```
======================================================================= Recent
                                                                        Recent
     PROGRAM RECENT                                                     Recent
     ==============                                                     Recent
     VERSION 79-1 (OCTOBER 1979)  CDC-7600                              Recent
     VERSION 80-1 (MAY 1980)      IBM, CDC AND CRAY VERSION             Recent
     VERSION 80-2 (DECEMBER 1980) IMPROVED TREATMENT OF UNRESOLVED      Recent
                                  REGION TO COMPUTE ALL REACTIONS AT    Recent
                                  THE SAME TIME.                        Recent
     VERSION 81-1 (MARCH 1981)  IMPROVED BASED ON USER COMMENTS.        Recent
     VERSION 81-2 (AUGUST 1981) ADDED MONITOR MODE. ADDED SPEED OPTION  Recent
                                TO BYPASS BACKWARDS THINNING IF FILE 3  Recent
                                ALLOWABLE ERROR = 0.0 (NOTE THIS OPTION Recent
                                WILL RESULT IN ALL TABULATED POINTS     Recent
                                FROM THE EVALUATION BEING KEPT IN THE   Recent
                                OUTPUT FROM THIS PROGRAM).              Recent
     VERSION 82-1 (JANUARY 1982) IMPROVED COMPUTER COMPATIBILITY.       Recent
     VERSION 83-1 (JANUARY 1983)*MAJOR RE-DESIGN.                       Recent
                                *PAGE SIZES INCREASED.                  Recent
                                *ELIMINATED COMPUTER DEPENDENT CODING.  Recent
                                *NEW, MORE COMPATIBLE I/O UNIT NUMBERS. Recent
                                *ADDED OPTION TO KEEP ALL RECONSTRUCTED Recent
                                 AND BACKGROUND ENERGY POINTS.          Recent
                                *ADDED STANDARD ALLOWABLE ERROR OPTIONS Recent
                                 (CURRENTLY 0.1 PER-CENT RECONSTRUCTION Recent
                                 AND 0.0 PER-CENT THINNING).            Recent
     VERSION 83-2 (OCTOBER 1983) IMPROVED BASED ON USER COMMENTS.       Recent
     VERSION 84-1 (JANUARY 1984) IMPROVED INTERVAL HALFING CONVERGENCE. Recent
     VERSION 85-1 (APRIL 1985)  *A BRAND NEW PROGRAM WHICH COMPLETELY   Recent
                                 SUPERCEDES ALL PREVIOUS VERSIONS OF    Recent
                                 THIS PROGRAM.                          Recent
                                *UPDATED FOR ENDF/B-VI FORMATS.         Recent
                                *ADDED GENERAL REICH-MOORE FORMALISM    Recent
                                 (WITH TWO FISSION CHANNELS).           Recent
                                *DECREASED RUNNING TIME.                Recent
                                *SPECIAL I/O ROUTINES TO GUARANTEE      Recent
                                 ACCURACY OF ENERGY.                    Recent
                                *DOUBLE PRECISION TREATMENT OF ENERGY   Recent
                                 (REQUIRED FOR NARROW RESONANCES).      Recent
     VERSION 85-2 (AUGUST 1985) *FORTRAN-77/H VERSION                   Recent
     VERSION 86-1 (JANUARY 1986)*ENERGY DEPENDENT SCATTERING RADIUS     Recent
     VERSION 86-2 (JUNE 1986)   *IF FIRST CHANCE FISSION (MT=19)        Recent
                                 BACKGROUND IS PRESENT ADD RESONANCE    Recent
                                 CONTRIBUTION OF FISSION TO IT.         Recent
     VERSION 86-3 (OCTOBER 1986)*MULTI-LEVEL OR REICH-MOORE..CORRECT    Recent
                                 POTENTIAL SCATTERING CROSS SECTION FOR Recent
                                 MISSING AND/OR FICTICIOUS (L,J)        Recent
                                 SEQUENCES.                             Recent
     VERSION 87-1 (JANUARY 1987)*IMPROVED COMBINING FILE 2+3            Recent
     VERSION 87-2 (MARCH 1987)  *CORRECTED ADLER-ADLER CALCULATIONS.    Recent
     VERSION 88-1 (JULY 1988)   *UPDATED REICH-MOORE ENDF/B-VI FORMAT   Recent
                                 TO BE THE SAME AS REICH-MOORE FORMAT   Recent
                                 IN EARLIER VERSIONS OF ENDF/B FORMAT.  Recent
                                *CHECK FOR PRELIMINARY ENDF/B-VI        Recent
                                 REICH-MOORE FORMAT (NOW ABANDONED)     Recent
                                 AND TERMINATE EXECUTION IF DATA IS     Recent
                                 IN THIS FORMAT.                        Recent
                                *CALCULATE CHANNEL RADIUS OR SET IT     Recent
                                 EQUAL TO THE SCATTERING RADIUS.        Recent
                                *IMPLEMENTED HYBRID R-FUNCTION WITH THE Recent
                                 FOLLOWING RESTRICTIONS                 Recent
                                 - ONLY INELASTIC COMPETITION (NO       Recent
                                   CHARGED PARTICLES)                   Recent
                                 - NO TABULATED FILE 2 BACKGROUND       Recent
                                 - NO TABULATED OPTICAL MODEL PHASE     Recent
                                   SHIFT                                Recent
                                *PROGRAM EXIT IF GENERAL R-MATRIX IN    Recent
                                 THE EVALUATION (THIS FORMALISM WILL    Recent
                                 BE IMPLEMENTED ONLY AFTER THE AUTHOR   Recent
                                 RECEIVES REAL EVALUATIONS WHICH USE    Recent
                                 THIS FORMALISM...UNTIL THEN IT IS      Recent
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                          IMPOSSIBLE TO ADEQUATELY TEST THAT     Recent
                          THE CODING FOR THIS FORMALISM IS       Recent
                          CORRECT).                              Recent
                         *INCREASED MAXIMUM NUMBER OF RESONANCES Recent
                          FROM 1002 TO 4008.                     Recent
                         *DOUBLE PRECISION RESONANCE REGION      Recent
                          LIMITS.                                Recent
                         *FILE 2 AND FILE 3 ENERGIES WHICH ARE   Recent
                          NEARLY EQUAL ARE TREATED AS EQUAL      Recent
                          (I.E., SAME TO ABOUT 9 DIGITS).        Recent
                         *CHECK FILE 3 BACKGROUND CROSS SECTIONS Recent
                          IN EDIT MODE.                          Recent
                         *OPTION...INTERNALLY DEFINE FILENAMES   Recent
                          (SEE SUBROUTINE FILEIO FOR DETAILS).   Recent
VERSION 89-1 (JANUARY 1989)*PSYCHOANALYZED BY PROGRAM FREUD TO   Recent
                          INSURE PROGRAM WILL NOT DO ANYTHING    Recent
                          CRAZY.                                 Recent
                         *UPDATED TO USE NEW PROGRAM CONVERT     Recent
                          KEYWORDS.                              Recent
                         *CORRECTED MULTILEVEL, REICH-MOORE AND  Recent
                          HYBRID R-FUNCTION POTENTIAL SCATTER    Recent
                          TO ACCOUNT FOR REPEATED J-VALUES FOR   Recent
                          THE SAME TARGET SPIN AND L-VALUE.      Recent
                         *ADDED LIVERMORE CIVIC COMPILER         Recent
                          CONVENTIONS.                           Recent
                         *UPDATED TO USE NEW ENDF/B-VI           Recent
                          CONVENTION TO ALLOW UNRESOLVED         Recent
                          RESONANCE CONTRIBUTION TO ALREADY      Recent
                          BE INCLUDED IN THE FILE 3 CROSS        Recent
                          SECTIONS (INFINITELY DIULUTE           Recent
                          CONTRIBUTION).                         Recent
VERSION 90-1 (JUNE 1990)  *UPDATED BASED ON USER COMMENTS        Recent
                         *ADDED FORTRAN SAVE OPTION              Recent
                         *NEW MORE CONSISTENT ENERGY OUTPUT      Recent
                          ROUTINE                                Recent
VERSION 91-1 (JULY 1991)  *NEW UNIFORM TREATMENT OF ALL RESONANCE Recent
                          FORMALISMS (SEE, COMMENTS BELOW)       Recent
                         *NEW REICH-MOORE ALGORITHM              Recent
                         *MORE EXTENSIVE ERROR CHECKING AND      Recent
                          ERROR MESSAGE EXPLANATIONS             Recent
VERSION 92-1 (JANUARY 1992)*MAJOR RESTRUCTING TO IMPROVE ACCURACY Recent
                          AND COMPUTER INDEPENDENCE.             Recent
                         *INCREASED ENERGY POINT PAGE SIZE FROM  Recent
                          1002 TO 4008.                          Recent
                         *NO MORE THAN 2 ENERGY POINTS WHERE     Recent
                          CROSS SECTION IS ZERO AT BEGINNING     Recent
                          OF A SECTION FOR EACH REACTION,E.G.,   Recent
                          THRESHOLD FISSION.                     Recent
                         *PROCESS ONLY A PORTION OF RESONANCE    Recent
                          REGION - SEE EXPLANATION BELOW         Recent
                         *ALL ENERGIES INTERNALLY ROUNDED PRIOR  Recent
                          TO CALCULATIONS.                       Recent
                         *COMPLETELY CONSISTENT I/O AND ROUNDING Recent
                          ROUTINES - TO MINIMIZE COMPUTER        Recent
                          DEPENDENCE.                            Recent
VERSION 93-1 (MARCH 1993)  *UPDATED REICH-MOORE TREATMENT TO USE  Recent
                          L DEPENDENT SCATTERING RADIUS (APL)    Recent
                          RATHER THAN SCATTERING RADIUS (AP)     Recent
                          (SEE, ENDF/B-VI FORMATS AND            Recent
                           PROCEDURES MANUAL, PAGE 2.6)          Recent
                         *INCREASED PAGE SIZE FROM 4008 TO       Recent
                          20040 DATA POINTS.                     Recent
                         *INCREASED MAXIMUM NUMBER OF RESONANCES Recent
                          FROM 4008 TO 20040.                    Recent
VERSION 94-1 (JANUARY 1994)*VARIABLE ENDF/B DATA FILENAMES       Recent
                          TO ALLOW ACCESS TO FILE STRUCTURES     Recent
                          (WARNING - INPUT PARAMETER FORMAT      Recent
                          HAS BEEN CHANGED).                     Recent
                         *CLOSE ALL FILES BEFORE TERMINATING     Recent
                          (SEE, SUBROUTINE ENDIT)                Recent
VERSION 94-2 (AUGUST 1994) *CORRECTED ADDJ FOR ENERGY DEPENDENT  Recent
```

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                          (TABULATED) SCATTERING RADIUS CASE.    Recent
VERSION 96-1 (JANUARY 1996) *COMPLETE RE-WRITE                   Recent
                          *IMPROVED COMPUTER INDEPENDENCE        Recent
                          *ALL DOUBLE PRECISION                  Recent
                          *ON SCREEN OUTPUT                      Recent
                          *UNIFORM TREATMENT OF ENDF/B I/O       Recent
                          *IMPROVED OUTPUT PRECISION             Recent
                          *ALWAYS INCLUDE THERMAL VALUE          Recent
                          *DEFINED SCRATCH FILE NAMES            Recent
VERSION 97-1 (APRIL 1997)   *OPTIONAL MAKE NEGATIVE CROSS        Recent
                            SECTION = 0 FOR OUTPUT               Recent
                          *INCREASED PAGE SIZE FROM 20040 TO     Recent
                          120000 DATA POINTS.                    Recent
                          *INCREASED MAXIMUM NUMBER OF RESONANCES Recent
                          FROM 20040 TO 120000.                  Recent
VERSION 99-1 (MARCH 1999)   *CORRECTED CHARACTER TO FLOATING     Recent
                            POINT READ FOR MORE DIGITS           Recent
                          *UPDATED TEST FOR ENDF/B FORMAT        Recent
                           VERSION BASED ON RECENT FORMAT CHANGE Recent
                          *UPDATED CONSTANTS BASED ON CSEWG      Recent
                           SUBCOMMITTEE RECOMMENDATIONS          Recent
                          *GENERAL IMPROVEMENTS BASED ON         Recent
                           USER FEEDBACK                         Recent
VERSION 99-2 (JUNE 1999)    *IMPLEMENTED NEW REICH-MOORE FORMALISM Recent
                            TO ALLOW DEFINITION OF (L,J,S) FOR   Recent
                            EACH SEQUENCE.                       Recent
                          *ASSUME ENDF/B-VI, NOT V, IF MISSING   Recent
                           MF=1, MT-451.                         Recent
VERS. 2000-1 (FEBRUARY 2000)*GENERAL IMPROVEMENTS BASED ON       Recent
                           USER FEEDBACK                         Recent
VERS. 2002-1 (MAY 2002)     *OPTIONAL INPUT PARAMETERS           Recent
             (SEPT. 2002)   *OUTPUT RESONANCE WITH 9 DIGITS      Recent
                          *TO BE C AND C++ COMPATIBLE OUTPUT     Recent
VERS. 2004-1 (JAN. 2004)    *ADDED INCLUDE 'recent.h'            Recent
                          *MADE ENDF/B-VII READY                 Recent
                          *UPDATED FOR NEW REICH-MOORE LRF=7     Recent
                           PARAMETERS WITH COMPETITION           Recent
                          *ADDED COULOMB PENETRATION FACTORS FOR Recent
                           LRF=7 COMPETITIVE CHANNELS.           Recent
                          *EXTENDED DEFINITIONS OF PENETRATION   Recent
                           FACTOR, LEVEL SHIFT FACTOR, AND       Recent
                           POTENTIAL SCATTERING PHASE SHIFT      Recent
                           ABOVE L = 5 TO INFINITY.              Recent
                          *ADDED QUICK CALCULATION - IF THE      Recent
                           INPUT ALLOWABLE ERROR IS 1.0 OR MORE  Recent
                           (100 % OR MORE) THERE IS NO ITERATION Recent
                           TO CONVERGENCE - CROSS SECTION ARE    Recent
                           QUICKLY CALCULATED ONLY AT A FIXED    Recent
                           SET OF ENERGY POINTS, BASED ON THE    Recent
                           ENERGY AND WIDTH OF ALL RESONANCES.   Recent
                           THIS CAN BE USED TO QUICKLY "SEE"     Recent
                           NEW EVALUATIONS THAT MAY CONTAIN      Recent
                           ERRORS, THAT WOULD OTHERWISE CAUSE    Recent
                           THIS CODE TO RUN FOR AN EXCESSIVELY   Recent
                           LONG TIME.                            Recent
VERS. 2005-1 (JUNE 2005)    *ADDED ENERGY DEPENDENT SCATTERING   Recent
                            RADIUS FOR ALL RESONANCE TYPES       Recent
                            (EARLIER ONLY BREIT-WIGNER ALLOWED). Recent
VERS. 2007-1 (JAN. 2007)    *CHECKED AGAINST ALL ENDF/B-VII.     Recent
                          *DECOUPLED PAGE SIZE FROM MAX. # OF    Recent
                           RESONANCES.                           Recent
                          *INCREASED PAGE SIZE FROM 120,000 TO   Recent
                           750,000 DATA POINTS.                  Recent
                          *KEPT MAX. # OF RESONANCE AT 120,000.  Recent
                          *CORRECTED ALL BACKGROUND = 0 CASE     Recent
VERS. 2007-2 (OCT. 2007)    *NO MT=19 OUTPUT IF NO BACKGROUND,   Recent
                            REGARDLESS OF INPUT OPTION.          Recent
                          *72 CHARACTER FILE NAMES.              Recent
VERS. 2008-1 (FEB. 2008)    *CORRECTED NAPS ERROR - NOW DEFINE FOR Recent
                            ALL TYPES OF PARAMETERS - EARLIER    Recent
                            ONLY DEFINED FOR B-W PARAMETERS.     Recent
```

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VERS. 2008-2 (APRIL 2008)   *CORRECTED NRO/NAPS=1/1 - MUST          Recent
                             DEFINE RHOX2 AT EACH RESONANCE USING  Recent
                             SETRHO1 BEFORE ENERGY DEPENDENT       Recent
                             CALCULATION.                          Recent
                            *ADDED PRECISION TO RESONANCE PROFILE  Recent
                             IN SUBROUTINE SUBINT                  Recent
VERS. 2009-1 (JULY 2009)    *NEW REICH-MOORE COMPETITIVE WIDTHS -  Recent
                             IF CHARGED PARTICLE REACTION (MT=103  Recent
                             THROUGH 107) WILL ADD RESONANCE       Recent
                             CONTRIBUTION TO COMPETITIVE MT AND IF Recent
                             PRESENT, THE GROUND LEVEL, MT = 600   Recent
                             THROUGH 800. IF COMPETITIVE CHANNEL   Recent
                             IS mt=4 (TOTAL N.N') IT WILL ALSO ADD Recent
                             COMPETITIVE RESONANCE CONTRIBUTION TO Recent
                             MT=50 (N,N' GROUND).                  Recent
                            *NEW REICH-MOORE - SUM COMPETITIVE     Recent
                             WIDTHS IF ALL FOR THE SAME STATE (MT) Recent
VERS. 2009-2 (AUG. 2009)    *RE-WRITE TO USE 12, RATHER THAN 6,    Recent
                             PAAMETERS PER RESONANCE.              Recent
                            *MAJOR RE-WRITE TO ACCOMODATE GENERAL  Recent
                             REICH-MOORE (LRF=7).                  Recent
                            *COMPLETE RE-WRITE FOR ADLER-ADLER     Recent
                             AND HRF (N O LONGER USED IN ENDF/B)   Recent
                             TO USE 12 PARAMETERS PER RESNANCE.    Recent
VERS. 2010-1 (April 2010)   *ADDED SAMRML LOGIC TO HANDLE ALL      Recent
                             LRF=7 CASES.                          Recent
                            *EXTENDED SAMRML LOGIC TO PROCESS ALL  Recent
                             EVALUATIONS = RESOLVED + UNRESOLVED + Recent
                             TABULATED - SAMRML ONLY DOES ONE      Recent
                             SECTION OF RESOLVED LRF=7 DATA        Recent
                             WITHOUT TABULATED BACKGROUND.         Recent
                            *UPDATED ELASTIC POTENTIAL CALCULATION Recent
                             FOR TOTAL (SLBW) AND CORRECTION FOR   Recent
                             MISSING SEQUENCES (MLBW, RM, HRF).    Recent
                            *ADDED HIDDEN (OPTIONAL) UNRESOLVED    Recent
                             COMPETITION LISTING (NOT ENDF/B).     Recent
                            *ADDED BOB MACFARLANE'S PROPOSAL - USE Recent
                             LRX TO DEFINE COMPETITIVE L VALUE -   Recent
                             COMPETITIVE L = LRX - 1, IF LRX > 0.  Recent
                            *CHECKED FOR NEGATIVE WIDTHS.          Recent
VERS. 2012-1 (Nov.  2012)   *ADDED ENERGY DEPENDENT STEP SIZE      Recent
                             FOR STARTING GRID AROUND RESONANCES.  Recent
                            *Added CODENAME                        Recent
                            *32 and 64 bit Compatible              Recent
                            *Added ERROR stops                     Recent
                            *Check for no capture for Reich-Moore. Recent
VERS. 2012-2 (Nov.  2012)   *Eliminated ERROR in NHIGH(0) index.   Recent
VERS. 2013-1 (Nov.  2013)   *Extended OUT9.                        Recent
VERS. 2015-1 (Jan.  2015)   *Multiple LRF=7, General Reich-Moore   Recent
                             Resonance Regions.                    Recent
                            *Added OUT10.                          Recent
                            *Replaced ALL 3 way IF Statements.     Recent
                            *Replaced ALL LOGICAL by INTEGER.      Recent
VERS. 2016-1 (Jan.  2016)   *Do not Change LSSF during the         Recent
                             reconstrcution - for compatibility    Recent
                             with later URR treatment.             Recent
                            *Insured that all ERROR stops print    Recent
                             a message explaining why the code     Recent
                             stopped.                              Recent
                            *Partial Energy Range Processing       Recent
                             no longer allowed - today's computers Recent
                             are so fast that this option is now   Recent
                             out-of-date and no longer allowed.    Recent
                            *L-Value dependent fission = Earlier   Recent
                             was done only by entire isotope.      Recent
                            *Denser Starting Energy Grid.          Recent
VERS. 2017-1 (May   2017)   *Corrected ERROR in LRF=3 treatment.   Recent
                             This ERROR only existed in version    Recent
                             2016-1, which was never released to   Recent
                             the general public, so it will not    Recent
                             effect any results calculated by code Recent
```

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                            users.                                  Recent
                           *All floating input parameters changed   Recent
                            to character input + IN9 conversion.    Recent
                           *Added points to starting energy grid    Recent
                            to approximate the shape of each        Recent
                            resonance = based on comparisons of     Recent
                            0.01% to 0.1% results.                  Recent
                           *Increased max. points to 1,200,000.     Recent
                           *LRF=7 Shift option no longer allowed    Recent
                            Set = 0, print WARNING and continue.    Recent
                           *Corrected COMMON/NAPRHO/NRO,NAPS        Recent
                            /NAPRHO/ mispelled - Freud found.       Recent
VERS. 2017-2 (Sept. 2017)  *Corrected Write statemnt at 5731.       Recent
VERS. 2018-1 (Jan.  2018)  *Added output for ALL ENDERROR           Recent
                                                                    Recent
OWNED, MAINTAINED AND DISTRIBUTED BY                                Recent
-----------------------------------                                 Recent
THE NUCLEAR DATA SECTION                                            Recent
INTERNATIONAL ATOMIC ENERGY AGENCY                                  Recent
P.O. BOX 100                                                        Recent
A-1400, VIENNA, AUSTRIA                                             Recent
EUROPE                                                              Recent
                                                                    Recent
ORIGINALLY WRITTEN BY                                               Recent
-----------------------------------                                 Recent
Dermott E. Cullen                                                   Recent
                                                                    Recent
PRESENT CONTACT INFORMATION                                         Recent
--------------------------                                          Recent
Dermott E. Cullen                                                   Recent
1466 Hudson Way                                                     Recent
Livermore, CA 94550                                                 Recent
U.S.A.                                                              Recent
Telephone  925-443-1911                                             Recent
E. Mail    RedCullen1@Comcast.net                                   Recent
Website    RedCullen1.net/HOMEPAGE.NEW                              Recent
                                                                    Recent
Acknowledgement (Version 2004-1)                                    Recent
================================================================== Recent
The author thanks Nancy Larson, ORNL, for providing her SAMRML      Recent
code for comparison to RECENT output for Reich-Moore evaluations,   Recent
in particular to verify results for the new LFR=7 evaluations. I    Recent
also thank her for providing guidance to help me understand and     Recent
implement this new teatment for Reich-Moore parameters.             Recent
                                                                    Recent
ACKNOWLEDGEMENT (VERSION 92-1)                                      Recent
================================================================== Recent
THE AUTHOR THANKS SOL PEARLSTEIN (BROOKHAVEN NATIONAL LAB) FOR      Recent
SIGNIFICANTLY CONTRIBUTING TOWARD IMPROVING THE ACCURACY AND        Recent
COMPUTER INDEPENDENCE OF THIS CODE - THANKS, SOL                    Recent
================================================================== Recent
                                                                    Recent
AUTHORS MESSAGE                                                     Recent
================================================================== Recent
THE REPORT DESCRIBED ABOVE IS THE LATEST PUBLISHED DOCUMENTATION    Recent
FOR THIS PROGRAM. HOWEVER, THE COMMENTS BELOW SHOULD BE CONSIDERED  Recent
THE LATEST DOCUMENTATION INCLUDING ALL RECENT IMPROVEMENTS. PLEASE  Recent
READ ALL OF THESE COMMENTS BEFORE IMPLEMENTATION, PARTICULARLY      Recent
THE COMMENTS CONCERNING MACHINE DEPENDENT CODING.                   Recent
                                                                    Recent
AT THE PRESENT TIME WE ARE ATTEMPTING TO DEVELOP A SET OF COMPUTER  Recent
INDEPENDENT PROGRAMS THAT CAN EASILY BE IMPLEMENTED ON ANY ONE      Recent
OF A WIDE VARIETY OF COMPUTERS. IN ORDER TO ASSIST IN THIS PROJECT  Recent
IT WOULD BE APPECIATED IF YOU WOULD NOTIFY THE AUTHOR OF ANY        Recent
COMPILER DIAGNOSTICS, OPERATING PROBLEMS OR SUGGESTIONS ON HOW TO   Recent
IMPROVE THIS PROGRAM. HOPEFULLY, IN THIS WAY FUTURE VERSIONS OF     Recent
THIS PROGRAM WILL BE COMPLETELY COMPATIBLE FOR USE ON YOUR          Recent
COMPUTER.                                                           Recent
                                                                    Recent
PURPOSE                                                             Recent
================================================================== Recent
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THIS PROGRAM IS DESIGNED TO RECONSTRUCT THE RESONANCE CONTRIBUTION Recent
TO THE CROSS SECTION IN LINEARLY INTERPOLABLE FORM, ADD IN ANY Recent
LINEARLY INTERPOLABLE BACKGROUND CROSS SECTION AND OUTPUT THE Recent
RESULT IN THE ENDF/B FORMAT. THE CROSS SECTIONS OUTPUT BY THIS Recent
PROGRAM WILL BE LINEARLY INTERPOLABLE OVER THE ENTIRE ENERGY RANGE Recent
Recent
THE RESONANCE CONTRIBUTION IS CALCULATED FOR TOTAL (MT=1), Recent
ELASTIC (MT=2), CAPTURE (MT=102) AND FISSION (MT=18), ADDED Recent
TO THE BACKGROUND (IF ANY) AND OUTPUT. IN ADDITION, IF THERE Recent
IS A FIRST CHANCE FISSION (MT=19) BACKGROUND PRESENT THE RESONANCE Recent
CONTRIBUTION OF FISSION WILL BE ADDED TO THE BACKGROUND AND Recent
OUTPUT. IF THERE IS NO FIRST CHANCE FISSION (MT=19) BACKGROUND Recent
PRESENT THE PROGRAM WILL NOT OUTPUT MT=19. Recent
Recent
IN THE FOLLOWING FOR SIMPLICITY THE ENDF/B TERMINOLOGY--ENDF/B Recent
TAPE--WILL BE USED. IN FACT THE ACTUAL MEDIUM MAY BE TAPE, CARDS, Recent
DISK OR ANY OTHER MEDIUM. Recent
Recent
PROCESSING DATA IN THE ENDF/B-VI FORMAT Recent
========== Recent
IT HAS NOW BEEN CONFIRMED (PRIVATE COMMUNICATION, CHARLES DUNFORD, Recent
APRIL, 1991) THAT THE PROPER PROCEDURE TO FOLLOW WHEN THERE ARE Recent
MISSING OR DUPLICATE J VALUES IS TO IN ALL CASES ADD A SEQUENCE Recent
WITH NO RESONANCES TO ACCOUNT FOR THE CONTRIBUTION OF THE SEQUENCE Recent
TO THE POTENTIAL SCATTERING CROSS SECTION. Recent
Recent
THIS IS THE PROCEDURE WHICH WAS FOLLOWED BY ALL VERSIONS OF RECENT Recent
SINCE 86-3 AND WILL CONTINUE TO BE THE PROCEDURE. Recent
Recent
INPUT ENDF/B FORMAT AND CONVENTIONS Recent
========== Recent
ENDF/B FORMAT Recent
---------- Recent
THIS PROGRAM ONLY USES THE ENDF/B BCD OR LINE IMAGE FORMAT (AS Recent
OPPOSED TO THE BINARY FORMAT) AND CAN HANDLE DATA IN ANY VERSION Recent
OF THE ENDF/B FORMAT (I.E., ENDF/B-I, II,III, IV, V OR VI FORMAT). Recent
Recent
IT IS ASSUMED THAT THE DATA IS CORRECTLY CODED IN THE ENDF/B Recent
FORMAT AND NO ERROR CHECKING IS PERFORMED. IN PARTICULAR IT IS Recent
ASSUMED THAT THE MAT, MF AND MT ON EACH LINE IS CORRECT. SEQUENCE Recent
NUMBERS (COLUMNS 76-80) ARE IGNORED ON INPUT, BUT WILL BE Recent
CORRECTLY OUTPUT ON ALL CARDS. THE FORMAT OF SECTION MF=1, MT=451 Recent
AND ALL SECTIONS OF MF=2 AND 3 MUST BE CORRECT. THE PROGRAM COPIES Recent
ALL OTHER SECTION OF DATA AS HOLLERITH AND AS SUCH IS INSENSITIVE Recent
TO THE CORRECTNESS OR INCORRECTNESS OF ALL OTHER SECTIONS. Recent
Recent
ENDF/B FORMAT VERSION Recent
---------- Recent
THE FORMATS AND CONVENTIONS FOR READING AND INTERPRETING THE DATA Recent
VARIES FROM ONE VERSION OF ENDF/B TO THE NEXT. HOWEVER, IF THE Recent
HOLLERITH SECTION (MF=1, MT=451) IS PRESENT IT IS POSSIBLE FOR Recent
THIS PROGRAM TO DISTINGUISH BETWEEN DATA IN THE ENDF/B-IV, V AND Recent
VI FORMATS AND TO USE THE APPROPRIATE CONVENTIONS FOR EACH Recent
ENDF/B VERSION (SEE, SUBROUTINE FILE1 FOR A DESCRIPTION OF HOW Recent
THIS IS DONE). IF THE HOLLERITH SECTION IS NOT PRESENT THE Recent
PROGRAM WILL ASSUME THE DATA IS IN THE ENDF/B-VI FORMAT AND USE Recent
ALL CONVENTIONS APPROPRIATE TO ENDF/B-V. USERS ARE ENCOURAGED TO Recent
INSURE THAT THE HOLLERITH SECTION (MF=1, MT=451) IS PRESENT IN Recent
ALL EVALUATIONS. Recent
Recent
INPUT OF ENERGIES Recent
---------- Recent
ALL ENERGIES ARE READ IN DOUBLE PRECISION (BY SPECIAL FORTRAN I/O Recent
ROUTINES) AND ARE TREATED IN DOUBLE PRECISION IN ALL CALCULATIONS. Recent
Recent
OUTPUT ENDF/B FORMAT AND CONVENTIONS Recent
========== Recent
CONTENTS OF OUTPUT Recent
---------- Recent
ENTIRE EVALUATIONS ARE OUTPUT, NOT JUST THE RECONSTRUCTED FILE Recent
3 CROSS SECTIONS, E.G. ANGULAR AND ENERGY DISTRIBUTIONS ARE Recent

ALSO INCLUDED. Recent

DOCUMENTATION

THE FACT THAT THIS PROGRAM HAS OPERATED ON THE DATA IS DOCUMENTED BY THE ADDITION OF COMMENT CARDS AT THE END OF EACH HOLLERITH SECTION IN THE FORM

********** RECENT (VERSION 2018-1) **********
RESONANCE CONTRIBUTION RECONSTRUCTED TO WITHIN 0.100 PER-CENT
COMBINED DATA NOT THINNED (ALL RESONANCE + BACKGROUND DATA KEPT)

THE ORDER OF ALL SIMILAR COMMENTS (FROM LINEAR, SIGMA1 AND GROUPY) REPRESENTS A COMPLETE HISTORY OF ALL OPERATIONS PERFORMED ON THE DATA, INCLUDING WHICH VERSION OF EACH PROGRAM WAS USED.

THESE COMMENT CARDS ARE ONLY ADDED TO EXISTING HOLLERITH SECTIONS, I.E., THIS PROGRAM WILL NOT CREATE A HOLLERITH SECTION. THE FORMAT OF THE HOLLERITH SECTION IN ENDF/B-V DIFFERS FROM THE THAT OF EARLIER VERSIONS OF ENDF/B. BY READING AN EXISTING MF=1, MT=451 IT IS POSSIBLE FOR THIS PROGRAM TO DETERMINE WHICH VERSION OF THE ENDF/B FORMAT THE DATA IS IN. WITHOUT HAVING A SECTION OF MF=1, MT=451 PRESENT IT IS IMPOSSIBLE FOR THIS PROGRAM TO DETERMINE WHICH VERSION OF THE ENDF/B FORMAT THE DATA IS IN, AND AS SUCH IT IS IMPOSSIBLE FOR THE PROGRAM TO DETERMINE WHAT FORMAT SHOULD BE USED TO CREATE A HOLLERITH SECTION.

REACTION INDEX

THIS PROGRAM DOES NOT USE THE REACTION INDEX WHICH IS GIVEN IN SECTION MF=1, MT=451 OF EACH EVALUATION.

THIS PROGRAM DOES NOT UPDATE THE REACTION INDEX IN MF=1, MT=451. THIS CONVENTION HAS BEEN ADOPTED BECAUSE MOST USERS DO NOT REQUIRE A CORRECT REACTION INDEX FOR THEIR APPLICATIONS AND IT WAS NOT CONSIDERED WORTHWHILE TO INCLUDE THE OVERHEAD OF CONSTRUCTING A CORRECT REACTION INDEX IN THIS PROGRAM. HOWEVER, IF YOU REQUIRE A REACTION INDEX FOR YOUR APPLICATIONS, AFTER RUNNING THIS PROGRAM YOU MAY USE PROGRAM DICTIN TO CREATE A CORRECT REACTION INDEX.

OUTPUT FORMAT OF ENERGIES

IN THIS VERSION OF RECENT ALL FILE 3 ENERGIES WILL BE OUTPUT IN F (INSTEAD OF E) FORMAT IN ORDER TO ALLOW ENERGIES TO BE WRITTEN WITH UP TO 9 DIGITS OF ACCURACY. IN PREVIOUS VERSIONS THIS WAS AN OUTPUT OPTION. HOWEVER USE OF THIS OPTION TO COMPARE THE RESULTS OF ENERGIES WRITTEN IN THE NORMAL ENDF/B CONVENTION OF 6 DIGITS TO THE 9 DIGIT OUTPUT FROM THIS PROGRAM DEMONSTRATED THAT FAILURE TO USE THE 9 DIGIT OUTPUT CAN LEAD TO LARGE ERRORS IN THE DATA JUST DUE TO TRANSLATION OF ENERGIES FROM THEIR INTERNAL (BINARY) REPRESENTATION TO THE ENDF/B FORMAT.

ACCURACY OF ENERGY

IN ORDER TO ALLOW ENERGIES TO BE ACCURATELY OUTPUT TO 9 DIGITS ON SHORT WORD LENGTH COMPUTERS (E.G. IBM) ALL ENERGIES AND ENERGY DEPENDENT TERMS ARE READ AND TREATED IN DOUBLE PRECISION.

OUTPUT OF RESONANCE PARAMETERS

A SPECIAL CONVENTION HAS BEEN INTRODUCED REGARDING RESONANCE PARAMETERS. IN ORDER TO ALLOW THE USER TO DOPPLER BROADEN AND/OR SELF-SHIELD CROSS SECTIONS THE RESONANCE PARAMETERS ARE ALSO INCLUDED IN THE OUTPUT WITH THE EVALUATION. IN ORDER TO AVOID THE POSSIBILITY OF ADDING THE RESONANCE CONTRIBUTION A SECOND TIME TWO CONVENTIONS HAVE BEEN ADOPTED TO INDICATE THAT THE RESONANCE CONTRIBUTION HAS ALREADY BEEN ADDED TO THE FILE 3 CROSS SECTIONS,

(1) WHEN THE DATA IS PROCESSED BY THIS PROGRAM LRP (IN MF=1, MT=451) IS SET EQUAL TO 2. THIS IS A CONVENTION WHICH HAS BEEN ADOPTED AS A STANDARD CONVENTION IN ENDF/B-VI, BUT IS ONLY TO BE

```
USED FOR PROCESSED DATA, AS OPPOSED TO THE ORIGINAL EVALUATIONS.   Recent
IN EVALUATIONS WHICH CONTAIN MF=1, MT=451 LRP CAN BE USED TO       Recent
DETERMINE IF THE MATERIAL HAS BEEN PROCESSED.                      Recent
                                                                   Recent
(2) THE LRU FLAG IN EACH SECTION OF FILE 2 DATA IS CHANGED TO      Recent
LRU=LRU+3. FOR EXAMPLE WHEN READING AN ENDF/B EVALUATION LRU=0     Recent
(NO RESONANCES), =1 (RESOLVED) OR =2 (UNRESOLVED) INDICATES THAT   Recent
THE DATA IS IN THE ORIGINAL ENDF/B FORM. LRU=3 (NO RESONANCES),    Recent
=4 (RESOLVED) OR =5 (UNRESOLVED) INDICATES THAT THE RESONANCE      Recent
CONTRIBUTION HAS ALREADY BEEN ADDED TO THE FILE 3 DATA. THIS       Recent
SECOND CONVENTION HAS BEEN ADOPTED AS INSURANCE THAT THE RESONANCE Recent
CONTRIBUTION WILL NOT BE ADDED TWICE, EVEN FOR EVALUATIONS WHICH   Recent
DO NOT CONTAIN MF=1, MT=451 (EVALUATIONS WHICH CONTAIN MF=1,       Recent
MT=451 ARE COVERED BY CONVENTION (1), DESCRIBED ABOVE).            Recent
                                                                   Recent
UNIFORM TREATMENT OF RESONANCE FORMALISMS                          Recent
================================================================== Recent
NORMALIZATION                                                      Recent
=============                                                      Recent
ALL OF THE RESONANCE FORMALISMS INCLUDE A FACTOR OF,               Recent
                                                                   Recent
PI*(FRACTIONAL ABUNDANCE)/(K**2)                                   Recent
                                                                   Recent
THIS FACTOR HAS BEEN REMOVED FROM THE CALCULATION OF EACH TYPE     Recent
OF RESONANCE FORMALISM AND IS APPLIED AS A FINAL NORMALIZATION     Recent
AFTER THE CALCULATION, ONLY ONE PLACE IN THIS PROGRAM.             Recent
                                                                   Recent
FOR SIMPLICITY THIS TERM IS NOT INCLUDED IN THE FOLLOWING          Recent
DERIVATIONS - IN ALL CASES THE ACTUAL CROSS SECTION IS A PRODUCT   Recent
OF THE ABOVE FACTOR TIMES THE RESULTS PRESENTED BELOW.             Recent
                                                                   Recent
SIMILARITIES                                                       Recent
============                                                       Recent
FOR THE RESOLVED RESONANCE REGION, EXCEPT FOR SINGLE LEVEL BREIT   Recent
WIGNER, PARAMETERS ALL OF THE FORMALISMS DEFINE THE CROSS SECTIONS Recent
IN AN EQUIVALENT FORM,                                             Recent
                                                                   Recent
TOTAL    = 2*GJ*REAL(1 - U)                                        Recent
         = 2*GJ*(1 - REAL(U))                                      Recent
ELASTIC  =   GJ*(1 - U)**2                                         Recent
         =   GJ*((1 - 2*REAL(U)) + (REAL(U)**2 + IM(U)**2))        Recent
         = 2*GJ*(1 - REAL(U)) - GJ*(1 - (REAL(U)**2 + IM(U)**2))   Recent
                                                                   Recent
SINCE THE FIRST TERM IS THE TOTAL, THE SECOND TERM MUST BE         Recent
ABSORPTION. SO WE FIND,                                            Recent
                                                                   Recent
ABSORPTION = GJ*(1 - (REAL(U)**2 + IM(U)**2))                      Recent
                                                                   Recent
IN ALL CASES U IS DEFINED IN THE FORM,                             Recent
                                                                   Recent
U        = EXP(-I*2*PS)*((1-X) - I*Y)                              Recent
                                                                   Recent
WHERE (X) AND (Y) ARE RELATED TO THE SYMMETRIC AND ANTI-SYMMETRIC  Recent
CONTRIBUTIONS OF THE RESONANCES, RESPECTIVELY. ONLY THE DEFINITION Recent
OF (X) AND (Y) WILL BE DIFFERENT FOR EACH RESONANCE FORMALISM.     Recent
BELOW WE WILL SHOW THAT WHAT MIGHT APPEAR TO BE A STRANGE CHOICE   Recent
OF DEFINITION OF THE SIGN OF (X) AND(Y) HAS BEEN SELECTED SO THAT  Recent
FOR BREIT-WIGNER PARAMETERS (X) AND (Y) CORRESPOND EXACTLY TO THE  Recent
SYMMETRIC AND ANTI-SYMMETRIC CONTRIBUTION OF THE RESONANCES.       Recent
                                                                   Recent
U        = (COS(2*PS) - I*SIN(2*PS))*((1-X) - I*Y)                 Recent
         =   ((1-X)*COS(2*PS) - Y*SIN(2*PS))                       Recent
         =-I*((1-X)*SIN(2*PS) + Y*COS(2*PS))                       Recent
                                                                   Recent
REAL(U)  = ((1-X)*COS(2*PS) - Y*SIN(2*PS))                         Recent
IM(U)    =-((1-X)*SIN(2*PS) + Y*COS(2*PS))                         Recent
                                                                   Recent
R(U)**2  =((1-X)*COS(2*PS))**2 + (Y*SIN(2*PS))**2                  Recent
          -2*(1-X)*Y*COS(2*PS)*SIN(2*PS)                           Recent
I(U)**2  =((1-X)*SIN(2*PS))**2 + (Y*COS(2*PS))**2                  Recent
          +2*(1-X)*Y*COS(2*PS)*SIN(2*PS)                           Recent
```

```
                                                                      Recent
THE TERMS 2*(1-X)*Y*COS(2*PS)*SIN(2*PS) CANCEL AND UPON USING         Recent
THE IDENTITY COS(2*PS)**2 + SIN(2*PS)**2 = 1,                         Recent
                                                                      Recent
SUM      = (1-X)**2 + (Y)**2                                          Recent
                                                                      Recent
WE NOW HAVE ALL THE QUANTITIES THAT WE NEED TO DEFINE THE CROSS       Recent
SECTIONS,                                                             Recent
                                                                      Recent
ELASTIC                                                               Recent
=======                                                               Recent
ELASTIC  =GJ*(1 - 2*REAL(U) + (REAL(U)**2 + IM(U)**2))                Recent
         =GJ*(1 - 2*((1-X)*COS(2*PS)-Y*SIN(2*PS))+(1-X)**2+(Y)**2)    Recent
                                                                      Recent
THIS CAN BE WRITTEN AS A SUM OF 2 SQUARES,                            Recent
                                                                      Recent
ELASTIC  =GJ*(COS(2*PS) - (1-X))**2 + (SIN(2*PS) + Y)**2              Recent
                                                                      Recent
         =GJ*((COS(2*PS))**2 - 2*(1-X)*COS(2*PS) + (1-X)**2) +        Recent
              (SIN(2*PS))**2 + 2*Y*SIN(2*PS)    + (Y)**2)             Recent
                                                                      Recent
AGAIN USING THE IDENTITY COS(2*PS)**2 + SIN(2*PS)**2 = 1, WE CAN      Recent
SEE THAT THE DEFINITION AS THE SUM OF 2 SQUARES IS IDENTICAL TO       Recent
THE PRECEDING DEFINITION OF THE ELASTIC.                              Recent
                                                                      Recent
ELASTIC  =GJ*(COS(2*PS) - (1-X))**2 + (SIN(2*PS) + Y)**2              Recent
         =GJ*((COS(2*PS)-1) + X)**2 + (SIN(2*PS) + Y)**2              Recent
                                                                      Recent
USING THE IDENTITY (1 - COS(2*PS))) = 2*SIN(PS)**2, WE OBTAIN         Recent
THE FINAL FORM FOR THE ELASTIC,                                       Recent
                                                                      Recent
ELASTIC =GJ*(2*SIN(PS)**2 - X)**2 + (SIN(2*PS) + Y)**2                Recent
                                                                      Recent
ABSORPTION                                                            Recent
==========                                                            Recent
ABSORPTION = GJ*(1 - (REAL(U)**2 + IM(U)**2))                         Recent
           = GJ*(1 - ((1-X)**2   + (Y)**2)                            Recent
           = GJ*(1 - (1 - 2*X + (X)**2 + (Y)**2)                      Recent
           = GJ*(2*X - (X)**2 + (Y)**2)                               Recent
                                                                      Recent
SINCE PHYSICALLY THE ABSORPTION CANNOT BE NEGATIVE WE CAN SEE         Recent
THAT (X) MUST BE POSITIVE AND 2*X MUST BE GREATER THAN                Recent
(X)**2 + (Y)**2, FOR ALL OF THE FORMALISMS.                           Recent
                                                                      Recent
TOTAL                                                                 Recent
=====                                                                 Recent
IN THIS PROGRAM THE TOTAL CROSS SECTION IS ALWAYS DEFINED TO BE       Recent
THE SUM OF ITS PARTS - SO THE ABOVE DEFINITION IS NEVER EXPLICITLY    Recent
USED. HOWEVER, WE CAN LEARN SOMETHING BY EXAMINING THE DEFINITION,    Recent
                                                                      Recent
TOTAL    = 2*GJ*REAL(1 - U)                                           Recent
         = 2*GJ*(1 - (((1-X)*COS(2*PS) - Y*SIN(2*PS)))                Recent
         = 2*GJ*((1 - COS(2*PS))*(1-X) - (1-X) + Y*SIN(2*PS))         Recent
         = 2*GJ*(2*SIN(PS)**2*(1-X)    - (1-X) + Y*SIN(2*PS))         Recent
                                                                      Recent
         = 4*GJ*SIN(PS)**2 +                                          Recent
           2*GJ*((X-1) - 2*X*SIN(PS)**2 +  Y*SIN(2*PS))               Recent
                                                                      Recent
THE IMPORTANT POINT TO NOTE IS THAT THE DEFINITION OF THE TOTAL       Recent
DOES NOT EXPLICITLY CONTAIN ANY DEPENDENCE ON X**2 AND Y**2 -         Recent
THE LEVEL-LEVEL INTERFERENCE TERMS.                                   Recent
                                                                      Recent
THIS IMPLIES THAT IF A GIVEN SET OF RESONANCE PARAMETERS ARE USED     Recent
WITH THIS DEFINITION THEY WILL PRODUCE EXACTLY THE SAME TOTAL         Recent
CROSS SECTION - WHETHER WE CLAIM THE PARAMETERS HAVE BEEN             Recent
PRODUCED USING A SINGLE OR MULTI-LEVEL FIT. THIS RESULT COULD         Recent
BE VERY MISLEADING, IF THIS RESULT FOR THE TOTAL IS IMPLIED TO        Recent
MEAN THAT ONE INTERPRETATION OR THE OTHER WILL NOT HAVE ANY           Recent
EFFECT ON THE INDIVIDUAL CROSS SECTIONS.                              Recent
                                                                      Recent
STARTING FROM EXACTLY THE SAME RESONANCE PARAMETERS, RELATIVE TO      Recent
```

THE RESULTS OBTAINED USING THE SINGLE LEVEL FORMULA, MULTI-LEVEL Recent
RESULTS WILL TEND TO ALWAYS DECREASE THE ABSORPTION AND INCREASE Recent
THE ELASTIC. THIS CAN BE IMMEDIATELY SEEN FROM OUR GENERAL Recent
MULTI-LEVEL DEFINITION OF ABSORPTION, Recent
Recent
ABSORPTION =GJ*(2*X - ((X)**2 + (Y)**2)) Recent
Recent
THE SINGLE LEVEL ABSORPTION IS, Recent
Recent
ABSORPTION =GJ*(2*X) Recent
Recent
THE DIFFERENCE BETWEEN THE TWO IS -2*GJ*(X**2 + Y**2), SO THAT Recent
REGARDLESS OF HOW WE DEFINE (X) AND (Y) THE INCLUSION OF THIS Recent
TERM WILL ALWAYS DECREASE ABSORPTION. SINCE THE TOTAL CROSS Recent
SECTION IS THE SAME IN BOTH CASE, THIS MEANS THAT THE ELASTIC Recent
HAS BEEN INCREASED BY THIS AMOUNT. Recent
Recent
AGAIN, THESE RESULTS ARE BASED ON STARTING FROM EXACTLY THE SAME Recent
PARAMETERS - IN ANY ACTUAL CASE THE PARAMETERS BASED ON A SINGLE Recent
OR MULTI-LEVEL FIT WILL BE QUITE DIFFERENT - THE POINT THAT WE Recent
WANT TO STRESS HERE IS THAT YOU SHOULD NEVER USE PARAMETERS Recent
WHICH HAVE BEEN DEFINED BY A FIT USING ONE FORMALISM - IN THE Recent
EQUATIONS FOR A DIFFERENT FORMALISM - AND ASSUME THAT THE RESULTS Recent
WILL BE CONSISTENT - AND NEVER USE THE TOTAL CROSS SECTION TO Recent
SEE WHETHER OR NOT A SET OF SINGLE LEVEL PARAMETERS CAN BE USED Recent
WITH A MULTI-LEVEL FORMALISM. Recent
Recent
POTENTIAL CROSS SECTION Recent
====================== Recent
FAR FROM RESONANCES (X) AND (Y) WILL BE SMALL AND THE ELASTIC Recent
CROSS SECTION REDUCES TO, Recent
Recent
ELASTIC =GJ*(2*SIN(PS)**2)**2 + (SIN(2*PS))**2 Recent
=GJ*4*(SIN(PS)**4 + SIN(2*PS)**2 Recent
Recent
USING THE IDENTITY SIN(2*PS) = 2*SIN(PS)*COS(PS) Recent
Recent
=4*GJ*(SIN(PS)**4 + (SIN(PS)*COS(PS))**2) Recent
=4*GJ*SIN(PS)**2*(SIN(PS)**2 + COS(PS)**2) Recent
=4*GJ*SIN(PS)**2 Recent
Recent
WHICH IS THE POTENTIAL CROSS SECTION. NOTE THAT THIS RESULT IS Recent
INDEPENDENT OF THE FORMALISM USED, AS IT MUST PHYSICALLY BE, Recent
AND AS SUCH ALTHOUGH AS YET WE HAVE NOT DEFINED IT, WE CAN Recent
NOW SEE THAT IN ALL CASES (PS) MUST BE THE PHASE SHIFT AND FOR Recent
CONSISTENCY IT MUST BE DEFINED USING EXACTLY THE SAME DEFINITION Recent
IN ALL CASES. Recent
Recent
IN ADDITION SINCE PHYSICALLY FOR EACH L VALUE WE EXPECT TO OBTAIN Recent
A POTENTIAL CROSS SECTION, Recent
Recent
4*(2*L+1)*SIN(PS)**2 Recent
Recent
OBVIOUSLY FOR CONSISTENCY WE MUST HAVE, Recent
Recent
(2*L+1) = (SUM OVER J) GJ Recent
Recent
ONLY IN THIS CASE WILL THE RESULTS BE CONSISTENT - THIS POINT WILL Recent
BE DISCUSSED IN DETAIL BELOW. Recent
Recent
WHAT ARE THIS TERMS (X) AND (Y) Recent
============================== Recent
(X) AND (Y) CAN BE EASILY IDENTIFIED BY CONSIDERING THE SINGLE Recent
AND MULTI-LEVEL BREIT WIGNER FORMALISMS. IN THESE CASES WE WILL Recent
FIND THAT, Recent
Recent
X = GAM(N)*GAM(T)/2/DEN Recent
Y = GAM(N)*(E-ER)/DEN Recent
DEN = ((E-ER)**2 + (GAM(T)/2)**2) Recent
Recent
EXTREME CARE HAS TO BE USED TO PROPERLY DEFINE (Y) SUCH THAT IT Recent

```
IS NEGATIVE FOR E LESS THAN ER AND POSITIVE FOR E GREATER THAN     Recent
ER. I WILL MERELY MENTION THAT THE EQUATIONS FOR ALL FORMALISMS    Recent
IN ENDF-102 DO NOT CONSISTENTLY USE (E - ER) - IN SOME CASES       Recent
THIS IS WRITTEN AS (ER - E), WHICH CAN LEAD TO AN INCORRECT        Recent
SIGN IN THE DEFINITION OF THE (Y) THAT WE REQUIRE.                 Recent
                                                                   Recent
THE INTERFERENCE TERMS CAN BE WRITTEN IN TERMS OF,                 Recent
1) LEVEL-SELF INTERFERENCE  = THE CONTRIBUTION OF EACH LEVEL       Recent
                              INTERFERRING WITH ITSELF             Recent
2) LEVEL-LEVEL INTERFERENCE = THE CONTRIBUTION OF EACH LEVEL       Recent
                              INTERFERRRING WITH ALL OTHER LEVELS  Recent
                                                                   Recent
WE WILL REFER TO THESE TWO AS (L-S) AND (L-L),                     Recent
                                                                   Recent
X**2     = (GAM(N)*(GAM(T)/2)**2/(DEN)**2      + (L-L)             Recent
         = (GAM(N)**2*((GAM(T)/2)**2)/(DEN)**2 + (L-L)             Recent
Y**2     = (GAM(N))**2*((E-ER))**2/(DEN)**2    + (L-L)             Recent
                                                                   Recent
X**2+Y**2= GAM(N)**2*DEN/(DEN)**2 = GAM(N)**2/DEN + (L-L)          Recent
                                                                   Recent
TO SEE THE EFFECT OF INCLUDING MULTI-LEVEL INTERFERENCE WE CAN     Recent
CONSIDER OUR GENERAL EXPRESSION FOR ABSORPTION,                    Recent
                                                                   Recent
ABSORPTION =GJ*(2*X - ((X)**2 + (Y)**2))                           Recent
                                                                   Recent
AND NOTE THAT FOR BOTH SINGLE AND MULTI-LEVEL BREIT WIGNER THE     Recent
ENDF-102 SAYS TO TREAT ABSORPTION IN A SINGLE LEVEL APPROXIMATION  Recent
I.E., IGNORE LEVEL-LEVEL INTERFERENCE. IF ALL INTERFERENCE IS      Recent
IGNORED THIS IS EQUIVALENT TO COMPLETELY IGNORING X**2 + Y**2 AND  Recent
DEFINING,                                                          Recent
                                                                   Recent
ABSORPTION =GJ*2*X                                                 Recent
           =2*GJ*GAM(N)*GAM(T)/DEN                                 Recent
                                                                   Recent
WHICH IS INCORRECT - SINCE THIS SEEMS TO INDICATE EVERYTHING IS    Recent
ABSORBED. IN ORDER TO OBTAIN THE CORRECT EXPRESSION WE CANNOT      Recent
COMPLETELY IGNORE INTERFERENCE - WE CAN IGNORE LEVEL-LEVEL         Recent
INTERFERENCE, BUT WE MUST INCLUDE LEVEL-SELF INTERFERENCE,         Recent
                                                                   Recent
X**2+Y**2= GAM(N)**2/DEN                                           Recent
                                                                   Recent
ABSORPTION =GJ*(2*X - ((X)**2 + (Y)**2))                           Recent
           =GJ*GAM(N)*(GAM(T)-GAM(N))/DEN                          Recent
           =GJ*GAM(N)*GAM(A)/DEN                                   Recent
                                                                   Recent
SUMMARY                                                            Recent
=======                                                            Recent
AN IMPORTANT POINT TO NOTE IS THE DEFINITION OF (X) AND (Y)        Recent
WHICH IN ALL CASES WILL CORRESPOND TO THE SYMMETRIC AND            Recent
ANTI-SYMMETRIC CONTRIBUTION OF THE RESONANCES. IN PARTICULAR       Recent
DEFINING (U) IN TERMS OF (1-X) INSTEAD OF (X) IS EXTREMELY         Recent
IMPORTANT. NOTE, THAT THE DEFINITION OF THE ELASTIC AND            Recent
ABSORPTION ONLY INVOLVE (X), NOT (1-X). FAR FROM RESONANCES        Recent
(X) CAN BE EXTREMELY SMALL, THEREFORE (1-X) WILL BE VERY CLOSE     Recent
TO (1). IF THE CALCULATION PROCEEDS BY FIRST CALCULATING (1-X)     Recent
AND THEN DEFINING (X) BY SUBTRACTING (1), EXTREME ROUND-OFF        Recent
PROBLEMS CAN RESULT. THESE PROBLEMS CAN BE AVOIDED BY IN ALL       Recent
CASES DEFINING (X) DIRECTLY, WITHOUT ANY DIFFERENCES.              Recent
                                                                   Recent
IN EACH FORMALISM THE DEFINITION OF (X) AND (Y) MAY BE DIFFERENT   Recent
BUT ONCE WE HAVE DEFINED (X) AND (Y) WE CAN IMMEDIATELY WRITE      Recent
THE CROSS SECTIONS USING A UNIFORM DEFINITION,                     Recent
                                                                   Recent
ELASTIC =GJ*(2*SIN(PS)**2 - X)**2 + (SIN(2*PS) + Y)**2)            Recent
                                                                   Recent
ABSORPTION =-GJ*(2*X + (X)**2 + (Y)**2)                            Recent
                                                                   Recent
AND DEFINE THE TOTAL AS THE SUM OF THESE 2 PARTS.                  Recent
                                                                   Recent
RELATIONSHIP TO SINGLE LEVEL                                       Recent
============================                                       Recent
```

HOW DO THE SINGLE AND MULTI-LEVEL FORMALISMS COMPARE. TO SEE, Recent
STARTING FROM OUR GENERAL DEFINITION OF THE ELASTIC IN THE FORM, Recent
Recent

```
ELASTIC =GJ*(2*SIN(PS)**2 + X)**2 + (SIN(2*PS) + Y)**2)
        =GJ*(4*SIN(PS)**4 - 4*X*SIN(PS)**2 + X**2
           + SIN(2*PS)**2 + 2*Y*SIN(2*PS)  + Y**2)

        =4*GJ*SIN(PS)**2 +
           GJ*(X**2 + Y**2
              -4*X*SIN(PS)**2
              +2*Y*SIN(2*PS))
```

Recent
AND OUR SPECIFIC DEFINITIONS OF (X) AND (Y) FOR MULTI-LEVEL BREIT- Recent
WIGNER PARAMETERS, Recent
Recent

```
X        = GAM(N)*GAM(T)/2/DEN
Y        = GAM(N)*(E-ER)/DEN
DEN      = ((E-ER)**2 + (GAM(T)/2)**2)
```

Recent

```
X**2+Y**2= GAM(N)**2/DEN + (L-L)
```

Recent
WE CAN RECOGNIZE X**2 AND Y**2 AS THE INTERFERENCE - (L-S) + (L-L) Recent
TERMS IN THE MULTI-LEVEL FORMALISM. IN ORDER TO OBTAIN THE SINGLE Recent
LEVEL EQUATION WE CAN ASSUME THAT EACH LEVEL DOES NOT INTERFERE Recent
WITH ANY OTHER LEVEL - THEREFORE THE (L-L) CONTRIBUTION IS ZERO. Recent
Recent

```
ELASTIC =4*GJ*SIN(PS)**2 +
           GJ*GAM(N)*(GAM(N)
                     -2*GAM(T)*SIN(PS)**2
                     +2*(E-ER)*SIN(2*PS))/DEN
```

Recent
WHICH IS THE FORM THAT IT APPEARS IN ENDF-102, EXCEPT FOR TWO Recent
TYPOGRAPHICAL ERRORS IN THE SECOND TERM, Recent
Recent

```
-2*GAM(T)*SIN(PS)**2
```

Recent

```
WHICH IN ENDF-102 IS WRITTEN,
```

Recent

```
-2*(GAM(T)-GAM(N))*SIN(2*PS)**2
```

Recent

```
PROGRAM CONVENTIONS
==================================================================
MINIMUM INPUT DATA
------------------
```

Recent
FOR EACH MATERIAL TO BE PROCESSED THE MINIMUM INPUT DATA ARE THE Recent
RESONANCE PARAMETERS IN FILE 2. IF THERE ARE NO FILE 2 PARAMETERS Recent
IN A GIVEN MATERIAL THE ENTIRE MATERIAL WILL SIMPLY BE COPIED. Recent
NEITHER THE HOLLERITH SECTION (MF=1, MT=451) NOR THE BACKGROUND Recent
CROSS SECTION (SECTIONS OF MF=3) NEED BE PRESENT FOR THIS PROGRAM Recent
TO EXECUTE PROPERLY. HOWEVER, SINCE THE CONVENTIONS USED IN Recent
INTERPRETING THE RESONANCE PARAMETERS DEPENDS ON ENDF/B VERSION Recent
USERS ARE STRONGLY RECOMMENDED TO INSURE THAT MF=1, MT=451 IS Recent
PRESENT IN EACH MATERIAL TO ALLOW THE PROGRAM TO DETERMINE THE Recent
ENDF/B FORMAT VERSION. Recent
Recent

```
RESONANCE PARAMETERS
--------------------
```

Recent
RESONANCE PARAMETERS MAY BE REPRESENTED USING ANY COMBINATION Recent
OF THE REPRESENTATIONS ALLOWED IN ENDF/B, Recent
(1) RESOLVED DATA Recent
    (A) SINGLE LEVEL BREIT-WIGNER Recent
    (B) MULTI-LEVEL BREIT-WIGNER Recent
    (C) ADLER-ADLER Recent
    (D) REICH-MOORE Recent
    (E) HYBRID R-FUNCTION Recent
(2) UNRESOLVED DATA Recent
    (A) ALL PARAMETERS ENERGY INDEPENDENT Recent
    (B) FISSION PARAMETERS ENERGY DEPENDENT Recent
    (C) ALL PARAMETERS ENERGY DEPENDENT Recent
Recent
THE FOLLOWING RESOLVED DATA FORMALISMS ARE NOT TREATED BY THIS Recent

VERSION OF THE CODE AND WILL ONLY BE IMPLEMENTED AFTER EVALUATIONS Recent
USING THESE FORMALISMS ARE AVAILABLE TO THE AUTHOR OF THIS CODE Recent
FOR TESTING IN ORDER TO INSURE THAT THEY CAN BE HANDLED PROPERLY Recent
(A) GENERAL R-MATRIX Recent
Recent
CALCULATED CROSS SECTIONS Recent
------------------------- Recent
THIS PROGRAM WILL USE THE RESONANCE PARAMETERS TO CALCULATE THE Recent
TOTAL, ELASTIC, CAPTURE AND POSSIBLY FISSION CROSS SECTIONS. THE Recent
COMPETITIVE WIDTH WILL BE USED IN THESE CALCULATIONS, BUT THE Recent
COMPETITIVE CROSS SECTION ITSELF WILL NOT BE CALCULATED. THE Recent
ENDF/B CONVENTION IS THAT ALTHOUGH A COMPETITIVE WIDTH MAY BE Recent
GIVEN, THE COMPETITIVE CROSS SECTION MUST BE SEPARATELY TABULATED Recent
AS A SECTION OF FILE 3 DATA. Recent
Recent
RESOLVED REGION Recent
--------------- Recent
IN THE RESOLVED REGION THE RESOLVED PARAMETERS ARE USED TO Recent
CALCULATE COLD (0 KELVIN), LINEARLY INTERPOLABLE, ENERGY DEPENDENT Recent
CROSS SECTIONS. Recent
Recent
SCATTERING RADIUS Recent
----------------- Recent
FOR SINGLE OR MULTI LEVEL BREIT-WIGNER PARAMETERS THE SCATTERING Recent
RADIUS MAY BE SPECIFIED IN EITHER ENERGY INDEPENDENT (CONSTANT) Recent
OR ENERGY DEPENDENT FORM (A TABLE OF ENERGY VS. RADIUS AND AN Recent
ASSOCIATED INTERPOLATION LAW). IN ALL OTHER CASE ONLY AN ENERGY Recent
INDEPENDENT SCATTERING RADIUS IS ALLOWED. Recent
Recent
FOR ANY ONE MATERIAL (I.E. MAT) IF ENERGY DEPENDENT SCATTERING Recent
RADII ARE GIVEN THE TOTAL NUMBER OF INTERPOLATION REGIONS AND Recent
TABULATED VALUES FOR THE ENTIRE MATERIAL CANNOT EXCEED, Recent
200 - INTERPOLATION REGIONS Recent
500 - TABULATED VALUES Recent
IF THESE LIMITS ARE EXCEEDED THE PROGRAM WILL PRINT AN ERROR Recent
MESSAGE AND TERMINATE. Recent
Recent
IF YOU REQUIRE A LARGER NUMBER OF INTERPOLATION REGION AND/OR Recent
TABULATED VALUES, Recent
(1) INTERPOLATION REGIONS - INCREASE THE DIMENSION OF NBTRHO AND Recent
INTRHO IN COMMON/TABRHO/ THROUGHOUT THE PROGRAM AND CHANGE MAXSEC Recent
IN SUBROUTINE RDAP (MAXSEC = MAXIMUM NUMBER OF INTERPOLATION Recent
REGIONS). Recent
(2) TABULATED VALUES - INCREASE THE DIMENSION OF ERHOTB, RHOTAB Recent
AND APTAB IN COMMON/TABRHO/ THROUGHOUT THE PROGRAM AND CHANGE Recent
MAXRHO IN SUBROUTINE RDAP (MAXRHO = MAXIMUM NUMBER OF TABULATED Recent
VALUES). Recent
Recent
RESOLVED REICH-MOORE AND MULTI-LEVEL BREIT-WIGNER PARAMETERS Recent
---------- Recent
CROSS SECTIONS FOR REICH-MOORE PARAMETERS ARE CALCULATED ACCORDING Recent
TO THE EQUATION (1) - (8) OF SECTION D.1.3 OF ENDF-102. IN ORDER Recent
TO CALCULATE CROSS SECTIONS FROM MULTI-LEVEL PARAMETERS IN A Recent
REASONABLE AMOUNT OF TIME THIS PROGRAM EXPRESSES THE CROSS SECTION Recent
IN TERMS OF A SINGLE SUM OVER RESONANCES (SEE, ENDF-102, SECTION Recent
D.1.2, EQUATIONS 6-7), RATHER THAN AS A DOUBLE SUM (SEE, ENDF-102 Recent
SECTION D.1.2, EQUATION 1-2). IN ORDER FOR THE ENDF-102 EQUATIONS Recent
TO BE CORRECT THE PARAMETERS MUST MEET THE FOLLOWING CONDITIONS, Recent
Recent
(1) FOR EACH L STATE ALL PHYSICALLY POSSIBLE J SEQUENCES MUST BE Recent
PRESENT. ONLY IN THIS CASE WILL THE CONTRIBUTIONS OF THE Recent
INDIVIDUAL J SEQUENCES ADD UP TO PRODUCE THE CORRECT POTENTIAL Recent
SCATTERING CONTRIBUTION FOR THE L STATE (SEE, ENDF-102, Recent
SECTION D.1.2, EQUATIONS 6-7). IF ANY J SEQUENCE IS MISSING Recent
THE PROGRAM WILL PRINT A WARNING AND ADD THE J SEQUENCE WITH Recent
NO RESONANCE PARAMETERS IN ORDER TO ALLOW THE POTENTIAL Recent
SCATTERING TO BE CALCULATED CORRECTLY (THIS IS EQUIVALENT TO Recent
ASSUMING THAT THE EVALUATOR REALIZES THAT ALL J SEQUENCES MUST Recent
BE AND ARE PRESENT AND THAT THE EVALUATION STATES THAT THERE Recent
ARE NO RESONANCES WITH CERTAIN PHYSICALLY POSSIBLE J VALUES... Recent
IN THIS CASE POTENTIAL CONTRIBUTION MUST STILL BE CONSIDERED). Recent

Recent

EXAMPLE Recent
======= Recent
AN EXAMPLE OF WHERE THIS OCCURS AND IS IMPORTANT TO CONSIDER Recent
IS U-238 IN ENDF/B-IV AND V LIBRARIES WHERE FOR L=1 THERE IS Recent
ONLY A J=1/2 SEQUENCE. NOT INCLUDING THE J=3/2 SEQUENCE LEADS Recent
TO UNDERESTIMATING THE POTENTIAL SCATTERING AND PRODUCES Recent
MINIMA IN THE ELASTIC CROSS SECTION WHICH ARE AN ORDER OF Recent
MAGNITUDE LOWER THAN THE CROSS SECTIONS OBTAINED BE INCLUDING Recent
THE J=3/2 SEQUENCE. Recent
Recent

(2) FOR A GIVEN TARGET SPIN AND L VALUE THERE MAY BE 2 POSSIBLE Recent
MEANS OF OBTAINING THE SAME J VALUE. WHEN THIS OCCURS IN Recent
ORDER TO CALCULATE THE CORRECT POTENTIAL SCATTERING CROSS Recent
SECTION IT IS IMPORTANT TO INCLUDE THE EFFECT OF BOTH Recent
POSSIBLE J SEQUENCES, EVEN THOUGH FROM THE ENDF/B DATA IT IS Recent
NOT POSSIBLE TO DETERMINE WHICH OF THE 2 POSSIBLE SEQUENCES Recent
ANY GIVEN RESONANCE BELONGS TO. IN THIS CASE THIS PROGRAM Recent
TREAT ALL RESONANCES WITH THE SAME J VALUE AS BELONGING TO Recent
THE SAME J SEQUENCE (TO ALLOW INTERFERENCE) AND WILL ADD AN Recent
ADDITIONAL J SEQUENCE WITH NO RESONANCES IN ORDER TO ALLOW Recent
THE POTENTIAL CROSS SECTION TO BE CALCULATED CORRECTLY. WHEN Recent
THIS OCCURS A WARNING MESSAGE IS PRINTED, BUT BASED ON THE Recent
ENDF/B DATA THERE IS NOTHING WRONG WITH THE DATA AND THERE IS Recent
NOTHING THAT THE USER CAN DO TO CORRECT OR IN ANY WAY MODIFY Recent
THE DATA TO ELIMINATE THE PROBLEM. Recent
Recent

EXAMPLE Recent
======= Recent
FOR A TARGET SPIN =1 AND L=1 THE 2 RANGES OF PHYSICALLY Recent
POSSIBLE J ARE 1/2, 3/2, 5/2 AND 1/2, 3/2. BY CHECKING THE Recent
ENDF/B DATA IT IS POSSIBLE TO INSURE THAT THE 3 POSSIBLE Recent
J VALUES (1/2, 3/2, 5/2) ARE PRESENT AND TO INCLUDE ALL 3 Recent
J SEQUENCES IN THE CALCULATIONS. HOWEVER, UNLESS ALL 5 Recent
POSSIBLE J SEQUENCES ARE INCLUDED THE STATISTICAL WEIGHTS Recent
OF THE J SEQUENCES WILL NOT SUM UP TO 2*L+1 AND THE Recent
POTENTIAL CROSS SECTION WILL BE UNDERESTIMATED. IN THIS Recent
EXAMPLE THE SUM OF THE 3 J SEQUENCES 1/2, 3/2, 5/2 IS 2, Recent
RATHER THAN 3 AS IT SHOULD BE FOR L=1, AND THE CONTRIBUTION Recent
OF THE L=1 RESONANCES TO THE POTENTIAL SCATTERING CROSS Recent
SECTION WILL ONLY BE 2/3 OF WHAT IT SHOULD BE, UNLESS THE Recent
OTHER 2 J SEQUENCES (WITH DUPLICATE J VALUES) ARE INCLUDED Recent
IN THE CALCULATION. Recent
Recent

(3) EACH RESONANCE MUST HAVE AN ASSIGNED, PHYSICALLY POSSIBLE Recent
J VALUE. PHYSICALLY IMPOSSIBLE OR AVERAGE J VALUES CANNOT BE Recent
UNIQUELY INTERPRETED USING THE EQUATIONS IN ENDF-102 AND Recent
THEIR USE WILL USUALLY RESULT IN PHYSICALLY UNRELIABLE CROSS Recent
SECTIONS. THIS PROGRAM WILL CHECK ALL J VALUES AND IF ANY ARE Recent
ARE FOUND TO BE PHYSICALLY IMPOSSIBLE (BASED ON TARGET SPIN Recent
AND L VALUE) AN ERROR MESSAGE WILL BE PRINTED TO INDICATE THAT Recent
THE RECONSTRUCTED CROSS SECTIONS WILL BE UNRELIABLE AND THE Recent
PROGRAM WILL CONTINUE. IN AN ATTEMPT TO CALCULATE THE CORRECT Recent
POTENTIAL SCATTERING CROSS SECTION THIS PROGRAM WILL SUBTRACT Recent
THE POTENTIAL SCATTERING CONTRIBUTION DUE TO ALL FICTICIOUS J Recent
SEQUENCES AND ADD THE CONTRIBUTION OF ALL PHYSICALLY POSSIBLE Recent
J SEQUENCES (AS DESCRIBED ABOVE). Recent
Recent

WARNING (LET THE USER BEWARE) Recent
============================== Recent
(A) IT CANNOT BE STRESSED ENOUGH THAT CROSS SECTIONS OBTAINED Recent
USING PHYSICALLY IMPOSSIBLE J VALUES FOR REICH-MOORE AND Recent
MULTI-LEVEL BREIT-WIGNER RESONANCE PARAMETERS WILL RESULT Recent
IN UNRELIABLE CROSS SECTIONS. THE DECISION TO HAVE THIS Recent
PROGRAM CONTINUE TO PROCESS WHEN THIS CONDITION IS FOUND Recent
IS BASED ON AN ATTEMPT TO ALLOW THE USER TO AT LEAST HAVE Recent
SOME RESULTS (HOWEVER BAD THEY MAY BE) IF THERE IS NO Recent
OTHER EVALUATED DATA AVAILABLE. Recent
(B) EVEN THOUGH THE REICH-MOORE AND MULTI-LEVEL EQUATIONS ARE Recent
DEFINED AS ABSOLUTE OR SQUARED CONTRIBUTIONS WHICH MUST Recent
ALL BE PHYSICALLY POSSIBLE, ATTEMPTING TO CORRECT THE Recent

POTENTIAL CROSS SECTION (AS DESCRIBED ABOVE) CAN LEAD TO NEGATIVE ELASTIC CROSS SECTIONS. THIS IS BECAUSE BASED ON THE INFORMATION AVAILABLE IN THE EVALUATION IT IS NOT NOT POSSIBLE TO CORRECTLY ACCOUNT FOR THE INTERFERENCE BETWEEN THE RESONANCE AND POTENTIAL CONTRIBUTIONS FOR EACH J SEQUENCE. Recent

UNRESOLVED RESONANCE REGION

IN THE UNRESOLVED RESONANCE REGION THE UNRESOLVED PARAMETERS ARE USED TO CALCULATE INFINITELY DILUTE AVERAGE CROSS SECTIONS. NOTE, IT IS IMPORTANT TO UNDERSTAND THAT FROM THE DEFINITION OF THE UNRESOLVED PARAMETERS IT IS NOT POSSIBLE TO UNIQUELY CALCULATE ENERGY DEPENDENT CROSS SECTIONS. ONLY AVERAGES OR DISTRIBUTIONS MAY BE CALCULATED.

UNRESOLVED INTERPOLATION

IN THE UNRESOLVED RESONANCE REGION CROSS SECTIONS AT EACH ENERGY ARE CALCULATED BY INTERPOLATING PARAMETERS. THIS IS THE CONVENTION USED IN ENDF/B-IV AND EARLIER VERSIONS OF ENDF/B. THE ENDF/B-V CONVENTION OF INTERPOLATING CROSS SECTIONS, NOT PARAMETERS, HAS BEEN ABANDONED AS IMPRACTICAL SINCE IT CAN LEAD TO THE SITUATION WHERE EXACTLY THE SAME PHYSICAL DATA CAN LEAD TO DIFFERENT RESULTS DEPENDING ON WHICH OF THE THREE ENDF/B UNRESOLVED PARAMTER FORMATS IS USED. FOR EXAMPLE, GIVEN A SET OF ENERGY INDEPENDENT UNRESOLVED PARAMETERS IT IS POSSIBLE TO CODE THESE PARAMETERS IN EACH OF THE THREE ENDF/B UNRESOLVED PARAMETER FORMATS. SINCE PHYSICALLY WE ONLY HAVE ONE SET OF PARAMETERS WE WOULD EXPECT THE RESULTS TO BE INDEPENDENT OF HOW THEY ARE REPRESENTED IN ENDF/B. UNFORTUNATELY USING THE ENDF/B-V CONVENTION TO INTERPOLATE CROSS SECTIONS CAN LEAD TO THREE COMPLETELY DIFFERENT RESULTS. IN CONTRAST USING THE ENDF/B-IV AND EARLIER CONVENTION OF INTERPOLATING PARAMETERS LEADS TO COMPLETELY CONSISTENT RESULTS.

INTERNAL REPRESENTATION OF UNRESOLVED PARAMETERS

ANY OF THE THREE POSSIBLE REPRESENTATIONS OF UNRESOLVED PARAMETERS CAN BE UNIQUELY REPRESENTED IN THE ALL PARAMETERS ENERGY DEPENDENT REPRESENTATIONS WITH THE APPROPRIATE (ENDF/B VERSION DEPENDENT) INTERPOLATION LAW. THIS IS DONE BY THE PROGRAM WHILE READING THE UNRESOLVED PARAMETERS AND ALL SUBSEQUENT CALCULATIONS NEED ONLY CONSIDER THE ALL PARAMETERS ENERGY DEPENDENT REPRESENTATION.

RESONANCE RECONSTRUCTION STARTING ENERGY GRID

AS IN ANY ITERATIVE METHOD THE WAY TO SPEED CONVERGENCE IS TO TRY TO START CLOSE TO THE ANSWER. THIS PROGRAM ATTEMPTS TO DO THIS BY STARTING FROM AN ENERGY GRID WHICH IS A GOOD APPROXIMATION TO A SIMPLE BREIT-WIGNER LINE SHAPE,

$$SIGMA(X)=1.0/(1.0+X*X)$$

WHERE X IS THE DISTANCE FROM THE PEAK IN HALF-WIDTHS

SUBROUTINE SUBINT HAS A BUILT-IN TABLE OF NODES WHICH ARE THE HALF-WIDTH MULTIPLES TO APPROXIMATE THE SIMPLE BREIT-LINE SHAPE TO WITHIN 1 PER-CENT OVER THE ENTIRE INTERVAL 0 TO 500 HALF-WIDTHS

BETWEEN ANY TWO RESOLVED RESONANCES THE STARTING GRID IS BASED ON THE HALF-WIDTHS OF THE TWO RESONANCES. FROM THE LOWER ENERGY RESONANCE UP TO THE MID-POINT BETWEEN THE RESONANCES (MID-POINT IS DEFINED HERE AS AN EQUAL NUMBER OF HALF-WIDTHS FROM EACH RESONANCE) THE HALF-WIDTH OF THE LOWER ENERGY RESONANCE IS USED. FROM THE MID-POINT UP TO THE HIGHER ENERGY RESONANCE THE HALF-WIDTH OF THE UPPER ENERGY RESONANCE IS USED.

WITH THIS ALOGORITHM CLOSELY SPACED RESONANCES WILL HAVE ONLY A FEW STARTING NODES PER RESONANCE (E.G. U-235). WIDELY SPACED RESONANCES WILL HAVE MORE NODES PER RESONANCE (E.G. U-238). FOR A MIX OF S, P, D ETC. RESONANCES THIS ALOGORITHM GUARANTEES AN

ADEQUTE DESCRIPTION OF THE PROFILE OF EVEN EXTREMELY NARROW Recent
RESONANCES (WHICH MAY IMMEDIATELY CONVERGENCE TO THE ACCURACY Recent
REQUESTED, THUS MINIMIZING ITERATION). Recent
Recent

BACKGROUND CROSS SECTIONS Recent
------------------------ Recent
THE PROGRAM WILL SEARCH FOR BACKGROUND CROSS SECTIONS FOR TOTAL Recent
(MT=1), ELASTIC (MT=2), FISSION (MT=18), FIRST CHANCE FISSION Recent
(MT=19) AND CAPTURE (MT=102). Recent
Recent

(1) THE BACKGROUND CROSS SECTIONS (FILE 3) CAN BE PRESENT OR NOT Recent
    PRESENT FOR EACH REACTION. Recent
(2) IF FOR A GIVEN REACTION THE BACKGROUND CROSS SECTION IS Recent
    PRESENT, IT WILL BE ADDED TO THE RESONANCE CONTRIBUTION AND Recent
    THE RESULT WILL BE OUTPUT. Recent
(3) IF FOR A GIVEN REACTION THE BACKGROUND IS NOT PRESENT THE Recent
    PROGRAM WILL, Recent
    (A) IF THE INPUT TO THE PROGRAM SPECIFIES NO OUTPUT FOR Recent
        REACTIONS WITH NO BACKGROUND THERE WILL BE NO OUTPUT. Recent
    (B) IF THE INPUT TO THE PROGRAM SPECIFIES OUTPUT FOR REACTIONS Recent
        WITH NO BACKGROUND, Recent
        (I) THE RESONANCE CONTRIBUTION TO TOTAL, ELASTIC OR Recent
            CAPTURE WILL BE OUTPUT. Recent
        (II) IF ALL FISSION RESONANCE PARAMETERS ARE ZERO THE Recent
             FISSION CROSS SECTION (MT=18) WILL NOT BE OUTPUT. Recent
             OTHERWISE THE RESONANCE CONTRIBUTION OF THE FISSION Recent
             (MT=18) WILL BE OUTPUT. Recent
        (III) THERE WILL BE NO OUTPUT FOR FIRST CHANCE FISSION Recent
              (MT=19). Recent
Recent

COMBINING RESONANCES AND BACKGROUND CROSS SECTIONS Recent
-- Recent
IN ORDER TO BE COMBINED WITH THE RESONANCE CONTRIBUTION THE Recent
BACKGROUND CROSS SECTIONS MUST BE GIVEN AT 0 KELVIN TEMPERATURE Recent
AND MUST BE LINEARLY INTERPOLABLE. IF THESE CONDITIONS ARE MET Recent
THE RESONANCE AND BACKGROUND CONTRIBUTIONS WILL BE ADDED TOGETHER Recent
AND OUTPUT. IF THESE CONDITIONS ARE NOT MET THE BACKGROUND CROSS Recent
SECTION WILL BE IGNORED AND ONLY THE RESONANCE CONTRIBUTION WILL Recent
BE OUTPUT. IF THE BACKGROUND HAS NOT BEEN ADDED TO THE RESONANCE Recent
CONTRIBUTION AFTER THIS PROGRAM FINISHES THE USER CAN MAKE THE Recent
RESONANCE AND BACKGROUND CONTRIBUTIONS COMPATIBLE BY, Recent
Recent

(1) IF THE BACKGROUND IS NOT LINEARLY INTERPOABLE, LINEARIZE THE Recent
    BACKGROUND (E.G., USE PROGRAM LINEAR). Recent
(2) IF THE BACKGROUND IS NOT GIVEN AT 0 KELVIN, DOPPLER BROADEN Recent
    THE RESONANCE (NOT BACKGROUND) CONTRIBUTION TO THE SAME Recent
    TEMPERATURE AS THE BACKGROUND (E.G., USE PROGRAM SIGMA1). Recent
Recent

ONCE THE RESONANCE AND BACKGROUND CONTRIBUTIONS HAVE BEEN MADE Recent
COMPATIBLE THEY CAN BE ADDED TOGETHER (E.G., USE PROGRAM MIXER). Recent
Recent

THE RECONSTRUCTION OF THE RESONANCE CONTRIBUTION TO THE CROSS Recent
SECTION CAN BE QUITE EXPENSIVE (IN TERMS OF COMPUTER TIME). SINCE Recent
THE RECONSTRUCTION IS PERFORMED BEFORE THE BACKGROUND CROSS Recent
SECTIONS ARE READ, THE ABOVE CONVENTIONS HAVE BEEN ADOPTED IN Recent
ORDER TO AVOID LOSE OF COMPUTER TIME INVOLVED IN RECONSTRUCTING Recent
THE RESONANCE CONTRIBUTION. Recent
Recent

COMMON ENERGY GRID Recent
------------------ Recent
THIS PROGRAM WILL RECONSTRUCT THE RESONANCE CONTRIBUTION TO THE Recent
TOTAL, ELASTIC, FISSION AND CAPTURE CROSS SECTIONS ALL ON THE Recent
SAME ENERGY GRID. EACH REACTION WILL THEN BE COMBINED WITH ITS Recent
BACKGROUND CROSS SECTION (IF ANY) AND OUTPUT WITHOUT ANY FURTHER Recent
THINNING. IF THERE ARE NO BACKGROUND CROSS SECTIONS, OR IF THE Recent
BACKGROUND CROSS SECTION FOR ALL FOUR REACTIONS ARE GIVEN ON A Recent
COMMON ENERGY GRID, THE OUTPUT FROM THIS PROGRAM WILL BE ON A Recent
COMMON ENERGY GRID FOR ALL FOUR REACTIONS. Recent
Recent

THERMAL ENERGY Recent
-------------- Recent

IF THE RESONANCE REGION SPANS THERMAL ENERGY (0.0253 EV) THIS Recent
POINT IS ALWAYS INCLUDED IN THE COMMON ENERGY GRID USED FOR ALL Recent
REACTIONS AND WILL ALWAYS APPEAR IN THE OUTPUT DATA. Recent
Recent
SECTION SIZE Recent
------------ Recent
SINCE THIS PROGRAM USES A LOGICAL PAGING SYSTEM THERE IS NO LIMIT Recent
TO THE NUMBER OF POINTS IN ANY SECTION, E.G., THE TOTAL CROSS Recent
SECTION MAY BE REPRESENTED BY 200,000 DATA POINTS. Recent
Recent
SELECTION OF DATA Recent
----------------- Recent
THE PROGRAM SELECTS MATERIALS TO BE PROCESSED BASED EITHER ON Recent
MAT (ENDF/B MAT NO.) OR ZA. THE PROGRAM ALLOWS UP TO 100 MAT OR Recent
ZA RANGES TO BE SPECIFIED. THE PROGRAM WILL ASSUME THAT THE Recent
ENDF/B TAPE IS IN EITHER MAT OR ZA ORDER, WHICHEVER CRITERIA IS Recent
USED TO SELECT MATERIALS, AND WILL TERMINATE WHEN A MAT OR ZA Recent
IS FOUND THAT IS ABOVE THE RANGE OF ALL REQUESTS. Recent
Recent
ALLOWABLE ERROR Recent
--------------- Recent
THE RECONSTRUCTION OF LINEARLY INTERPOLABLE CROSS SECTIONS FROM Recent
RESONANCE PARAMETERS CANNOT BE PERFORMED EXACTLY. HOWEVER IT CAN Recent
BE PERFORMED TO VIRTUALLY ANY REQUIRED ACCURACY AND MOST Recent
IMPORTANTLY CAN BE PERFORMED TO A TOLERANCE THAT IS SMALL COMPARED Recent
TO THE UNCERTAINTY IN THE CROSS SECTIONS THEMSELVES. AS SUCH THE Recent
CONVERSION OF CROSS SECTIONS TO LINEARLY INTERPOLABLE FORM CAN BE Recent
PERFORMED WITH ESSENTIALLY NO LOSS OF INFORMATION. Recent
Recent
THE ALLOWABLE ERROR MAY BE ENERGY INDEPENDENT (CONSTANT) OR ENERGY Recent
DEPENDENT. THE ALLOWABLE ERROR IS DESCRIBED BY A TABULATED Recent
FUNCTION OF UP TO 20 (ENERGY,ERROR) PAIRS AND LINEAR INTERPOLATION Recent
BETWEEN TABULATED POINTS. IF ONLY ONE TABULATED POINT IS GIVEN THE Recent
ERROR WILL BE CONSIDERED CONSTANT OVER THE ENTIRE ENERGY RANGE. Recent
WITH THIS ENERGY DEPENDENT ERROR ONE MAY OPTIMIZE THE OUTPUT FOR Recent
ANY GIVEN APPLICATION BY USING A SMALL ERROR IN THE ENERGY RANGE Recent
OF INTEREST AND A LESS STRINGENT ERROR IN OTHER ENERGY RANGES, Recent
E.G., 0.1 PER-CENT FROM 0 UP TO THE LOW EV RANGE AND A LESS Recent
STRINGENT TOLERANCE AT HIGHER ENERGIES. Recent
Recent
DEFAULT ALLOWABLE ERROR Recent
----------------------- Recent
IN ORDER TO INSURE CONVERENCE OF THE RESONANCE RECONSTRUCTION THE Recent
ALLOWABLE ERROR MUST BE POSITIVE. IF THE USER INPUTS AN ERROR FOR Recent
RESONANCE RECONSTRUCTION THAT IS NOT POSITIVE IT WILL BE SET TO Recent
THE DEFAULT VALUE (CURRENTLY 0.1 PER-CENT) AND INDICATED AS SUCH Recent
IN THE OUTPUT LISTING. Recent
Recent
INTERVAL HALVING ALGORITHM Recent
------------------------- Recent
THIS PROGRAM WILL START BY CALCULATING THE CROSS SECTIONS AT THE Recent
ENERGIES CORRESPONDING TO THE PEAK OF EACH RESONANCE, AS WELL AS Recent
A FIXED NUMBER OF HALF-WIDTHS ON EACH SIDE OF EACH RESONANCE. Recent
STARTING FROM THIS BASIC GRID OF POINTS THE PROGRAM WILL CONTINUE Recent
TO HALF EACH INTERVAL UNTIL THE CROSS SECTIONS FOR ALL REACTIONS Recent
AT THE CENTER OF THE INTERVAL CAN BE DEFINED BY LINEAR Recent
INTERPOLATION FROM THE ENDS OF THE INTERVAL TO WITHIN THE USER Recent
SPECIFIED ACCURACY CRITERIA. Recent
Recent
DISTANT RESONANCE TREATMENT Recent
--------------------------- Recent
THE OPTION TO TREAT DISTANT RESONANCES, WHICH WAS AVAILABLE IN Recent
EARLIER VERSIONS OF THIS PROGRAM, IS NO LONGER AVAILABLE, BECAUSE Recent
IT WAS FOUND TO PRODUCE UNRELIABLE RESULTS. IN THIS VERSION OF Recent
THE PROGRAM ALL RESONANCES ARE TREATED EXACTLY. Recent
Recent
PROGRAM OPERATION Recent
=== Recent
EDIT MODE Recent
--------- Recent
IT IS SUGGESTED THAT BEFORE RUNNING THIS PROGRAM TO RECONSTRUCT Recent

CROSS SECTIONS FROM RESONANCE PARAMETERS (WHICH CAN BE QUITE EXPENSIVE) THE USER FIRST RUN THE PROGRAM IN THE EDIT MODE (SEE, DESCRIPTION OF INPUT PARAMETERS BELOW). IN THE EDIT MODE THE PROGRAM WILL READ, LIST AND EXTENSIVELY CHECK THE CONSISTENCY OF ALL RESONANCE PARAMETERS AND ENDF/B DEFINED RESONANCE FLAGS. THIS IS A VERY INEXPENSIVE MEANS OF CHECKING ALL DATA BEFORE INVESTING A LARGE AMOUNT OF MONEY IN RECONSTRUCTING CROSS SECTIONS. ANY AND ALL DIGNOSTICS RECEIVED FROM THE EDIT WILL SUGGEST HOW TO CORRECT THE EVALUATED DATA TO MAKE IT CONSISTENT BEFORE RECONSTRUCTING CROSS SECTIONS. IN ORDER TO OBTAIN MEANINGFUL RESULTS FROM THE RECONSTRUCTION ALL SUGGESTED CHANGES TO THE EVALUATION SHOULD BE PERFORMED BEFORE TRYING RECONSTRUCTION (OTHERWISE THE RESULT OF RECONSTRUCTION WILL NOT BE RELIABLE).

RECONSTRUCTION MODE

FOR EACH REQUESTED MATERIAL

IF SECTION MF=1, MT=451 IS PRESENT COMMENTS WILL BE ADD TO DOCUMENT THAT THE MATERIAL HAS BEEN PROCESSED. MF=1, MT=451 WILL ALSO BE USED TO DETERMINE THE VERSION OF THE ENDF/B FORMAT WHICH WILL ALLOW THE PROGRAM TO USE THE APPROPRIATE CONVENTIONS.

ALL OF THE FILE 2 RESONANCE PARAMETERS ARE FIRST READ AND THE LINEARLY INTERPOLABLE CONTRIBUTION OF THE RESONANCE PARAMETERS TO THE TOTAL, ELASTIC, CAPTURE AND FISSION CROSS SECTIONS IS CALCULATED SIMULTANEOUSLY USING A COMMON ENERGY GRID FOR ALL FOUR REACTIONS.

AFTER THE RESONANCE CONTRIBUTION HAS BEEN RECONSTRUCTED EACH OF THE FIVE REACTIONS (MT=1, 2, 18, 19, 102) IS CONSIDERED SEPARATELY FOR COMBINATION WILL THE BACKGROUND CROSS SECTION, IF ANY, AS DESCRIBED ABOVE.

OUTPUT WILL INCLUDE THE ENTIRE EVALUATION, INCLUDING RESONANCES PARAMETERS WITH LRU MODIFIED (AS DESCRIBED ABOVE) TO INDICATE THAT THE RESONANCE CONTRIBUTION HAS ALREADY BEEN ADDED TO THE FILE 3 CROSS SECTIONS.

THE CYCLE OF RECONSTRUCTING THE RESONANCE CONTRIBUTION AND ADDING THE BACKGROUND WILL BE REPEATED FOR EACH MATERIAL REQUESTED.

-----2016/3/10 - This option is no longer allowed - today's computers are so mjuch faster that this option is no longer needed.

PROCESS ONLY A PORTION OF RESONANCE REGION

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MODERN EVALUATIONS MAY BE EXTREMELY LARGE AND IT MAY NOT BE POSSIBLE TO PROCESS AN ENTIRE EVALUATION (I.E., ADD THE RESONANCE CONTRIBUTION) DURING A SINGLE COMPUTER RUN.

ALSO IN THE CASE WHERE YOU ARE ONLY INTERESTED IN THE CROSS SECTIONS OVER A SMALL ENERGY RANGE, YOU MAY NOT WANT TO PROCESS AN ENTIRE EVALUATION, E.G., IF YOU ONLY WANT TO KNOW WHAT THE CROSS SECTIONS ARE NEAR THERMAL ENERGY, 0.0253 EV.

IN ORDER TO ALLOW AN EVALUATION TO BE PROCESSED USING A NUMBER OF SHORTER COMPUTER RUNS AN OPTION HAS BEEN ADDED TO THIS PROGRAM TO ALLOW THE USER TO SPECIFY THE ENERGY RANGE TO BE PROCESSED.

USING THIS OPTION YOU MAY START AT THE LOWEST ENERGY (ZERO UP TO SOME ENERGY) AND USE THE RESULTS OF THIS RUN AS INPUT TO THE NEXT RUN, WHERE YOU CAN SPECIFY THE NEXT ENERGY RANGE. THIS CYCLE CAN BE REPEATED UNTIL YOU HAVE PROCESSED THE ENTIRE EVALUATION.

WARNING - THIS OPTION SHOULD BE USED WITH EXTREME CARE - THIS OPTION HAS BEEN RELUCTANTLY ADDED - RELUCTANTLY BECAUSE IT CAN BE EXTREMELY DANGEROUS TO USE THIS OPTION UNLESS YOU CAREFULLY CHECKED WHAT YOU ARE DOING.

```
     THE OPTION SHOULD ONLY BE USED AS FOLLOWS,                              Recent
     1) YOU MUST PROCESS USING ENERGY RANGES STARTING AT LOW ENERGY          Recent
        AND WORKING YOUR WAY TOWARD HIGH ENERGY, E.G.,                       Recent
         0.0   TO  3.0+3                                                     Recent
         3.0+3 TO 10.0+3                                                     Recent
        10.0+3 TO 80.0+3, ETC.                                               Recent
     2) FOR THE LAST ENERGY RANGE THE LOWER ENERGY LIMIT MUST BE             Recent
        NON-ZERO (WHERE TO START) AND THE UPPER ENERGY LIMIT MUST            Recent
        BE ZERO (NO LIMIT)                                                   Recent
        80.0+3 TO  0.0                                                       Recent
                                                                             Recent
     IF YOU ARE ONLY INTERESTED IN THE CROSS SECTION OVER A NARROW           Recent
     ENERGY INTERVAL AND DO NOT INTENT TO MAKE ANY OTHER USE OF THE          Recent
     RESULTS, YOU CAN IGNORE THESE WARNINGS AND MERELY SPECIFY ANY           Recent
     ENERGY INTERVAL OVER WHICH YOU WISH CALCULATIONS TO BE                  Recent
     PERFORMED.                                                              Recent
                                                                             Recent
     NORMALLY WHEN THIS PROGRAM PROCESSES AN EVALUATION IT WILL SET          Recent
     FLAGS IN THE EVALUATION TO PREVENT THE SAME RESONANCE                   Recent
     CONTRIBUTION FROM BEING ADDED TO THE CROSS SECTION MORE THAN            Recent
     ONCE, SHOULD YOU USE THE OUTPUT FROM THIS PROGRAM AS INPUT TO           Recent
     THE PROGRAM.                                                            Recent
                                                                             Recent
     WHEN PROCESSING ONLY PORTIONS OF THE RESONANCE REGION THIS              Recent
     PROGRAM CANNOT SET THESE FLAGS TO PROTECT AGAINST ADDING THE            Recent
     RESONANCE CONTRIBUTION MORE THAN ONCE - WHICH MAKES USE OF              Recent
     THIS OPTION EXTREMELY DANGEROUS.                                        Recent
                                                                             Recent
     ONLY YOU CAN CHECK TO MAKE SURE THAT YOU HAVE CORRECTLY                 Recent
     INCLUDED EACH ENERGY RANGE ONLY ONCE - SEE THE COMMENT LINES            Recent
     AT THE END OF SECTION, MF=1, MT=451, FOR A COMPLETE RECORD              Recent
     OF EACH RUN USING THIS PROGRAM. THIS SECTION WILL CONTAIN               Recent
     LINES OF THE FORM                                                       Recent
                                                                             Recent
     ***************** PROGRAM RECENT (VERSION 2018-1) *************         Recent
     ONLY PROCESS  0.00000+ 0 TO  3.00000+ 3 EV                              Recent
     ***************** PROGRAM RECENT (VERSION 2018-1) *************         Recent
     ONLY PROCESS  3.00000+ 3 TO  1.00000+ 4 EV                              Recent
     ***************** PROGRAM RECENT (VERSION 2018-1) *************         Recent
     ONLY PROCESS  1.00000+ 4 TO  8.00000+ 4 EV                              Recent
     ***************** PROGRAM RECENT (VERSION 2018-1) *************         Recent
     ONLY PROCESS  8.00000+ 4 TO  2.00000+ 7 EV                              Recent
                                                                             Recent
     YOU SHOULD CHECK TO INSURE THAT THERE ARE NO OVERLAPPING ENERGY          Recent
     RANGES OR MISSING ENERGY RANGES.                                        Recent
                                                                             Recent
     WHEN YOU INDICATE BY INPUT THAT YOU ARE ABOUT TO PROCESS THE            Recent
     LAST ENERGY RANGE (SEE ABOVE, LOWER ENERGY LIMIT = NON-ZERO,            Recent
     UPPER ENERGY LIMIT = ZERO), THIS PROGRAM WILL ASSUME THAT               Recent
     YOU HAVE NOW COMPLETED ALL PROCESSING - AND ONLY THEN WILL              Recent
     IT SET FLAGS IN THE EVALUATION TO PREVENT THE RESONANCE                 Recent
     CONTRIBUTION FROM BEING ADDED MORE THAN ONCE. FOR THIS REASON           Recent
     YOU CANNOT PROCESS STARTING WITH ENERGY INTERVALS AT HIGH               Recent
     ENERGY AND WORKING TOWARD LOW ENERGY - YOU MUST START AT LOW            Recent
     ENERGY AND WORK TOWARD HIGH ENERGY.                                     Recent
-----2016/3/10 - This option is no longer allowed - today's computers        Recent
                                                                             Recent
     I/O FILES                                                               Recent
     ======================================================================= Recent
     INPUT FILES                                                             Recent
     -----------                                                             Recent
     UNIT  DESCRIPTION                                                       Recent
     ----  -----------                                                       Recent
       2   INPUT LINE (BCD - 80 CHARACTERS/RECORD)                           Recent
      10   ORIGINAL ENDF/B DATA (BCD - 80 CHARACTERS/RECORD)                 Recent
                                                                             Recent
     OUTPUT FILES                                                            Recent
     ------------                                                            Recent
     UNIT  DESCRIPTION                                                       Recent
     ----  -----------                                                       Recent
       3   OUTPUT REPORT (BCD - 120 CHARACTERS/RECORD)                       Recent
```

```
 11   FINAL ENDF/B DATA (BCD - 80 CHARACTERS/RECORD)                Recent
                                                                    Recent
SCRATCH FILES                                                       Recent
-------------                                                       Recent
UNIT  DESCRIPTION                                                   Recent
----  -----------                                                   Recent
 12   SCRATCH FILE FOR DATA RECONSTRUCTED FROM RESONANCE            Recent
      PARAMETERS (BINARY - 100200 WORDS/RECORD)                     Recent
 14   SCRATCH FILE FOR COMBINED FILE 2 AND 3 DATA                   Recent
      (BINARY - 40080 WORDS/RECORD)                                 Recent
                                                                    Recent
OPTIONAL STANDARD FILE NAMES (SEE SUBROUTINE FILEIO)                Recent
================================================================== Recent
UNIT  FILE NAME                                                     Recent
----  ----------                                                    Recent
  2   RECENT.INP                                                    Recent
  3   RECENT.LST                                                    Recent
 10   ENDFB.IN                                                      Recent
 11   ENDFB.OUT                                                     Recent
 12   (SCRATCH)                                                     Recent
 14   (SCRATCH)                                                     Recent
                                                                    Recent
INPUT CARDS                                                         Recent
================================================================== Recent
LINE  COLS.  FORMAT  DESCRIPTION                                    Recent
----  -----  ------  -----------                                    Recent
  1    1-11    I11   RETRIEVAL CRITERIA (0=MAT, 1=ZA)              Recent
                     THIS OPTION DEFINED WHETHER COLUMNS 1-22 OF    Recent
                     SUBSEQUENT INPUT CARDS SHOULD BE INTERPRETED   Recent
                     TO BE MAT OR ZA RANGES.                        Recent
       12-22  E11.4  FILE 2 MINIMUM ABSOLUTE CROSS SECTION          Recent
                     (IF 1.0E-10 OR LESS IS INPUT THE PROGRAM       Recent
                     WILL USE 1.0E-10)                              Recent
       23-33    I11   TREATMENT OF REACTIONS FOR WHICH BACKGROUND   Recent
                     CROSS SECTION IS NOT GIVEN.                    Recent
                     = 0 - IGNOR (I.E. NO OUTPUT)                   Recent
                     = 1 - OUTPUT RESONANCE CONTRIBUTION.           Recent
                     THIS OPTION IS USEFUL WITH PARTIAL EVALUATION  Recent
                     (E.G. ENDF/B-V DOSIMETRY LIBRARY) WHERE ONLY   Recent
                     ONE OR MORE OF THE REACTIONS ARE OF ACTUAL     Recent
                     INTEREST.                                      Recent
                     WARNING...THE USE OF THIS FIELD HAS BEEN       Recent
                     CHANGED. THIS FIELD WAS PREVIOUSLY USED TO     Recent
                     DEFINE THE PRECISION OF THE CALCULATION AND    Recent
                     OUTPUT. THE FORMER DEFINITION OF THIS FIELD    Recent
                     WAS...                                         Recent
                     MINIMUM ENERGY SPACING FLAG                    Recent
                     = 0 - 6 DIGIT MINIMUM ENERGY SPACING.          Recent
                           STANDARD 6 DIGIT E11.4 OUTPUT.           Recent
                     = 1 - 9 DIGIT MINIMUM ENERGY SPACING.          Recent
                           STANDARD 6 DIGIT E11.4 OUTPUT.           Recent
                     = 2 - 9 DIGIT MINIMUM ENERGY SPACING.          Recent
                           VARIABLE 9 DIGIT F FORMAT OUTPUT.        Recent
                     FROM EXPERIENCE IT HAS BEEN FOUND THAT         Recent
                     FAILURE TO SET THIS OPTION TO 2 CAN RESULT     Recent
                     IN LARGE ERRORS IN THE FINAL DATA. THEREFORE   Recent
                     INTERNALLY THIS OPTION IS SET TO 2.            Recent
       34-44    I11   OPERATING MODE                                 Recent
                     = 0 - CACULATE. MINIMUM OUTPUT LISTING         Recent
                     = 1 - CACULATE. LIST ALL RESONANCE PARAMETERS  Recent
                     = 2 - EDIT MODE. NO CALCULATION. LIST ALL      Recent
                           RESONANCE PARAMETERS.                    Recent
                     NOTE, THE EDIT MODE (=2) IS THE SUGGESTED      Recent
                     MODE TO FIRST TEST THE CONSISTENCY OF THE      Recent
                     EVALUATED DATA, BEFORE RECONSTRUCTING CROSS    Recent
                     SECTIONS (SEE, COMMENTS ABOVE).                Recent
       45-55    I11   NEGATIVE CROSS SECTIOIN TREATMENT              Recent
                     = 0 - O.K. - NO CHANGE                         Recent
                     = 1 - SET = 0                                  Recent
       56-66    I11   MONITOR MODE SELECTOR                          Recent
                     = 0 - NORMAL OPERATION                         Recent
```

```
                          = 1 - MONITOR PROGRESS OF RECONSTRUCTION OF   Recent
                                FILE 2 DATA AND COMBINING FILE 2 AND    Recent
                                FILE 3 DATA. EACH TIME A PAGE OF DATA   Recent
                                POINTS IS WRITTEN TO A SCRATCH FILE     Recent
                                PRINT OUT THE TOTAL NUMBER OF POINTS    Recent
                                ON SCRATCH AND THE LOWER AND UPPER      Recent
                                ENERGY LIMITS OF THE PAGE (THIS OPTION  Recent
                                MAY BE USED IN ORDER TO MONITOR THE     Recent
                                EXECUTION SPEED OF LONG RUNNING JOBS).  Recent
       2     1-72     A72    ENDF/B INPUT DATA FILENAME                 Recent
                             (STANDARD OPTION = ENDFB.IN)               Recent
       3     1-72     A72    ENDF/B OUTPUT DATA FILENAME                Recent
                             (STANDARD OPTION = ENDFB.OUT)              Recent
     4-N     1-11     I11    MINIMUM MAT OR ZA (SEE COLS. 1-11, LINE 1) Recent
            12-22     I11    MAXIMUM MAT OR ZA (SEE COLS. 1-11, LINE 1) Recent
                             UP TO 100 MAT OR ZA RANGES MAY BE SPECIFIED, Recent
                             ONE RANGE PER LINE. THE LIST IS TERMINATED  Recent
                             BY A BLANK LINE. IF THE THE UPPER LIMIT OF  Recent
                             ANY REQUEST IS LESS THAN THE LOWER LIMIT THE Recent
                             UPPER LIMIT WILL BE SET EQUAL TO THE LOWER  Recent
                             LIMIT. IF THE FIRST REQUEST LINE IS BLANK IT Recent
                             WILL TERMINATE THE REQUEST LIST AND CAUSE ALL Recent
                             DATA TO BE RETRIEVED (SEE EXAMPLE INPUT).   Recent
----- 2016/3/10 - Partial Processing no longer allowed.                  Recent
                  If these fields are not blank the code will STOP      Recent
                  with a WARNING that this is no longer allowed.        Recent
            23-33   E11.4  LOWER ENERGY LIMIT FOR PROCESSING.           Recent
            34-44   E11.4  UPPER ENERGY LIMIT FOR PROCESSING.           Recent
                           *THE LOWER AND UPPER ENERGY LIMITS MUST BE   Recent
                            ZERO, OR BLANK, UNLESS YOU WISH TO ONLY     Recent
                            PROCESS A PORTION OF RESONANCE REGIONS.     Recent
                           *THESE ENERGY LIMITS ARE ONLY READ FROM THE  Recent
                            FIRST MAT/ZA REQUEST LINE                   Recent
                           *IF BOTH ARE ZERO (OR BLANK) THE ENTIRE      Recent
                            RESONANCE REGION FOR EACH MATERIAL WILL BE  Recent
                            PROCESSED                                   Recent
                           *IF LIMITS ARE INPUT ONLY THAT PORTION OF THE Recent
                            RESONANCE REGION FOR EACH MATERIAL WHICH    Recent
                            LIES BETWEEN THESE LIMITS WILL BE PROCESSED Recent
                           *SEE INSTRUCTIONS ABOVE BEFORE USING THIS    Recent
                            OPTION.                                     Recent
----- 2016/3/10 - Partial Processing no longer allowed.                  Recent
     VARY   1-11   E11.4  ENERGY FOR FILE 2 ERROR LAW     (  SEE   )    Recent
            12-22  E11.4  ERROR FOR FILE 2 ERROR LAW      (COMMENTS)    Recent
                                                          ( BELOW  )    Recent
                                                                        Recent
     NOTE, THIS VERSION OF THE PROGRAM DOES NOT THIN THE COMBINED FILE   Recent
     FILE 2 + 3 DATA. AS SUCH THE ERROR LAW FOR COMBINING FILE 2 + 3     Recent
     WHICH WAS REQUIRED IN EARLIER VERSIONS OF THIS CODE ARE NO LONGER    Recent
     REQUIRED.                                                          Recent
                                                                        Recent
     THE FILE 2 ERROR LAW MAY BE ENERGY INDEPENDENT (DEFINED BY A       Recent
     SINGLE ERROR) OR ENERGY DEPENDENT (DEFINED BY UP TO 20 ENERGY,     Recent
     ERROR PAIRS). FOR THE ENERGY DEPENDENT CASE LINEAR INTERPOLATION   Recent
     WILL BE USED TO DEFINE THE ERROR AT ENERGIES BETWEEN THOSE AT      Recent
     WHICH THE ERROR IS TABULATED. THE ERROR LAW IS TERMINATED BY A     Recent
     BLANK LINE. IF ONLY ONE ENERGY, ERROR PAIR IS GIVEN THE LAW WILL   Recent
     BE CONSIDERED TO BE ENERGY INDEPENDENT. IF MORE THAN ONE PAIR      Recent
     IS GIVEN IT BE CONSIDERED TO BE ENERGY DEPENDENT (NOTE, THAT       Recent
     FOR A CONSTANT ERROR THE ENERGY INDEPENDENT FORM WILL RUN FASTER.  Recent
     HOWEVER, FOR SPECIFIC APPLICATIONS AN ENERGY DEPENDENT ERROR MAY   Recent
     BY USED TO MAKE THE PROGRAM RUN CONSIDERABLE FASTER).              Recent
                                                                        Recent
     ALL ENERGIES MUST BE IN ASCENDING ENERGY ORDER. FOR CONVERGENCE    Recent
     OF THE FILE 2 RECONSTRUCTION ALGORITHM ALL THE ERRORS MUST BE      Recent
     POSITIVE. IF ERROR IS NOT POSITIVE IT WILL BE SET EQUAL TO THE     Recent
     STANDARD OPTION (CURRENTLY 0.001, CORRESPONDING TO 0.1 PER-CENT).  Recent
     IF THE FIRST LINE OF THE ERROR LAW IS BLANK IT WILL TERMINATE THE  Recent
     ERROR LAW AND THE ERROR WILL BE TREATED AS ENERGY INDEPENDENT,     Recent
     EQUAL TO THE STANDARD OPTION (CURRENTLY, 0.1 PER-CENT). SEE,       Recent
     EXAMPLE INPUT 4.                                                   Recent
```

```
                                                                    Recent
    EXAMPLE INPUT NO. 1                                             Recent
    ------------------                                              Recent
    CONSIDER ALL URANIUM ISOTOPES AND TH-232. CONSIDER CROSS SECTIONS Recent
    WHICH ARE LARGER THAN 1.0E-8 BARNS IN ABSOLUTE VALUE. ONLY OUTPUT Recent
    REACTIONS FOR WHICH A BACKGROUND IS GIVEN. LIST ALL PARAMETERS AND Recent
    CALCULATE CROSS SECTIONS. MONITOR THE EXECUTION PROGRESS OF THE  Recent
    PROGRAM. BETWEEN 0 AND 100 EV USE 0.1 PER-CENT ACCURACY. BETWEEN Recent
    100 EV AND 1 KEV VARY THE ACCURACY FROM 0.1 TO 1 PER-CENT. ABOVE Recent
    1 KEV USE 1 PER-CENT ACCURACY.                                  Recent
                                                                    Recent
    EXPLICITLY SPECIFY THE STANDARD FILENAMES.                      Recent
                                                                    Recent
    THE FOLLOWING 11 INPUT CARDS ARE REQUIRED.                      Recent
                                                                    Recent
         1 1.00000-08          0          1          0         1    Recent
ENDFB.IN                                                            Recent
ENDFB.OUT                                                           Recent
     92000      92999                                               Recent
     90232                  (UPPER LIMIT AUTOMATICALLY SET TO 90232) Recent
                            (END REQUEST LIST)                      Recent
0.00000+ 0 1.00000-03                                               Recent
1.00000+02 1.00000-03                                               Recent
1.00000+03 1.00000-02                                               Recent
1.00000+09 1.00000-02                                               Recent
                            (END FILE 2 ERROR LAW)                  Recent
                                                                    Recent
    EXAMPLE INPUT NO. 2                                             Recent
    ------------------                                              Recent
    CONSIDER ALL URANIUM ISOTOPES AND TH-232. CONSIDER CROSS SECTIONS Recent
    WHICH ARE LARGER THAN 1.0E-8 BARNS IN ABSOLUTE VALUE. ONLY OUTPUT Recent
    REACTIONS FOR WHICH A BACKGROUND IS GIVEN. CROSS SECTIONS WILL BE Recent
    CALCULATED, BUT PARAMETERS WILL NOT BE LISTED. THE PROGRESS OF THE Recent
    PROGRAM WILL NOT BE MONITORED. USE 0.1 PER-CENT ACCURACY FOR ALL Recent
    ENERGIES. SINCE 0.1 PER-CENT IS THE STANDARD OPTION FOR THE ERROR Recent
    LAW THE FIRST ERROR LAW LINE MAY BE LEFT BLANK.                 Recent
                                                                    Recent
    LEAVE THE DEFINITION OF THE FILENAMES BLANK - THE PROGRAM WILL  Recent
    THEN USE THE STANDARD FILENAMES.                                Recent
                                                                    Recent
    THE FOLLOWING 7 INPUT CARDS ARE REQUIRED.                       Recent
                                                                    Recent
         1 1.00000-08          0          0          0         0    Recent
                                                                    Recent
                                                                    Recent
     92000      92999                                               Recent
     90232                  (UPPER LIMIT AUTOMATICALLY SET TO 90232) Recent
                            (END REQUEST LIST)                      Recent
                            (USE STANDARD OPTION FOR ERROR LAW)     Recent
                                                                    Recent
    EXAMPLE INPUT NO. 3                                             Recent
    ------------------                                              Recent
    THE SAME AS EXAMPLE INPUT NO. 2, ONLY IN THIS CASE ONLY CALCULATE Recent
    CROSS SECTIONS OVER THE ENERGY RANGE 0.01 TO 0.1 EV - ACROSS THE Recent
    THERMAL ENERGY RANGE. NOTE, THE ONLY DIFFERENCE BETWEEN THE INPUT Recent
    PARAMETERS IN THIS CASE AND IN EXAMPLE NO. 2, IS THAT ON THE    Recent
    SECOND INPUT LINE WE HAVE ADDED THE ENERGY RANGE 0.01 TO 0.1 EV. Recent
    USE \PREPRO94\LINEAR\ENDFB.OUT AS INPUT AND ENDFB.OUT AS OUTPUT - Recent
    SINCE ENDFB.OUT IS THE STANDARD OUTPUT FILENAME THE NAME CAN BE Recent
    EITHER INCLUDED IN THE INPUT OR LEFT BLANK.                     Recent
                                                                    Recent
    THE FOLLOWING 7 INPUT CARDS ARE REQUIRED.                       Recent
                                                                    Recent
         1 1.00000-08          0          0          0         0    Recent
\PREPRO94\LINEAR\ENDFB.OUT                                          Recent
ENDFB.OUT                                                           Recent
     92000      92999 1.00000- 2 1.00000- 1                         Recent
     90232                  (UPPER LIMIT AUTOMATICALLY SET TO 90232) Recent
                            (END REQUEST LIST)                      Recent
                            (USE STANDARD OPTION FOR ERROR LAW)     Recent
                                                                    Recent
```

```
    EXAMPLE INPUT NO. 4                                                 Recent
    ------------------                                                  Recent
    RECONSTRUCT ALL DATA. OUTPUT ALL REACTIONS, REGARDING OF WHETHER    Recent
    OR NOT THERE IS A BACKGROUND CROSS SECTION. DO NOT MONITOR THE      Recent
    PROGRESS OF THE PROGRAM. RECONSTRUCT CROSS SECTIONS TO 1 PER-CENT   Recent
    ACCURACY. USE \ENDFB6\LINEAR\ZA092238 AS INPUT AND                  Recent
    \ENDFB6\RECENT\ZA092238 AS OUTPUT.                                  Recent
                                                                        Recent
    THE FOLLOWING 6 INPUT CARDS ARE REQUIRED.                           Recent
                                                                        Recent
         0 0.0                1          0          0         0       Recent
\ENDFB6\ZA092238                                                        Recent
\ENDFB6\RECENT\ZA092238                                                 Recent
                   (RETRIEVE ALL DATA, END REQUEST LIST)                Recent
           1.00000- 2                                                   Recent
                   (END FILE 2 ERROR LAW)                               Recent
                                                                        Recent
    EXAMPLE INPUT NO. 5                                                 Recent
    ------------------                                                  Recent
    RECONSTRUCT ALL DATA. ONLY OUTPUT REACTIONS FOR WHICH A BACKGROUND  Recent
    CROSS SECTION IS GIVEN. DO NOT MONITOR THE PROGRESS OF THE PROGRAM  Recent
    RECONSTRUCT CROSS SECTIONS TO 0.1 PER-CENT ACCURACY. USE ENDFB.IN   Recent
    AS INPUT AND ENDFB.OUT AS OUTPUT.                                   Recent
                                                                        Recent
    THIS CORRESPONDS TO USING ALL OF THE STANDARD OPTONS BUILT-IN TO    Recent
    THE PROGRAM AND ALL INPUT CARDS MAY BE BLANK.                       Recent
                                                                        Recent
    IN THIS CASE THE FOLLOWING 5 INPUT CARDS ARE REQUIRED.              Recent
    (ZEROES ARE INDICATED ON THE FIRST LINE, BELOW, ONLY TO INDICATE    Recent
    WHERE THE LINE IS. THE ACTUAL INPUT LINE CAN BE COMPLETELY BLANK).  Recent
                                                                        Recent
         0 0.0                0          0          0         0       Recent
                   (USE STANDARD INPUT FILENAME = ENDFB.IN)             Recent
                   (USE STANDARD OUTPUT FILENAME = ENDFB.OUT)           Recent
                   (RETRIEVE ALL DATA, END REQUEST LIST)                Recent
                   (0.1 ERROR, END FILE 2 ERROR LAW)                    Recent
                                                                        Recent
======================================================================= Recent
```