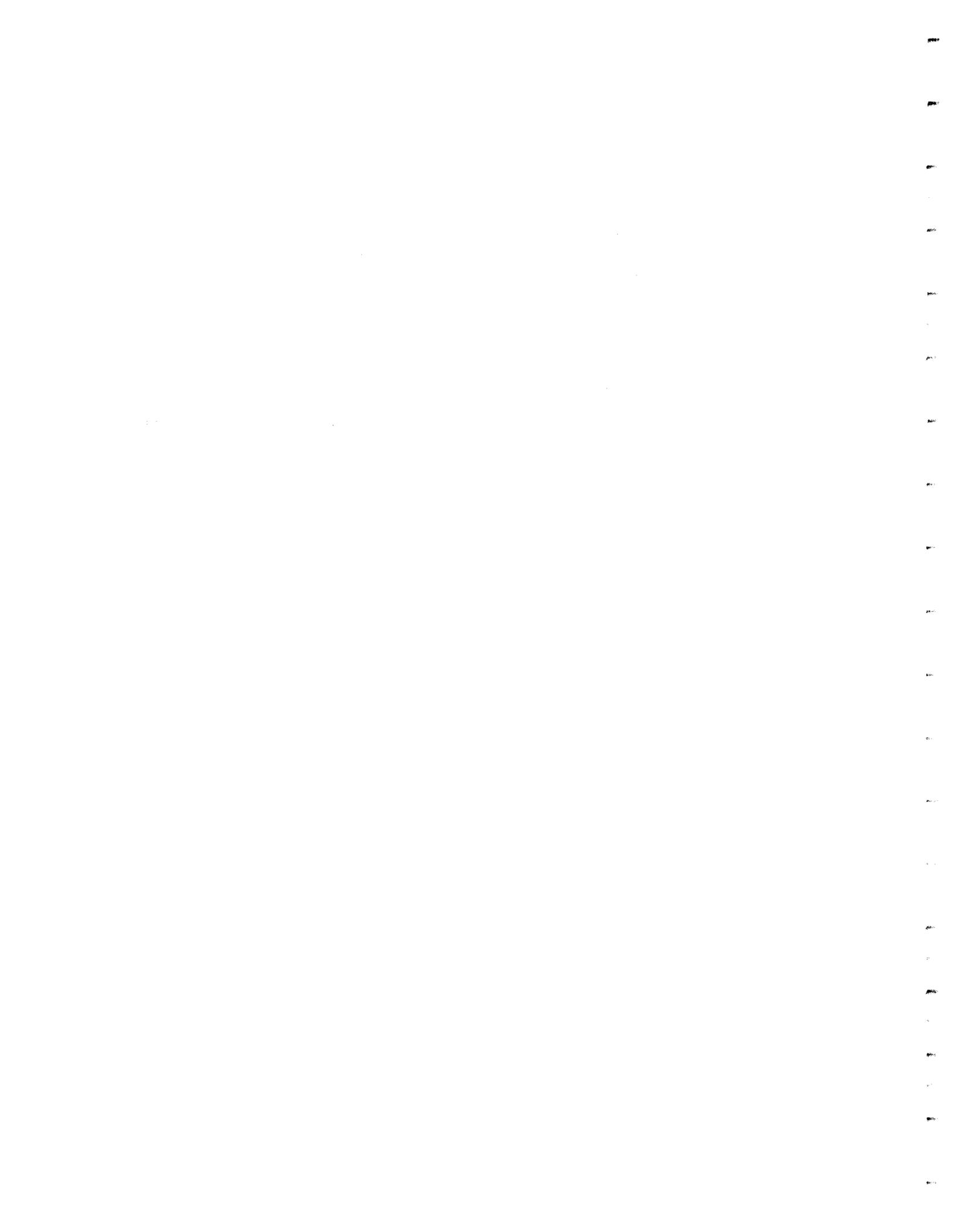
or telephoned to

Area Code 615; 483-8611, extension 3-6944, or to
FTS xx-615-483-6944.

Persons requesting the code package should send a reel of magnetic tape to the above address, specifying how it should be written.

13. DATE OF ABSTRACT

November 1972.



RSIC CODE PACKAGE PSR-8

1. NAME AND TITLE OF CODE

AUTOJOM-JOMREAD: Computer Programs to Generate or Check Coefficients for Quadratic Equations Describing 3D Geometries.

2. CONTRIBUTOR

Research and Technology Division, Air Force Weapons Laboratory, Kirtland Air Force Base, New Mexico.

3. CODING LANGUAGE AND COMPUTER

FORTRAN IV; CDC 6600.

4. NATURE OF PROBLEM SOLVED

AUTOJOM generates the coefficients of any quadratic equation used to define conic volumes (cones, ellipsoids, spheres, cylinders, paraboloids) and also the coefficients of the planes needed to define parallelepipeds, wedges and pyramids. The amount of user input is minimal (a single reference point, a few directional vectors to orientate the surface in space, and a few scalars).

JOMREAD is designed to check 3D geometries composed of and constructed with quadratic surfaces.

5. METHOD OF SOLUTION

In AUTOJOM the derivation of the equation of any conic quadratic surface is performed by assuming first that the surface is symmetric about the origin, and oriented along the X-axis. The X, Y, and Z coordinate axis system is then rotated in turn about the X, Y, and Z axes until the surface has the same orientation as its height vector (HXO, HYO, HZO). It is then displaced by translatory motion until the reference vertex is at its final (given) location (P_0). The transformation of axes during the rotations is performed by matrix multiplication. The derivation of the equations of parallelepipeds, wedges, and pyramids is performed using the

basic equation for a plane. The input needed is a vertex point and height vectors locating the positions and giving the length and edges of the volume.

JOMREAD requires the presence of the following: a grid network to help subdivide the spacial volume of interest, a list of which surfaces are relevant to each volume, identifiers to indicate on which side of the surface the volume of interest lies, and identifiers for the type of volume.

The coefficients are printed or punched out into cards in the format of PHOTRAN, AFWL-TR-65-171, Volume I (March 1966), by C. D. Zerby and J. Agresta.

6. RESTRICTIONS OR LIMITATIONS

At least 60K of core memory is needed.

7. TYPICAL RUNNING TIME

No study of typical running time has been made by RSIC.

8. COMPUTER HARDWARE REQUIREMENTS

The code was designed for and is operable on the CDC 6600 computer.

9. COMPUTER SOFTWARE REQUIREMENTS

A standard FORTRAN IV compiler may be used.

10. REFERENCES

Ronald J. Cahill, "AJTOJOM: A Computer Program to Generate Coefficients for Quadratic Equations," AFWL-TR-67-60 (July 1967).

Ronald J. Cahill and Guy C. Spitale, "JOMREAD, A Computer Code Designed to Check 3D Geometries," AFWL-TR-67-36 (June 1967).

11. CONTENTS OF CODE PACKAGE

The package contains the following items:

- a. the referenced documents,
- b. a reel of magnetic tape on which is written in 2 files: the source card decks for AUTOJOM and JOMREAD.

12. HOW TO OBTAIN PACKAGE

Inquiries or requests for the code package may be mailed to

CODES COORDINATOR
Radiation Shielding Information Center
Oak Ridge National Laboratory
Post Office Box X
Oak Ridge, Tennessee 37830

or telephoned to

Area Code 615; 483-8611, extension 3-6944, or to
FTS xx-615-483-6944.

Persons requesting the code package should send a reel of magnetic tape to the above address.

13. DATE OF ABSTRACT

November 1972.

RSIC CODE PACKAGE PSR-9

1. NAME AND TITLE OF CODE

CSP: Neutron Cross Section Averaging Code.

2. CONTRIBUTOR

Neutron Physics Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

3. CODING LANGUAGE AND COMPUTER

FORTRAN IV; IBM 360/75/91.

4. NATURE OF PROBLEM SOLVED

Using an O5R master cross-section library tape as basic input data, group averaged neutron cross sections, suitable for input to transport codes, are generated. Arbitrary group structure may be specified. The weighting function for the averaging process may be arbitrarily specified by input data, or optionally chosen as being inversely proportional to neutron speed or energy. The group-to-group transfer cross sections are produced by calculating and summing contributions from elastic and inelastic scattering and from $(n,2n)$ and $(n,n'\alpha)$ reactions. If desired, the cross sections may be punched on cards in the ANISN-DOT format.

5. METHOD OF SOLUTION

The transition matrix elements are computed by integrating the probability, upon interaction, of transferring from one group (source) to another group (sink) over the energy ranges of the two groups, the source group integration being weighted by the assumed flux spectrum. The integrations are done numerically using a trapezoidal rule for both variables of integration. For elastic scattering, the integration variables used are source group energy and center-of-mass scattering angle cosine. For inelastic scattering and $(n,2n)$ and $(n,n'\alpha)$ reactions, the integration variables are source and sink group energies.

6. RESTRICTIONS OR LIMITATIONS

The generated cross-section tables include only downscattering transfer cross sections and the code does not have any provision for a thermal energy region scattering law treatment.

Some dimensional limits are as follows:

Maximum number of energy groups (arbitrary boundaries): 200

Maximum order of Legendre Expansion approximation: 10

Maximum number of data points for input cross sections
(arbitrary spacing): 1000

Maximum number of resolved inelastic levels: 10

7. TYPICAL RUNNING TIME

Estimated running time of sample problem: 4 minutes.

8. COMPUTER HARDWARE REQUIREMENTS

CSP was designed for the IBM 360 computer and uses 5 tape units.

9. COMPUTER SOFTWARE REQUIREMENTS

The code is operable on the IBM 360/75/91 System using OS-360 FORTRAN H, Levels 13 and 14 compilers.

10. REFERENCE

K. J. Yost and N. M. Greene, "CSP-I: A Neutron Cross-Section Averaging Package for Use with the O5R Data Tape," ORNL-4130 (December 1967).

11. CONTENTS OF CODE PACKAGE

The package contains the following items:

- a. the referenced document,
- b. a reel of magnetic tape on which is written in 6 files: the source card deck, input for a sample problem and output from the sample problem.

12. HOW TO OBTAIN PACKAGE

Inquiries or requests for the code package may be mailed to

CODE COORDINATOR
Radiation Shielding Information Center
Oak Ridge National Laboratory
Post Office Box X
Oak Ridge, Tennessee 37830

or telephoned to

Area Code 615; 483-8611, extension 3-6944, or to
FTS xx-615-483-6944.

Persons requesting the code package should send a reel of magnetic
tape to the above address.

13. DATE OF ABSTRACT

May 1972.



RSIC CODE PACKAGE PSR-10

1. NAME AND TITLE OF CODE

EVAP: Calculation of Particle Evaporation from Excited Compound Nuclei.

An early version of EVAP is also packaged with CCC-7/NTC and with CCC-47/LEP. This version, EVAP-4, represents the latest modification and extension of the original program. It is identical to EVAP-3 in all respects except that an "improved-termination" procedure has been added.

2. CONTRIBUTOR

Neutron Physics Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

3. CODING LANGUAGE AND COMPUTER

FORTRAN IV; IBM 360. A random number generator is in machine language.

4. NATURE OF PROBLEM SOLVED

EVAP calculates the types, multiplicities, and energy distributions of particles evaporated from excited compound nuclei. The version in this package calculates the excitation energy of the compound nucleus from the data furnished for the target nucleus and incident particle; other versions are packaged with Bertini's intranuclear cascade code (CCC-47) which accept instead the output from a cascade calculation to determine the initial conditions for the evaporation. Other than the determination of these initial conditions, both versions are identical.

5. METHOD OF SOLUTION

The evaporation process is started with the collision of an incident particle with a target nucleus. An excited compound

nucleus is formed, from which particles are emitted until evaporation is no longer energetically possible.

The calculation is based on a theory originally proposed by Weisskopf [Phys. Rev. 52, 295 (1937)], and on a Monte Carlo code written by Dostrovsky [Phys. Rev. 116, 683 (1959); Phys. Rev. 118, 781 and 791 (1960)].

6. RESTRICTIONS OR LIMITATIONS

There are none noted.

7. TYPICAL RUNNING TIME

No study of typical running time has been made by RSIC.

8. COMPUTER HARDWARE REQUIREMENTS

The code was designed for and is operable on the IBM 360.

9. COMPUTER SOFTWARE REQUIREMENTS

Standard FORTRAN IV compiler.

10. REFERENCES

Miriam P. Guthrie, "Another Modification of a Code to Calculate Particle Evaporation from Excited Compound Nuclei," ORNL-TM-3119 (September 1970).

M. P. Guthrie, EVAP-2 and EVAP-3: Modifications of a Code to Calculate Particle Evaporation from Excited Compound Nuclei," ORNL-4379 (March 1969).

Background reference: L. Dresner, "EVAP - A FORTRAN Program for Calculating the Evaporation of Various Particles from Excited Nuclei," ORNL-TM-196 (1961).

11. CONTENTS OF CODE PACKAGE

The package contains the following items:

- a. the first two referenced documents,

- b. a reel of magnetic tape on which is written in 5 files: the source decks for EVAP-4, EBCDIC input for a sample problem, and an output listing from the sample problem.

12. HOW TO OBTAIN PACKAGE

Inquiries or requests for the code package may be mailed to

CODES COORDINATOR
Radiation Shielding Information Center
Oak Ridge National Laboratory
Post Office Box X
Oak Ridge, Tennessee 37830

or telephoned to

Area Code 615; 483-8611, extension 3-6944, or to
FTS xx-615-483-6944.

Persons requesting the code package should send a reel of magnetic tape to the above address, specifying how it should be written.

13. DATE OF ABSTRACT

September 1972.

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RSIC CODE PACKAGE PSR-11

1. NAME AND TITLE OF CODE

POPOP4: Converter of Gamma-Ray Spectra to Secondary Gamma-Ray Production Cross Sections.

2. CONTRIBUTOR

Computing Technology Center and Oak Ridge National Laboratory, Union Carbide Nuclear Division, Oak Ridge, Tennessee.

3. CODING LANGUAGE AND COMPUTER

FORTRAN IV; IBM 360.

4. NATURE OF PROBLEM SOLVED

POPOP4 produces multigroup transfer cross sections for representing gamma-ray production due to neutron interactions. Any gamma-ray producing reaction (capture, inelastic scattering, etc.) can be represented as long as appropriate data describing the reaction is provided as input. Input can be from cards or a library tape. Two basic forms of data are allowed, gamma-ray production cross sections (barns) and yields (number of gamma rays per reaction). In the latter case the microscopic neutron cross sections for the given reaction are also required to convert the yields to gamma-ray production cross sections.

The output from POPOP4 then can be combined with output from codes that produce neutron-to-neutron group transfer cross sections (such as GAM-II and PSR-13/SUPERTOG) and gamma-ray to gamma-ray group transfer cross sections [such as GAMLEG (CCC-42) and PSR-7/MUG] to produce a coupled set of cross sections. This coupled set can then be used in codes such as CCC-46/DTF-IV, CCC-82/ANISN, CCC-89/DOT, and CCC-127/MORSE to perform calculations which account for both neutron and secondary gamma-ray transport.

5. METHOD OF SOLUTION

In general, input data is specified for given neutron and gamma-ray group structures. Output is required for different group structures. Yield data is converted from the given structures to the required structures by multiplying by ratios proportional to mismatch between the given and required neutron and gamma-ray group structures.

Data in the form of yields are converted to production cross sections by multiplying by the microscopic neutron cross sections for the reaction. The neutron cross sections are usually taken from multigroup libraries.

6. RESTRICTIONS OR LIMITATIONS

The number of reactions which can be summed in one POPOP4 case is limited to 10.

7. TYPICAL RUNNING TIME

No study of typical running time has been made by RSIC.

8. COMPUTER HARDWARE REQUIREMENTS

The code was designed for and is operable on the IBM 360 computer.

9. COMPUTER SOFTWARE REQUIREMENTS

A standard FORTRAN IV compiler may be used.

10. REFERENCES

Walter E. Ford, III, and David H. Wallace, "POPOP4, A Code for Converting Gamma-Ray Spectra to Secondary Gamma-Ray Production Cross Sections," CTC-12 (May 1969).

W. E. Ford, III, and D. H. Wallace, "The Use and 'Testing' of Al, Fe, Ni, Cu, and Pb Secondary Gamma-Ray Production Data Sets from the POPOP4 Library," CTC-20 (July 1970).

W. E. Ford, III, "The POPOP4 Library of Neutron-Induced Secondary Gamma-Ray Yield and Cross Section Data," CTC-42 (1970).

11. CONTENTS OF CODE PACKAGE

The package contains the following items:

- a. the referenced documents,
- b. a reel of magnetic tape on which is written in 13 files: BCD source card decks for POPOP4, coupling code and TAPEMAKER, BCD input for a sample problem and an output listing from the problem.
- c. a reel of magnetic tape on which is written a library of cross-section data for use with POPLIB (DLC-12).

12. HOW TO OBTAIN PACKAGE

Inquiries or requests for the code package may be mailed to

CODES COORDINATOR
Radiation Shielding Information Center
Oak Ridge National Laboratory
Post Office Box X
Oak Ridge, Tennessee 37830

or telephoned to

Area Code 615; 483-8611, extension 3-6944, or to
FTS xx-615-483-6944.

Persons requesting the code package should send a reel of magnetic tape to the above address, and a second reel for the data library, specifying in each case how the tapes should be written.

13. DATE OF ABSTRACT

November 1972.



RSIC CODE PACKAGE PSR-12

1. NAME AND TITLE OF CODE

GGC: Multigroup Cross Section Code System for Use in Diffusion and Transport Codes. PSR-12A/GGC-3; PSR-12B/GGC-4.

GGC-4 is packaged in the Argonne Code Center, Abstract 298.

2. CONTRIBUTOR

Gulf General Atomic, San Diego, California.

3. CODING LANGUAGE AND COMPUTER

FORTRAN IV, UNIVAC 1108 and IBM 360.

4. NATURE OF PROBLEM SOLVED

The GGC System is a package of codes designed for the production of multigroup cross section sets. The program solves the multigroup spectrum equations with spatial dependence represented by a single positive input buckling. Broad group cross sections are prepared for diffusion and transport codes by averaging with the calculated spectra over input-designated energy limits.

The fast section of GGC as an option adjusts fine group absorption and fission cross sections by performing resonance integral calculations; calculates the energy dependent fast spectrum using an input buckling and a P_1 , B_1 , B_2 , or B_3 approximation; as an option, calculates either 2 or 6 spatial moments of the spectrum due to a plane source; and performs, for as many input designated broad group structures as desired, spectrum weighted averages of microscopic and macroscopic cross sections and transfer arrays.

The thermal section determines a thermal spectrum by reading it as input, or by calculating a Maxwellian spectrum for a given temperature, or by an iterative solution of the P_0 , B_0 , P_1 , or B_1 thermalization equations for an input buckling; as an option, calculates time moments of the time and energy dependent diffusion

equations using the input buckling to represent leakage; produces spectrum weighted broad group averaged cross sections and transfer arrays.

The combining section takes the broad group averaged cross sections from the fast and thermal portions and forms multigroup cross section tables. It is also possible to use the combining section to produce mixtures not used in the spectrum calculations or to combine the results of different fast and thermal calculations.

GGC-4 includes new options for a spectrum calculation for systems with a negative or zero buckling; a calculation of effective resonance integrals; and a procedure for calculating a consistent set of transport cross sections.

5. METHOD OF SOLUTION

The code systems are based on the work of Joanou, Dudek, Smith, and Vieweg (GAM II, GA-4265, 1965; GATHER II, GA-4132, 1963, and GGC-II, GA-4436). The code system is divided into fast (GAM), Thermal (GATHER), and Combining sections, described above.

In the fast section either the P_1 or the B_1 , B_2 , or B_3 approximation is made to the transport equation using the positive, energy-independent buckling. In each approximation Legendre moments of the angular flux are computed by direct numerical integration of the slowing down equations. In the resonance calculations, Doppler broadened absorption and scattering cross sections are used. The resonance treatment allows up to two admixed moderators in an absorber lump imbedded in a surrounding moderator. The absorber in the lump is treated by using either the narrow resonance approximation, the narrow resonance infinite mass approximation, or a solution of the slowing down integral equations to determine the collision density through the resonance. The admixed moderators are treated by using either an asymptotic form of, or an integral equation solution for, the collision density. In the resonance calculation either standard geometry collision probabilities are used or tables are entered. Dancoff corrections can also be made. In the region of

unresolved resonances, resonance absorption is calculated by using Porter-Thomas distributions, but only S-wave neutrons are considered.

In the thermal section either the B_0 , B_1 , P_0 , or P_1 approximation to the transport equation is made, and in all options Legendre moments of the angular flux are computed. A trapezoidal energy integration mesh is used, and the resulting equations are solved iteratively by using a source-normalized, over-relaxed, Gaussian technique. Averages over broad groups are performed by simple numerical integration.

The results obtained in the fast and thermal sections are stored on tapes, which may contain results for a number of problems, each of which includes fine group cross section data for a number of nuclides. If the problem number is specified on the tapes, and a desired list of nuclides is given, the combining code will punch microscopic cross sections for the requested list of nuclides. The program also treats mixtures. Given the atomic densities of the nuclides in the mixture, the code will punch macroscopic cross sections. An option in GGC makes it possible to shorten the punching process for large 2-dimensional transfer arrays, by specifying a maximum number of desired upscattering and downscattering terms.

Several auxiliary codes are included in the package to prepare, handle, and update the basic cross section tapes which are used as input to GGC (MAKE, MST, PRINT, MIXER, WTFG, MGT3, and SPRINT).

6. RESTRICTIONS OR LIMITATIONS

Maxima of: 99 fast groups, 101 thermal fine groups, 99 fast broad groups, 50 thermal broad groups, 50 broad groups in the combining section, 100 resonances per nuclide, 2 moderators mixed with a resonance absorber, 305 entries in the escape probability table for cylindrical geometries, 505 entries in the escape probability table for slab geometries, and a single and positive value for the buckling must be supplied.

7. TYPICAL RUNNING TIME

No study has been made by RSIC to establish typical running time.

8. COMPUTER HARDWARE REQUIREMENTS

The code was designed for the UNIVAC 1108 and is also operable on the IBM 360 and the CDC 6600.

9. COMPUTER SOFTWARE REQUIREMENTS

A standard FORTRAN IV compiler on the above computers may be used.

10. REFERENCES

J. Adir and K. D. Lathrop, "Theory of Methods Used in the GGC-3 Multigroup Cross Section Code," GA-7156 (July 1967).

J. Adir, S. S. Clark, R. Froehlich, and L. L. Todt, "User's and Programmer's Manual for the GGC-3 Multigroup Cross Section Code, Parts 1 and 2," GA-7157 (July 1967).

M. K. Drake, C. V. Smith, and L. J. Todt, "Description of Auxiliary Codes Used in the Preparation of Data for the GGC-3 Code," GA-7158 (August 1967).

J. Adir and K. D. Lathrop, "Theory of Methods Used in the GGC-4 Multigroup Cross Section Code," GA-9021 (October 1968).

11. CONTENTS OF CODE PACKAGE

The package contains the following items:

- a. the referenced documents,
- b. a reel of magnetic tape on which is written in 20 files: the BCD source decks for each code in the GGC-3 System, BCD input for each of the codes and an output listing from running the sample problems, packaged as PSR-12A. (19,305 records).

- c. a reel of tape on which is written in 10 files: the BCD source card decks for each code in the GGC-4 System, and BCD input for a sample problem for each of the codes and an output listing from running the problems, packaged as PSR-12B. (29,698 records.)
- d. 2 reels of tape on which the library of data is written in binary, and
- e. 3 reels of tape on which is written (9-track, 800 bpi) a BCD library of data.

12. HOW TO OBTAIN PACKAGE

Inquiries or requests for the code package may be mailed to

CODES COORDINATOR
Radiation Shielding Information Center
Oak Ridge National Laboratory
Post Office Box X
Oak Ridge, Tennessee 37830

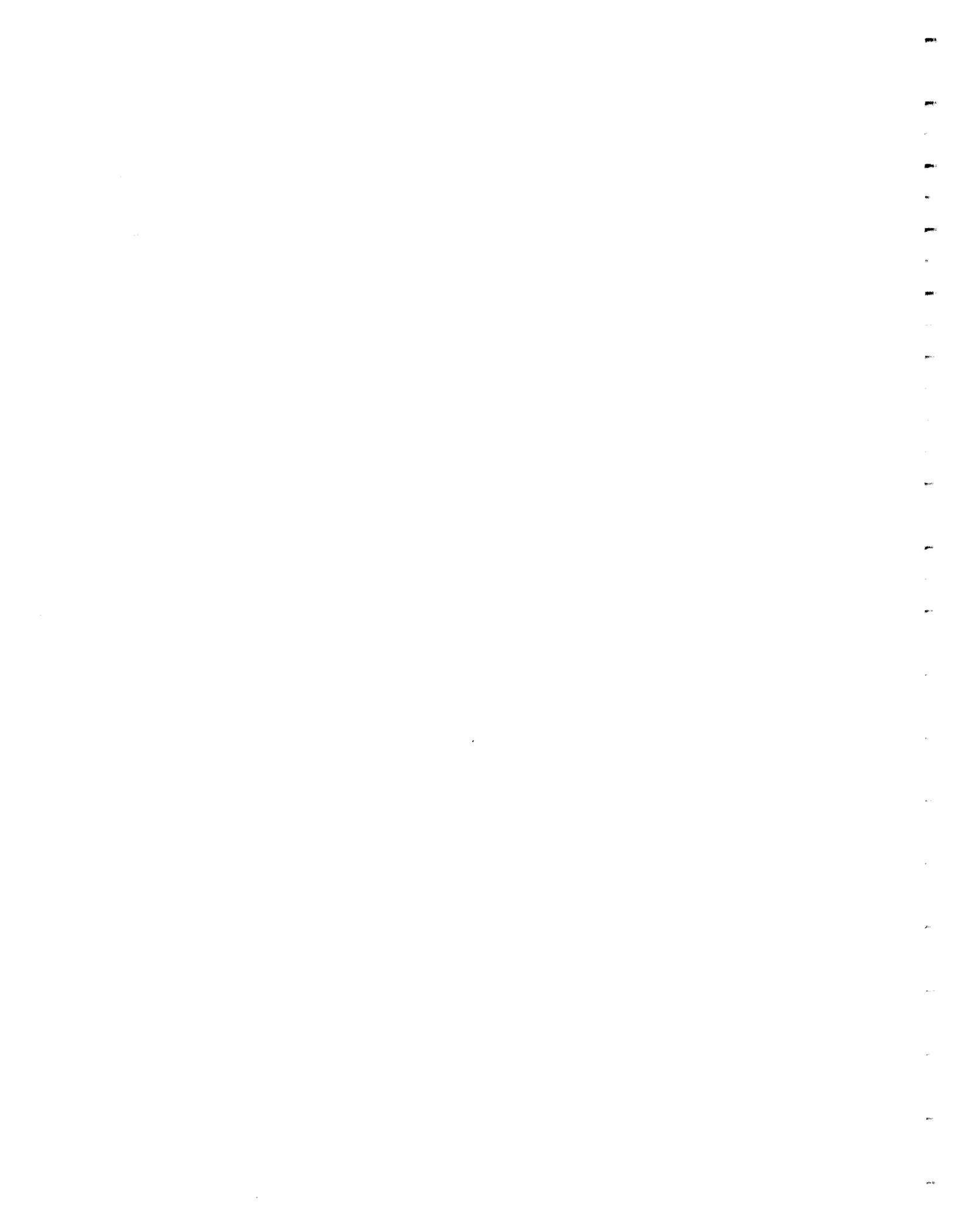
or telephoned to

Area Code 615, 483-8611, extension 3-6944, or to
FTS xx-615-483-6944.

Persons requesting the code package should send reels of magnetic tape to the above address: for 9-track, 800 bpi as indicated above; for 7-track, 556 or 800 bpi: 1 reel for either GGC-3 or 4 program package, and 11 reels of magnetic tape for the data library.

13. DATE OF ABSTRACT

November 1972.



RSIC CODE PACKAGE PSR-13

1. NAME AND TITLE OF CODE

SUPERTO_G III: Data Generator - Fine Group Constants and P_n
Scattering Matrices from ENDF/B

AUXILIARY ROUTINES

The DLC-2 RETRIEVAL PROGRAM retrieves SUPERTO_G output from a card image tape written in the ANISN card image format. This program will retrieve data from a maximum of 46 data sets and merge this data onto one data set. It will then, by input option, edit the data, punch cards in either the ANISN or DTF-IV format, or write an unformatted tape for use by ANISN. Another program is available which will merge up to a maximum of four card image tapes written in the GAM-II update format onto a single tape. This program can also take the one-dimensional arrays from one tape and the two-dimensional arrays from another tape and merge this information onto a single tape. The single tape is input to the SUPERTO_G version of the GAM-II update program. The GAM-II update program has been modified to accept output from SUPERTO_G on either punched cards or magnetic tape.

2. CONTRIBUTOR

Oak Ridge National Laboratory, Oak Ridge, Tennessee.

3. CODING LANGUAGE AND COMPUTER

FORTRAN IV; IBM 360, CDC 6400.

4. NATURE OF THE PROBLEM SOLVED

SUPERTO_G-III accepts nuclear data in either a point by point or parametric representation as specified by ENDF/B. This data is averaged over each specified group width. The explicit assumption is made that the flux per unit lethargy is constant or that a suitable weight function will be supplied by the user. When resonance data is available, resolved and unresolved resonance contribu-

tions are calculated and used as specified by input options. Fine group constants such as one-dimensional reaction arrays (absorption, fission, etc.), P_n elastic scattering matrices, and inelastic and (n,2n) scattering matrices are generated and placed on tapes in formats suitable for use by GAM-I, GAM-II, ANISN, or DOT.

5. METHOD OF SOLUTION

The single-level Breit-Wigner formalism is used for calculation of cross sections in the resolved resonance region. Cross sections in the unresolved resonance region are computed by taking averages over suitable Porter-Thomas distributions of the neutron and fission widths. Smooth cross sections are calculated by integration of point-cross-section data given in ENDF/B file 3. Elastic scattering matrices are computed from Legendre coefficients of the scattering angular-distribution data. Inelastic scattering and (n,2n) matrices are computed from excitation functions for individual levels and by using a nuclear evaporation model above the region of resolved levels.

6. RESTRICTIONS OR LIMITATIONS

Since fixed, rather than flexible, dimensions are used, it is important to be aware of the maximum values allowed for certain key variables. Examples are: number of groups ≤ 150 , number of data points for each reaction type ≤ 4000 , and the number of Legendre coefficients ≤ 30 .

SUPERTOG-III employs a rather elaborate overlay structure and extensive use of equivalence statements to minimize core requirements.

7. TYPICAL RUNNING TIME

(Times quoted are for the IBM 360/91.) Running time varies greatly and is a function, primarily, of the number of groups, the number of resolved resonances, and the length of the elastic scattering matrix. The average time required to generate DLC-2D from ENDF/B Version III data was 2.2 minutes per nuclide.

Estimated running time of the packaged sample problem for the GAM-II, 99-group structure (239-Pu) MAT:1159 with P-3 elastic scattering is 3.0 minutes.

8. COMPUTER HARDWARE REQUIREMENTS

SUPERTOG-III is designed to operate on computers of the IBM 360/50/65/75/91 and CDC 6600 class. Approximately 366K bytes or 94K words of directly addressable core are required.

9. COMPUTER SOFTWARE REQUIREMENTS

The coding is entirely in ASA standard FORTRAN (FORTRAN-IV), uses no programming tricks, and takes no advantage of any particular hardware or software.

10. REFERENCES

R. Q. Wright, N. M. Greene, J. L. Lucius, C. W. Craven, Jr., "SUPERTOG: A Program to Generate Fine Group Constants and P_n Scattering Matrices from ENDF/B," ORNL-TM-2679 (September 1969).

11. CONTENTS OF CODE PACKAGE

The package contains the following items:

- a. the referenced document,
- b. a reel of magnetic tape on which is written in 6 separate files: the library, source deck, and sample problem.

12. HOW TO OBTAIN PACKAGE

Inquiries or requests for the code package may be mailed to

CODES COORDINATOR
Radiation Shielding Information Center
Oak Ridge National Laboratory
Post Office Box X
Oak Ridge, Tennessee 37830

or telephoned to

Area Code 615; 483-8611, extension 3-6944, or to
FTS xx-615-483-6944.

Persons requesting the package should send a reel of magnetic tape to the above address.

13. DATE OF ABSTRACT

September 1972.

RSIC CODE PACKAGE PSR-14

1. NAME AND TITLE OF CODE

O5S: Response Function Generator - A Modified O5R Monte Carlo Code for Calculating Pulse Height Distributions Due to Monoenergetic Neutrons Incident on Organic Scintillators.

AUXILIARY ROUTINES:

XSECT: Cross Section Handling Code.

SMOOTHIE: Histogram Data Smoother (in 360 version only).

2. CONTRIBUTORS

Computing Technology Center and Oak Ridge National Laboratory, Union Carbide Nuclear Division, Oak Ridge, Tennessee.

NASA Lewis Research Center, Cleveland, Ohio.

3. CODING LANGUAGE AND COMPUTER

PSR-14A: FORTRAN 63 and CODAP; CDC-1604.

PSR-14B: FORTRAN IV and Assembler Language; IBM 360.

PSR-14C: FORTRAN IV and MAP; IBM 7090.

4. NATURE OF PROBLEM SOLVED

O5S is designed to directly simulate the experimental techniques used to obtain the pulse height distribution for a parallel beam of monoenergetic neutrons incident on organic scintillator systems. Developed to accurately calibrate the nominally 2 in. by 2 in. liquid organic scintillator NE-213 (composition CH-1.2), the code should be readily adaptable to many similar problems.

5. METHOD OF SOLUTION

O5S is a Monte Carlo code patterned after the general-purpose Monte Carlo neutron transport code system, O5R (CCC-17). The O5S Monte Carlo "experiment" follows the course of each neutron through the scintillator and obtains the energy-deposits of the ions produced

by elastic scatterings and reactions. The light pulse produced by the neutron is obtained by summing up the contributions of the various ions with the use of appropriate light vs. ion-energy tables.

Because of the specialized geometry and simpler cross section needs O5S is able to by-pass many features included in O5R. For instance, neutrons may be followed individually, their histories analyzed as they occur, and upon completion of the experiment, the results analyzed to obtain the pulse-height distribution during one pass on the computer.

O5S does allow the absorption of neutrons, but does not allow splitting or Russian roulette (biased weighting schemes).

SMOOTHIE is designed to smooth O5S histogram data using Gaussian functions with parameters specified by the user.

6. RESTRICTIONS OR LIMITATIONS

None noted.

7. TYPICAL RUNNING TIME

No study of typical running time has been made by RSIC.

Estimated running time of the packaged sample problem: XSECT, 2 minutes; O5S, 2 minutes.

8. COMPUTER HARDWARE REQUIREMENTS

The code was designed for and is operable on the CDC-1604 computer (PSR-14A). In addition, conversions have been made to the IBM 7090 (PSR-14C) and to the IBM 360 (PSR-14B). A maximum of 2 tape units or direct access devices are used.

9. COMPUTER SOFTWARE REQUIREMENTS

Standard Monitor Systems may be used in each version. The OS/360 uses FORTRAN H-level compiler. Non-standard library routines are included in the packages.

10. REFERENCE

R. E. Textor and V. V. Verbinski, "O5S: A Monte Carlo Code for Calculating Pulse Height Distributions Due to Monoenergetic Neutrons Incident on Organic Scintillators," ORNL-4160 (1968).

11. CONTENTS OF CODE PACKAGE

The package contains the following items:

- a. the referenced document,
- b. a reel of magnetic tape for each of the versions (A,B,C) on which is written in several files as follows:
 - PSR-14A: 9 files - the source card decks for XSECT, O5S; BCD input for a sample problem to be run on each code, and BCD listings of the output from the problems.
 - PSR-14B: 16 files - the source cards for XSECT, O5S, SMOOTHIE; BCD input for a sample problem for each code and the BCD output listings from running the problems.
 - PSR-14C: 8 files - the source card decks for XSECT, O5S; BCD input for a sample problem for each, and BCD output listings from running the problems.

12. HOW TO OBTAIN PACKAGE

Inquiries or requests for the code package may be mailed to

CODES COORDINATOR
Radiation Shielding Information Center
Oak Ridge National Laboratory
Post Office Box X
Oak Ridge, Tennessee 37830

or telephoned to

Area Code 615; 483,8611, extension 3-6944, or to
FTS xx-615-483-6944.

Persons requesting the code package should send a reel of magnetic tape to the above address, specifying the version desired.

13. DATE OF ABSTRACT

November 1972.

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RSIC CODE PACKAGE PSR-15

1. NAME AND TITLE OF CODE

UKE: Cross Section Format Translator - UKAEA-NDL to ENDF/B.

2. CONTRIBUTOR

Computing Technology Center and Oak Ridge National Laboratory,
Union Carbide Nuclear Division, Oak Ridge, Tennessee.

3. CODING LANGUAGE AND COMPUTER

FORTRAN IV; IBM 360.

4. NATURE OF PROBLEM SOLVED

UKE is designed to translate neutron cross sections on computer tape from the United Kingdom Atomic Energy Authority (UKAEA) Nuclear Data Library (NDL) format to that of the Evaluated Nuclear Data File (ENDF/B). The code will translate UKAEA library smooth cross section data, secondary angular distributions, and secondary energy distributions to the ENDF/B format. The secondary angular distributions are translated as differential scattering probabilities only, and no Legendre expansion coefficients are given. No resonance parameters, thermal scattering data, or photon data are considered.

5. METHOD OF SOLUTION

Not applicable.

6. RESTRICTIONS OR LIMITATIONS

The following limits apply: number of cross-section data points for each reaction type, less than or equal to 4000; number of reaction types on the UKAEA tape, 80/material; number of interpolation regions for ENDF/B data, 10; number of UKAEA reaction types which have angular distribution data, 50, and which have secondary energy distribution data, 50 per material.

7. TYPICAL RUNNING TIME

30 seconds per nuclide on the CPU of the 350/65 is typical.

8. COMPUTER HARDWARE REQUIREMENTS

The code was designed for and is operable on the IBM 360. Approximately 30K words of directly addressable core storage are needed. Two tape units and two scratch disks are used in addition to the I-O units.

9. COMPUTER SOFTWARE REQUIREMENTS

UKE may be compiled and executed on the IBM OS/360, FORTRAN H-level compiler.

10. REFERENCE

R. Q. Wright, S. N. Cramer, and D. C. Irving, "UKE - A Computer Program for Translating Neutron Cross-Section Data from the UKAEA Nuclear Data Library to the Evaluated Nuclear Data File Format," ORNL-TM-2880 (March 1970).

11. CONTENTS OF CODE PACKAGE

The package contains the following items:

- a. the referenced document,
- b. a reel of magnetic tape on which is written in 6 files: the source card decks, BCD input data (including UKAEA cross sections) for a sample problem, and a BCD output listing from running the problem.

12. HOW TO OBTAIN PACKAGE

Inquiries or requests for the code package may be mailed to

CODES COORDINATOR
Radiation Shielding Information Center
Oak Ridge National Laboratory
Post Office Box X
Oak Ridge, Tennessee 37830

or telephoned to

Area Code 615; 483-8611, extension 3-6944, or to
FTS xx-615-483-6944.

Persons requesting the code package should send a reel of magnetic
tape to the above address, specifying how it should be written.

13. DATE OF ABSTRACT

November 1972.



RSIC CODE PACKAGE PSR-16

1. NAME AND TITLE OF CODE

RANGE: Range-Energy Relation Code - Charged Particles in
Chemical Elements.

2. CONTRIBUTOR

Virginia Polytechnic Institute, Blacksburg, Virginia.
Lawrence Radiation Laboratory, Berkeley, California.

3. CODING LANGUAGE AND COMPUTER

FORTRAN IV; IBM 7090.

4. NATURE OF PROBLEM SOLVED

RANGE is designed to calculate the differential energy loss and the range of charged particles, electrons and positrons excepted, with kinetic energies between 1 MeV and 500 BeV in any chemical element. With the results of the element calculations, the energy loss and range can be readily computed for chemical compounds and mixtures.

5. METHOD OF SOLUTION

Direct integration of the Bethe-Bloch equation, using low-energy proton experimental ranges to initiate the integration, is employed in RANGE. The range of a particle is given as a function of energy or momentum in terms of three units: centimeters, gram-centimeters², and moles of electrons/centimeters². This calculation is made for any homogeneous target material that is a chemical element.

6. RESTRICTIONS OR LIMITATIONS

None noted.

7. TYPICAL RUNNING TIME

No study has been made by RSIC of typical running time.

8. COMPUTER HARDWARE REQUIREMENTS

The code was designed for and is operable on the IBM 7090.

9. COMPUTER SOFTWARE REQUIREMENTS

The packaged code was compiled and executed under the IBM 7090 FORTRAN (IBSYS) Monitor System.

10. REFERENCE

W. Peter Trower, "FORTRAN Subroutine RANGE: Calculating the Range-Energy Relation for Charged Particles in Chemical Elements," UCRL-11647 Rev. (1966).

11. CONTENTS OF CODE PACKAGE

The package contains the following items:

- a. the referenced document,
- b. a reel of magnetic tape on which is written in 3 files: the BCD source card deck, the binary object deck, and BCD input for a sample problem.

12. HOW TO OBTAIN PACKAGE

Inquiries or requests for the code package may be mailed to

CODES COORDINATOR
Radiation Shielding Information Center
Oak Ridge National Laboratory
Post Office Box X
Oak Ridge, Tennessee 37830

or telephoned to

Area Code 615; 483-8611, extension 3-6944, or to
FTS xx-615-483-6944.

Persons requesting the code package should send a reel of magnetic tape to the above address, or, if necessary, the code may be transmitted on cards.

13. DATE OF ABSTRACT

November 1972.

RSIC CODE PACKAGE PSR-17

1. NAME AND TITLE OF CODE

FERDOR-COOLC: Spectra Unfolding Codes.

2. CONTRIBUTOR

Neutron Physics Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Intelcom Radiation Technology, San Diego, California.

3. CODING LANGUAGE AND COMPUTER

CCC-17A: FORTRAN IV; IBM 7090 (FERDOR)

CCC-17B: FORTRAN IV; UNIVAC 1108 (FERDOR)

CCC-17C: FORTRAN IV; IBM 360 (COOLC)

4. NATURE OF PROBLEM SOLVED

FERDOR - COOLC is designed to calculate a neutron energy spectrum from a pulse-height spectrum produced by a detector system using the liquid scintillator NE-213.

5. METHOD OF SOLUTION

The program estimates the counts which would be observed in an ideal detector system having a response which is specified by the user. The solution implicitly takes into account the non-negativity of the desired neutron spectrum. The solution is obtained by finding a nearly optimal combination of slices through the spectrometer response functions such that their sum approximates the response of a channel of the ideal analyzer, and then uses the coefficients so determined to obtain an estimate of the desired neutron spectrum.

The principal difference between FERDOR and COOLC is that the latter includes provision for arranging the observed pulse-height spectrum in appropriate bins; this operation must be carried out separately in the former. Both programs require the user to furnish a matrix of actual response functions and one of idealized response functions.

6. RESTRICTIONS OR LIMITATIONS

There are none noted.

7. TYPICAL RUNNING TIME

No study of typical running time has been made by RSIC for the FERDOR sample problem.

Estimated running time of the two packaged sample problems for COOLC: 2 minutes on IBM 360/75.

8. COMPUTER HARDWARE REQUIREMENTS

FERDOR is operable on the UNIVAC 1108 and IBM 7090.

COOLC is operable on the IBM 360. For the sample problem approximately 300K bytes are required.

9. COMPUTER SOFTWARE REQUIREMENTS

The IBM 7090 version of FERDOR is written in FORTRAN II. The UNIVAC 1108 version of FERDOR is written in FORTRAN IV. A standard ASA FORTRAN IV compiler may be used for COOLC.

10. REFERENCES

Bert W. Rust and Walter R. Burrus, "Suboptimal Methods for Solving Estimation Problems," TPR-0145 (DASA 2604) (January 1971).

W. R. Burrus and V. V. Verbinski, "Fast-Neutron Spectroscopy with Thick Organic Scintillators," ORNL-TM-2225 (June 1968).

C. E. Clifford, E. A. Straker, F. J. Muckenthaler, V. V. Verbinski, R. M. Freestone, Jr., K. M. Henry, and W. R. Burrus, "Measurements of the Spectra of Uncollided Fission Neutrons Transmitted Through Thick Samples of Nitrogen, Oxygen, Carbon, and Lead: Investigation of the Minima in Total Cross Sections," Nucl. Sci. Eng. 27, 299-307 (1967).

W. R. Burrus and C. Schneeberger, "A Simple Algorithm for Computing the Generalized Inverse of a Matrix," Communications of the ACM, Vol. 9, No. 5, 381-385 (May 1966).

V. V. Verbinski, J. C. Courtney, and N. Betz, "A Method of Evaluating Fast-Neutron Differential Scattering Cross Sections with Short Experimental Runs," N.I.M. 52, 181-192 (1967)

R. L. Heath, "Data Processing Techniques for Routine Application of Gamma-Ray Scintillation Spectrometry," TID-7594, 147-158, Symposium (1960).

W. Zobel, "Spectrometry for Gamma Rays from Proton-Bombarded Nuclei," ORNL-3360, pp. 306-309 (1969).

L. Harris, Jr., H. Kendrick, Y. D. Naliboff, and S. M. Sperling, "Time-Dependent Fast Neutron and Secondary Gamma Ray Spectrum Measurements in Concrete," GA-9751, Vol. II (DASA 2401-2) Appendix B (November 1969).

H. Kendrick and S. M. Sperling, "An Introduction to the Principles and Use of the FERDOR Unfolding Code," GA-9882 (January 1970).

W. R. Burrus, "Utilization of A Priori Information by Means of Mathematical Programming in the Statistical Interpretation of Measured Distributions," ORNL-3743 (June 1965).

R. S. Booth, "A Comparison of Folding and Unfolding Techniques for Determining the Gamma Spectrum from Thermal Neutron Capture in Aluminum," N.I.M. 85, 69-76 (1970).

Informal Notes.

11. CONTENTS OF CODE PACKAGE

The package contains the following items:

- a. the referenced documents,
- b. a reel of magnetic tape on which is written in several separate files: The BCD source decks and data for PSR-17A, the BCD source only for PSR-17B, and the BCD source, data, sample problem and output listing for PSR-17C.

12. HOW TO OBTAIN PACKAGE

Inquiries or requests for the code package may be mailed to

CODES COORDINATOR
Radiation Shielding Information Center
Oak Ridge National Laboratory
Post Office Box X
Oak Ridge, Tennessee 37830

or telephoned to

Area Code 615; 483-8611, extension 3-6944, or to
FTS xx-615-483-6944.

Persons requesting the package should send a reel of magnetic tape to the above address, specifying the version desired, and indicating how the tape should be written.

13. DATE OF ABSTRACT

September 1972.

RSIC CODE PACKAGE PSR-18

1. NAME AND TITLE OF CODE

PLOTFB-I: ENDF/B Data Plotting Code.

2. CONTRIBUTOR

National Neutron Cross Section Center, Brookhaven National Laboratory, Upton, New York, and Mathematics Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

3. CODING LANGUAGE AND COMPUTER

FORTRAN IV; IBM 360.

4. NATURE OF PROBLEM SOLVED

PLOTFB-I will produce CRT (cathode ray tube) plots of ENDF/B formatted data in either BCD or binary mode. In contrast to the parent code PLOTFB, PLOTFB-I will plot quantities more directly related to experimental results. The differential cross section is now plotted in ENDF/B files 4, 5, 14, and 15. The units are millibarns per steradian and millibarns per kilo-electron volt.

5. METHOD OF SOLUTION

ENDF/B data, which may be considered as ordered pairs of data points, is scaled and plotted on the CRT plotter. Plotting is performed at the ENDF file level (MAT, MF). Neutron cross section data (Files 3 - 5), photon production data (Files 12 - 15), and photon interaction data (File 23) are plotted on request. Selective plots within a file is not allowed.

The basic input is identical to that for PLOTFB. However, for users who wish to keep track of different versions of an evaluation (e.g., the DNA data library), then column 20 of the "blank card" following the request card is used to define a MOD number.

6. RESTRICTIONS OR LIMITATIONS

Since ENDF/B utility codes exist for the purpose of producing interpreted listings of the data files, no attempt was made to maintain the listing option available in PLOTFB. In addition, a restriction has been placed on File 4 (neutron angular distributions) plots. A File 3 request must precede the File 4 request.

7. TYPICAL RUNNING TIME

Typical running times are difficult to define. Obviously, the quantity of ENDF/B data to be plotted is directly proportional to the running time. Complete plots of most evaluations contained in the DNA data library require 4 minutes or less on the IBM 360/91. The exceptions being N-14 (DNA 4133) and Fe (DNA 4180).

8. COMPUTER HARDWARE REQUIREMENTS

IBM 360 series computer with a minimum of 340K bytes of core storage. Auxiliary storage such as magnetic tape or disk devices must be available for logical units 2, 3, 4, and 20. Needless to say, a CRT plotter is required.

9. SOFTWARE REQUIREMENTS

IBM OS 360 with the FORTRAN H compiler (MVT version 20.1).

10. REFERENCES

J. E. White and R. Q. Wright, "Modification of PLOTFB for DNA Phase I Data Testing Program," Neutron Phys. Div. Ann. Progr. Rep. May 31, 1972, ORNL-4800, p. 51.

H. C. Honeck, "Description of the ENDF/B Processing Codes and Retrieval Subroutines," BNL-13582 (ENDF-110) (Rev. Sept. 1970).

11. CONTENTS OF CODE PACKAGE

The package contains the following items:

- a. the referenced documents,

- b. a reel of magnetic tape on which is written in six files the ENDF/B formatted data in BCD, the source deck and sample problem, and an output listing.

12. HOW TO OBTAIN PACKAGE

Inquiries or requests for the code package may be mailed to

CODES COORDINATOR
Radiation Shielding Information Center
Oak Ridge National Laboratory
Post Office Box X
Oak Ridge, Tennessee 37830

or telephoned to:

Area Code 615; 483-8611, extension 3-6944, or to
FTS xx-615-483-6944.

Persons requesting the package should send a reel of magnetic tape to the above address, specifying the version desired, and indicating how the tape should be written.

13. DATE OF ABSTRACT

February 1973.

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RSIC CODE PACKAGE PSR-19

1. NAME AND TITLE OF CODE

AGN-GAM - Flux Spectra and Multigroup Constant Generator.

AUXILIARY ROUTINES

INSECT: Inelastic Scattering Matrix

SCRIBBLE: Library Tape Update

POP1: Elastic Scattering Matrix

2. CONTRIBUTOR

Aerojet-General Nucleonics, San Ramon, California

3. CODING LANGUAGE AND COMPUTER

FORTRAN II and FAP; IBM 7090.

4. Nature of Problem Solved

AGN-GAM calculates the subgroup fluxes and current terms from a solution of the P_1 or B_1 equations. The P_1 equations incorporate both volume and surface sources, allowing spectral calculations in reflector regions. Other spectral options are flux known, current term calculated and both flux and current terms known. The age for the material is obtained from a second moments calculation.

5. METHOD OF SOLUTION

The method of Adler, Hinman and Nordheim is used to calculate resonance absorption and fission cross sections. Multigroup constants are generated by spectral averaging over the subgroups.

Punched card output for use in several nuclear codes can be obtained. A library of cross sections (75 subgroups) employing 180 materials; and routines to update the library are packaged.

6. RESTRICTIONS OR LIMITATIONS

32 fast groups, 33 groups down scatter, in the output matrices.

7. TYPICAL RUNNING TIME

No study of typical running time has been made by RSIC.

8. COMPUTER HARDWARE REQUIREMENTS

The code is designed for a 32K IBM 7090 with 6 tape units.

9. COMPUTER SOFTWARE REQUIREMENTS

The IBM 7090 and 7094 FORTRAN II compiler may be used.

10. REFERENCE

T. P. Wilcox and S. T. Perkins, "AGN-GAM, An IBM 7090 Code to Calculate Spectra and Multigroup Constants," AGN TM-407 (April 1965).

11. CONTENTS OF CODE PACKAGE

The package contains the following items:

- a. the referenced document,
- b. a reel of magnetic tape on which is written in 6 files: the BCD source card decks, and BCD input for a sample problem.

12. HOW TO OBTAIN PACKAGE

Inquiries or requests for the code package may be mailed to

CODES COORDINATOR
Radiation Shielding Information Center
Oak Ridge National Laboratory
Post Office Box X
Oak Ridge, Tennessee 37830

or telephoned to

Area Code 615; 483-8611, extension 3-6944, or to
FTS xx-615-483-6944.

Persons requesting the code package should send a reel of magnetic tape to the above address.

13. DATE OF ABSTRACT

November 1972.

RSIC CODE PACKAGE PSR-20

1. NAME AND TITLE OF CODE

LAPHANO: P₀ Multigroup Photon Production Matrix and Source
Vector Code for ENDF Data.

This code replaces LAPH.

AUXILIARY ROUTINES

Data should be preprocessed with CHECKER and with VIXEN to eliminate errors in format syntax and physical consistency.

2. CONTRIBUTOR

Theoretical Division, Los Alamos Scientific Laboratory, Los Alamos, New Mexico.

3. CODING LANGUAGE AND COMPUTER

FORTRAN IV; CDC 6600, CDC 7600, IBM 360, and UNIVAC 1108.

4. NATURE OF PROBLEM SOLVED

LAPHANO retrieves photon production cross sections or multiplicities and corresponding neutron interaction cross sections from the ENDF/B data file, applies suitable weighting functions over G specified photon groups and N specified neutron broad groups, and constructs a G x N photon production matrix (microscopic and/or macroscopic). As an option, it operates on this matrix with flux vectors from a neutronics code, as well as with scalar multipliers such as atom number densities and effective photon group energies, to directly provide spatially dependent photon source vectors (number or energy) for transport calculations. Multiple zones can be accommodated, with separate cross-section weighting functions for each zone. Input is in the DTF-IV (CCC-42) format and source vector output is also in this format, allowing direct coupling to DTF-IV. Complete freedom is allowed to pick those materials and reaction types for which photon production matrices are desired.

5. METHOD OF SOLUTION

LAPHANO first constructs photon production cross sections, pointwise in neutron and photon energy, from the ENDF/B data. These cross sections are then integrated over photon energy groups with either constant or direct energy weighting. After integrating over neutron energy in all neutron fine groups, weighting in neutron broad groups is by input fine-group weighting functions, usually the scalar fluxes from a fine-group neutronics calculation. Macroscopic photon production matrices and photon energy production matrices are then computed by scalar multiplication. Photon source vectors are computed by operating on these matrices with spatially dependent neutron flux vectors.

6. RESTRICTIONS OR LIMITATIONS

The microscopic pointwise data must be in ENDF format. The code is presently restricted to 99 fine or broad groups, 49 photon groups, and 50 mixture specifications.

7. TYPICAL RUNNING TIME

The central processor time on the CDC 6600 for a sample problem to produce a microscopic matrix for one material (oxygen) using 18 photon groups and 22 neutron fine and broad groups is approximately one minute. The same problem on the CDC 7600 executes in approximately 18 seconds.

8. COMPUTER HARDWARE REQUIREMENTS

(a) CDC 6600 and 7600: 65 k_{10} words of memory; (b) one magnetic tape -- the ENDF data tape is designated as tape 20. All other tapes are virtual tapes on disk, extended core storage, or other peripheral storage device.

9. COMPUTER SOFTWARE REQUIREMENTS

The code runs under the CDC SCOPE 3.1.2 System (locally modified) for the CDC 6600, and under the LASL CROS System for the CDC 7600.

10. REFERENCES

Donald J. Dudziak, Alan H. Marshall, and Robert E. Seamon, "LAPH: A Multigroup Photon Production Matrix and Source Vector Code for ENDF/B," LA-4337 (1969).

Donald J. Dudziak, Robert E. Seamon, and Dante V. Susco, "LAPHANO: A P₀ Multigroup Photon Production Matrix and Source Code for ENDF," LA-4750-MS (ENDF-156) (1971).

Henry C. Honeck, "Retrieval Subroutines for the ENDF/B System," BNL-13582 (ENDF-110) (1967). (Revised CHECKER code by Oak Ridge National Laboratory, 1970.)

Donald J. Dudziak and Johnny M. Romero, "VIXEN, A Physical Consistency Checking Code for Photon Production Data in Revised ENDF Format," LA-4739 (1971).

11. CONTENTS OF CODE PACKAGE

The package contains the following items:

- a. the first two referenced documents,
- b. a reel of magnetic tape on which is written the following files:
 - (1) a card-image copy of the BCD source deck which is operable on the CDC 6600,
 - (2) the sample problem input in BCD card image,
 - (3) the sample problem output listing (run on the CDC 6600),
 - (4) an INDEX (cross reference) listing of the source deck, and
 - (5) the ENDF data for the sample problem.

12. HOW TO OBTAIN PACKAGE

Inquiries or requests for the code package may be mailed to

CODES COORDINATOR
 Radiation Shielding Information Center
 Oak Ridge National Laboratory
 Post Office Box X
 Oak Ridge, Tennessee 37830

or telephoned to

Area Code 615, 483-8611, extension 3-6944, or to
FTS xx-615-483-6944.

Persons requesting the package should send one reel of magnetic
tape to the above address.

13. DATE OF ABSTRACT

September 1972.

RSIC CODE PACKAGE PSE-21

1. NAME AND TITLE OF CODE

PHOX: Code to Check Syntax and Physical Realism of Photon
Production Data.

AUXILIARY ROUTINE

CHECKER: A Format Syntax Checking Code for ENDF/B.

2. CONTRIBUTOR

Los Alamos Scientific Laboratory, Los Alamos, New Mexico.

3. CODING LANGUAGE AND COMPUTER

FORTTRAN IV: (A) CDC 6600, PHOXE
(B) IBM 360, PHOXE
(C) B 5500, PHOX.

4. NATURE OF PROBLEM SOLVED

An ENDF/B data tape is read and checks are made on the data in Files 3, 14, and 15 (neutron interaction cross sections, photon angular distributions, and photon production multiplicities or cross sections, respectively). These checks are for physical realism and internal consistency. Suspected errors are flagged, assumptions are made to resolve inconsistencies if necessary, and an attempt is made to continue processing. The data should be preprocessed by the CHECKER code to detect and remove most format syntax errors.

5. METHOD OF SOLUTION

Typical checks are (1) threshold energies against Q values, (2) reasonable sign and magnitude of Q , (3) consistency and reasonableness of level energies and photon energies, (4) total photon energy released against reaction energetics, etc. The code is in a dynamic state of development, so successive versions include additional checks.

6. RESTRICTIONS AND LIMITATIONS

There are no restrictions other than those imposed by the ENDF format and procedures.

7. TYPICAL RUNNING TIME

The central processor time on a CDC 6600 for the sodium data in the reference document (the sample problem in the code package) is less than one minute.

Estimated running time of packaged sample problem on the IBM 360/91: Go Step, CPU, 15.62 seconds.

8. COMPUTER HARDWARE REQUIREMENTS

IBM 360/75/91 uses standard I-O and one additional tape unit. (Go Step REGION USED: 228K).

The CDC 6600 version requires 65K memory and an additional tape unit.

9. COMPUTER SOFTWARE REQUIREMENTS

The code runs under the SCOPE 3.2 System for the CDC 6600 and is also operable on the IBM 360/75/91 Operating System using OS-360 FORTRAN H-Compiler. An ENDF/B data library is required.

10. REFERENCES

Donald J. Dudziak, "PHOXE: A FORTRAN IV Code to Check Format Syntax, Consistency, and Physical Realism of ENDF/B Photon Production Data," LA-4506-MS or ENDF-140 (September 1970).

Donald J. Dudziak, "Translation to ENDF/B and 'Physics' Checking of Cross Sections for Shielding," DAS 2379 or ENDF-130, University of Virginia (1969).

11. CONTENTS OF CODE PACKAGE

The package contains the following items:

- a. the referenced documents,

- b. a reel of magnetic tape on which is written in several files:
the BCD source card deck, BCD input for a sample problem, and BCD data (sodium) in the ENDF format. Output for the sample problem is written on tape for B (IBM 360) version only.

12. HOW TO OBTAIN PACKAGE

Inquiries or requests for the code package may be mailed to

CODES COORDINATOR
Radiation Shielding Information Center
Oak Ridge National Laboratory
Post Office Box X
Oak Ridge, Tennessee 37830

or telephoned to

Area Code 615; 483-8611, extension 3-6944, or to
FTS 615-483-6944.

Persons requesting the code package should send a reel of magnetic tape to the above address.

13. DATE OF ABSTRACT

May 1972.



RSIC CODE PACKAGE PSR-22

1. NAME AND TITLE OF CODE

RICE: Calculation of Primary Recoil Atom Spectra from ENDF/B Data.

The code package is also available from the Argonne Code Center.

2. CONTRIBUTOR

Reactor Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

3. CODING LANGUAGE AND COMPUTER

FORTRAN IV; IBM 360.

4. NATURE OF PROBLEM SOLVED

The program calculates an energy exchange matrix which describes the probability that a neutron with energy E will produce a recoil atom with energy T in a given material. In addition, it can calculate the primary recoil atom energy spectrum for a given neutron spectrum, the damage cross section for the material, and an optimum lower energy limit for use in comparing the relative damage in different reactor spectra. RICE accepts neutron scattering data directly from the ENDF/B library tapes and, in the case of a resonance nuclide, from a tape generated by SUPERTOG (PSR-13).

5. METHOD OF SOLUTION

The energy transfer matrix is obtained from a solution of the two body kinematic equations. The solution incorporates information on anisotropic elastic scattering and inelastic scattering available from ENDF/B. Damage cross sections and primary recoil spectra are obtained by combining the energy transfer matrix with suitable secondary displacement models and neutron flux spectra.

RICE lacks the capability of calculating elastic scattering cross sections from resonance parameters. The code SUPERTO (ORNL-TM-2679) can be used to produce smooth elastic scattering cross sections for RICE in cases where resonance parameters are included in the ENDF/B data. The multigroup codes GAM-II, ANISN (CCC-82), and XSDRN (CCC-123) can be used to produce neutron spectra for use in RICE.

6. RESTRICTIONS AND LIMITATIONS

RICE does not recognize all of the multiplicity of data formats allowed by ENDF/B. It is programmed to accept the most prevalent formats. These restrictions are described in detail in the program manual. In addition, the neutron energy distribution is restricted to a 99-group representation and the recoil energies are represented by 200 energy groups.

7. TYPICAL RUNNING TIME

Running time on the IBM 360/75 for one element with all options requested is approximately 10 min.

8. COMPUTER HARDWARE REQUIREMENTS

The code was designed for and is operable on the IBM 360. Approximately 110,000 words of core storage and five I/O devices, excluding input-output and system requirements, are needed. A plotting routine makes use of ORNL system subroutines and a Calcomp CTR plotter.

9. COMPUTER SOFTWARE REQUIREMENTS

The packaged code has been run on the IBM OS/360 Operating System with the FORTRAN H compiler.

10. REFERENCE

J. D. Jenkins, "RICE: A Program to Calculate Primary Recoil Atom Spectra from ENDF/B Data," ORNL-TM-2706 (1970).

11. CONTENTS OF CODE PACKAGE

The package contains the following items:

- a. the referenced document,
- b. a reel of magnetic tape on which is written in 6 files: the BCD source card decks, BCD input for a sample problem, punched card output, and a BCD output listing from running the sample problem.

12. HOW TO OBTAIN PACKAGE

Inquiries or requests for the code package may be mailed to

CODES COORDINATOR
Radiation Shielding Information Center
Oak Ridge National Laboratory
Post Office Box X
Oak Ridge, Tennessee 37830

or telephoned to

Area Code 615; 483-8611, extension 3-6944, or to
FTS xx-615-483-6944.

Persons requesting the code package should send a reel of magnetic tape to the above address.

13. DATE OF ABSTRACT

November 1972.

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RSIC CODE PACKAGE PSR-23

1. NAME AND TITLE OF CODE

SPECTER: Calculation of Energy Distribution of Nuclear Reaction Products.

2. CONTRIBUTOR

Teledyne Brown Engineering Company, Huntsville, Alabama.

3. CODING LANGUAGE AND COMPUTER

FORTRAN IV; IBM 360 (PSR-23A) and 7094 (PSR-23B).

4. NATURE OF PROBLEM SOLVED

Specter calculates the energy spectra of particles emerging from reactions of the types (y,n) , (y,p) , (y,α) , $(y,2n)$, (y,np) , (y,pn) , and $(y,2p)$, where the incident particle y may be either n , p , or α . In addition, the code calculates the cross section for each of these reactions.

5. METHOD OF SOLUTION

SPECTER is an outgrowth of EDISN (PSR-6). Whereas EDISN is capable of handling only (n,n') and $(n,2n)$ reactions, SPECTER can treat all the reactions specified above. SPECTER makes use of the Weisskopf-Ewing formula to calculate the energy distributions and reaction cross sections. The cross sections for compound-nucleus formation that are needed in evaluating this formula are calculated by the continuum theory of nuclear reactions. Data required as input are the bombarding energy, the masses of all nuclear species taking part in the reaction, and certain parameters that specify the level density of participating nuclei.

For completeness, a subroutine for calculating the nuclear level density has been included. This subroutine makes use of the commonly adopted level density formula $\rho = C \exp(2aU)^{1/2}$ derived from the Fermi gas model. U is obtained by adjusting the excitation

energy to account for the pairing energy. The user may wish to employ some other analytic expression for ρ or a table of values. In this event the subroutine may be suitably modified or replaced.

A table of cross sections for compound nucleus formation as a function of bombarding energy and target mass number is generated during the first run and written on magnetic tape for use in all subsequent runs. These cross sections are calculated by the continuum theory. Optionally the user could perform a more sophisticated treatment by replacing this table by a similar one generated from optical model calculations.

6. RESTRICTIONS OR LIMITATIONS

Ideally the code is suited to reactions which proceed through the formation of a compound nucleus (CN). In cases, however, in which the direct interaction mechanism (DI) is also operative, the code is useful in estimating the relative contribution from direct effects, provided the entire cross section for the process, $\sigma_{\text{CN+DI}}$, be known, e.g., from experiment. In addition, it is required that the level structures for all residual nuclei be adequately described by continuous level densities.

7. TYPICAL RUNNING TIME

Running time is highly dependent on the number of energy increments used in the numerical integrations. The maximum degree of accuracy is attained with 50 increments. In this case a typical calculation on ^{56}Fe at 14 MeV which takes into consideration the reactions (n,n'), (n,2n), and (n,p) takes about three minutes on IBM 7094 time.

8. COMPUTER HARDWARE REQUIREMENTS

The code was designed for the IBM 7094 and is also operable on the IBM 360. 29K of memory is required. However, with some sacrifice in accuracy this requirement may be relaxed considerably by the reduction of certain array dimensions.

9. COMPUTER SOFTWARE REQUIREMENTS

Standard Monitor systems are used; IBSYS Version 13, IBM 7094 and H-level compiler on IBM 360.

10. REFERENCE

R. Snow and M. C. George, "A Computer Code for Calculating the Energy Distribution of Nuclear Reaction Products," SMSD-SSL-1100 (February 1970).

11. CONTENTS OF CODE PACKAGE

The package contains the following items:

- a. the referenced document,
- b. a reel of magnetic tape for each hardware version (A,B) on which is written in 3 files: the BCD source card deck, BCD input for a sample problem and the BCD output listing from running it.

12. HOW TO OBTAIN PACKAGE

Inquiries and requests for the code package may be mailed to

CODES COORDINATOR
Radiation Shielding Information Center
Oak Ridge National Laboratory
Post Office Box X
Oak Ridge, Tennessee 37830

or telephoned to

Area Code 615; 483-8611, extension 3-6944, or to
FTS xx-615-483-6944.

Persons requesting the code package should send a reel of magnetic tape to the above address, specifying which version is wanted and how the tape is to be written.

13. DATE OF ABSTRACT

November 1972.

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RSIC CODE PACKAGE PSR-24

1. NAME AND TITLE OF PACKAGE

IER: Integral Evaluation Routines

AUXILIARY ROUTINES

SIR: Sievert's Integral

ENOFX: Exponential Integral

2. CONTRIBUTORS

University of Tulsa and Warren Research Foundation (SIR).

Neutron Physics Division, Oak Ridge National Laboratory (ENOFX).

3. CODING LANGUAGE AND COMPUTER

FORTRAN, IBM 360.

4. NATURE OF PROBLEM SOLVED

SIR is designed to evaluate Sievert's Integral

$$F(x, \theta) = \int_0^{\theta} \exp(-x \sec y) dy .$$

ENOFX is designed for the exponential integrals

$$E_n(x) = x^{n-1} \int_x^{\infty} \exp(-y) y^{-n} dy = \int_1^{\infty} \exp(-xt) t^{-n} dt$$

where $E_n(x)$ is solved for all n from 1 to a specified N .

SIR and ENOFX may be used as subroutines in any program to evaluate the above integrals. Main routines are provided in the package as examples. They provide a table of values similar to published tables. The SIR-1 program produces the referenced table for $0 \leq x \leq 10$ and $\theta = 10^\circ, 20^\circ, 30^\circ, 50^\circ, 60^\circ, 75^\circ, \text{ and } 90^\circ$.

The SIR-2 program produces a 4-page table similar to SIR-1, but with $0 \leq x \leq 30$, and $\theta = 1^\circ-10^\circ, 12^\circ, 14^\circ, 16^\circ, 18^\circ, 20^\circ, 25^\circ, 30^\circ, 35^\circ, 40^\circ, 45^\circ, 50^\circ, 55^\circ, 60^\circ, 65^\circ, 70^\circ, 75^\circ, 80^\circ, 85^\circ, \text{ and } 90^\circ$.

5. METHOD OF SOLUTION

SIR: A Gauss-based quadrature formula is applied to Sievert's integral.

ENOFX: The Maclaurin series is used for $x \leq 2$ and an asymptotic expansion for $x > 2$. The recurrence relation

$$E_{n+1}(x) = \frac{1}{n} [e^{-x} - xE_n(x)] \text{ for } n \geq 1$$

is used to generate higher order integrals.

6. RESTRICTIONS OR LIMITATIONS

None noted.

7. TYPICAL RUNNING TIME

Estimated running time of the packaged sample problems on the IBM 360 computer: SIR, 3 seconds/table; ENOFX, 2 seconds/table.

8. COMPUTER HARDWARE REQUIREMENTS

The packaged codes are operable on the IBM 360.

9. COMPUTER SOFTWARE REQUIREMENTS

A standard IBM 360 compiler was used by RSIC: G-level for SIR and H-level for ENOFX.

10. REFERENCES

C. Farmer, D. S. Gooden, and S. Hogarth, "On a Gauss Based Integration Formula for the Sievert Integral," Informal Notes (1970).

M. Abramovitz and I. A. Stegun (editors), Handbook of Mathematical Functions, with Formulas, Graphs, and Mathematical Tables, Dover, New York (1966), MR 34 #8606, page 228 and 1000.

Margaret V. Brady, V. R. Cain, and D. K. Trubey, "Notes on ENOFX and Sample Calling Program," Informal Notes (1970).

11. CONTENTS OF CODE PACKAGE

The package contains the following items:

- a. the referenced documents,
- b. a reel of magnetic tape on which is written in 11 files: the BCD source card decks for each routine, BCD input for sample problems, and output listings from running them.

12. HOW TO OBTAIN THE PACKAGE

Inquiries or requests for the code package may be mailed to

CODES COORDINATOR
Radiation Shielding Information Center
Oak Ridge National Laboratory
Post Office Box X
Oak Ridge, Tennessee 37830

or telephoned to

Area Code 615; 483-8611, extension 3-6944, or to
FTS xx-615-483-6944.

Persons requesting the code package should send a reel of magnetic tape to the above address.

13. DATE OF ABSTRACT

September 1972.

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RSIC CODE PACKAGE PSR-25

1. NAME AND TITLE OF CODE

DUCAL: Neutron-Capture Gamma-Ray Cascade Model.

2. CONTRIBUTOR

Neutron Physics Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

3. CODING LANGUAGE AND COMPUTER

FORTRAN IV and Assembler Language; IBM 360.

4. NATURE OF PROBLEM SOLVED

The neutron capture gamma-ray cascade is described by a combined experimental and theoretical approach. The theoretical part of the model is largely statistical. In describing the radiative transition probabilities, the model explicitly accounts for the spin and parity of the initial and final states. Presently, only dipole and quadrupole transitions are allowed.

5. METHOD OF SOLUTION

Primary line intensities derived from experimental data are parameterized. A numerical method is then used to "extrapolate and interpolate" the measured data.

6. RESTRICTIONS OR LIMITATIONS

None noted.

7. TYPICAL RUNNING TIME

No study has been made by RSIC as to typical running time.

8. COMPUTER HARDWARE REQUIREMENTS

The code was designed for and is operable on the IBM 360.

9. COMPUTER SOFTWARE REQUIREMENTS

The standard IBM 360/75 Monitor System was used. A random number generator and a nonstandard library subroutine are written in Assembler Language for the IBM 360.

10. REFERENCES

K. J. Yost, "A Method for Calculation of Neutron-Capture Gamma-Ray Spectra," Nucl. Sci. Eng. 32, 62-75 (1968).

John White, "Description of I-O Operations," unpublished Memo (1970).

11. CONTENTS OF CODE PACKAGE

The package contains the following items:

- a. the referenced documents,
- b. a reel of magnetic tape on which is written in 5 files: two assembler language routines, the BCD source card deck (FORTRAN), BCD input for a sample problem and a BCD output listing of the sample problem.

12. HOW TO OBTAIN PACKAGE

Inquiries or requests for the code package may be mailed to

CODES COORDINATOR
Radiation Shielding Information Center
Oak Ridge National Laboratory
Post Office Box X
Oak Ridge, Tennessee 37830

or telephoned to

Area Code 615; 483-8611, extension 3-6944, or to
FTS xx-615-483-6944.

Persons requesting the code package should send a reel of magnetic tape to the above address.

13. DATE OF ABSTRACT

November 1972.