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Graphs of the Cross Sections in the Alternate Monte Carlo Cross Section Library at the Los Alamos Scientific Laboratory

University of California

LOS ALAMOS SCIENTIFIC LABORATORY

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GRAPHS OF THE CROSS SECTIONS IN THE ALTERNATE MONTE CARLO CROSS SECTION LIBRARY AT THE LOS ALAMOS SCIENTIFIC LABORATORY

by

R. E. Seamon and P. D. Soran

ABSTRACT

Graphs of all neutron cross sections and photon production cross sections on the Alternate Monte Carlo Cross Section (AMCCS) library have been plotted along with local neutron heating numbers. The values of ν, the average number of neutrons per fission, are also plotted for appropriate isotopes.

I. INTRODUCTION

This report is a sequel to Ref. 1 in which the cross sections on the Recommended Monte Carlo Cross Section (RMCCS) library are presented in hard copy format. In this report we provide microfiche containing the same sort of information from the AMCCS library. These cross section files have been prepared for the Monte Carlo neutron-photon transport code MCNP.[2] The format in which the neutron and photon production cross section information is stored on the RMCCS and AMCCS files is described in Appendix E of Ref. 2.

In the same spirit in which the RMCCS cross sections are presented in Ref. 1, we give here the AMCCS cross section curves with all their "warts and wrinkles," no attempt having been made to smooth the curves, to make polynomial fits to the data, or in other ways to make the curves cosmetically more acceptable. It is true that the negative heating numbers have been cut off as reported in the DISCUSSION section of Ref. 1.

II. CONTENTS OF THE VOLUME

With this volume we present on microfiche the plots of the neutron interaction and photon production cross sections for the 39 elements and

isotopes listed in Table I. The nuclide identifier name, ZAID, is followed by the chemical symbol for the element or isotope as well as its elemental name. The source of the evaluation from which the data were taken is given as well as information about the temperature at which the cross sections were calculated, the upper and lower energy limits of each cross section set, and the quality of the heating numbers.

The nuclide identifier name ZAID is a floating point number used to identify the evaluation. The portion of ZAID to the left of the decimal point is ZA, where ZA = 1000*Z + A, Z is the charge number (atomic number) for the element and A is the mass number; the unique ID identifier for the cross section set is to the right of the decimal point.

The cross sections on AMCCS come from three sources: the Evaluated Nuclear Data Files ENDF/B-III and ENDF/B-IV,[3] the Evaluated Nuclear Data Library ENDL,[4] and the Atomic Weapons Research Establishment Library UK.[5]

In general, the lower energy limit for the cross section sets is 10^{-5} eV (10^{-11} MeV); the upper energy limit is 20 MeV; EXCEPTIONS to this rule are noted in Table I.

There are 39 sets of graphs contained on the microfiche, one set for each of the elements or isotopes on the AMCCS file. The arrangement of the graphs is precisely the same as that described for the RMCCS library in Ref. 1. We remind our readers that the unit for all cross sections is barns and that for local neutron heating is MeV/collision.

III. DISCUSSION

One remarkable difference between the AMCCS and RMCCS libraries is that on AMCCS there may be more than one evaluation for a particular isotope. Specifically, for ^{235}U there are seven cross section sets, for ^{238}U there are four sets, and for ^{239}Pu there are six sets. Closer inspection of Table I shows that many of the sets came from ENDF/B-IV and that the difference between them is the temperature at which the cross sections were calculated. These are "doppler broadened" cross sections. Temperature broadening is carried out in the NJOY[6] code after the pointwise cross sections have been reconstructed from the resonance parameters and background given in the original evaluation.

There are several sets of cross sections with negative heating numbers as shown by the crosses in the last column of Table I. The origin of this difficulty has been reviewed in detail in the DISCUSSION section of Ref. 1. As

pointed out there, some of these problems can be explained by the fact that we have mixed together photon production and neutron cross sections from different evaluations. This problem is much more pronounced on the AMCCS library. It should be noted in particular that on the RMCCS library the ENDL evaluations do not have negative heating numbers whereas on the AMCCS library it appears that they do. It must be emphasized that the footnotes for Table I are very significant; the ENDL evaluations which appear on AMCCS did NOT have photon production information associated with them; we used photon production matrices from other sources in concert with the ENDL neutron cross sections, there was not energy consistency between the neutron and photon data, and the negative heating numbers resulted. The MCNP code does not use the negative heating numbers, but instead they are set to 0.0.

The average number of neutrons per fission, $\bar{\nu}$, is an important quantity which must be displayed for the fissionable isotopes. The curves for prompt and total $\bar{\nu}$ for the ENDF/B-IV evaluations of ^{235}U, ^{238}U, ^{239}Pu, and ^{240}Pu have already been displayed in Appendix B of Ref. 1. It remains to display the values of prompt $\bar{\nu}$ which are provided with the various ENDL evaluations on AMCCS for ^{235}U, ^{238}U, ^{239}Pu, and ^{240}Pu. These curves are shown in Fig. 1; the relationships between the curve labels and the ENDL evaluations are given in Table II. The curves for the two ^{235}U evaluations are essentially indistinguishable and show more variation as a function of energy.

IV. ACKNOWLEDGMENTS

The cross section plots on the microfiche were generated using program EVALPLOT[7] modified for use here at LASL. We thank D. E. Cullen for making the original version of that program available to us. We also thank J. Briesmeister for her assistance in generating the plots of $\bar{\nu}$ versus energy and D. Morris for secretarial assistance in preparation of the manuscript.

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TABLE I

ISOTOPES AND ELEMENTS ON AMCCS

ZAID	Chemical Symbol	Element Name	Evaluation Source	Temperature (K)	Lowest Energy (MeV)	Highest Energy (MeV)	Negative Heating
1001.30	^{1}H	hydrogen	*ENDL-76[a]	0	10^{-10}		x
1002.04	^{2}D	deuterium	*ENDF/B-IV	0			x
1003.30	^{3}T	tritium	ENDL-76	0	10^{-10}		
2004.30	^{4}He	helium	ENDL-76	0	10^{-10}		
5010.02	^{10}B	boron	*ENDF/B-III[b]	0		15.0	
7014.30	^{14}N	nitrogen	*ENDL-76[a]	0	10^{-10}		
8016.30	^{16}O	oxygen	*ENDL-76[c]	0	10^{-10}		
9019.01	^{19}F	fluorine	*ENDL-73[a]	0	10^{-10}		x
13027.01	^{27}Al	aluminum	*ENDL-73[c]	0	10^{-10}		x
14000.01	Si	silicon	*ENDL-73[c]	0	10^{-10}		x
17000.01	Cl	chlorine	*ENDL-73[d]	0	10^{-10}		x
20000.01	Ca	calcium	*ENDL-73[d]	0	10^{-10}		x
22000.01	Ti	titanium	ENDL-73	0	10^{-10}		
24000.01	Cr	chromium	UK	0	10^{-10}	15.0	
26000.30	Fe	iron	*ENDL-76[c]	0	10^{-10}		x
28000.01	Ni	nickel	UK	0	10^{-10}	15.0	
29000.01	Cu	copper	*ENDL-73[c]	0	10^{-10}		x
40000.01	Zr	zirconium	UK	0	10^{-10}	17.0	
41093.01	^{93}Nb	niobium	ENDL-73	0	10^{-10}		
73181.01	^{181}Ta	tantalum	ENDL-76	0	2.5×10^{-8}	14.6	
82000.01	Pb	lead	*ENDL-73[c]	0	10^{-10}		x
92235.01	^{235}U	uranium	*ENDL-73	0	10^{-10}		
92235.10	^{235}U	uranium	*ENDF/B-IV	0			
92235.11	^{235}U	uranium	*ENDF/B-IV	300			
92235.15	^{235}U	uranium	*ENDF/B-IV	1.2×10^{7}			
92235.18	^{235}U	uranium	*ENDF/B-IV	3000			
92235.20	^{235}U	uranium	*ENDF/B-IV	6×10^{5}			
92235.30	^{235}U	uranium	*ENDL-76[c]	0	10^{-10}		
92238.01	^{238}U	uranium	*ENDL-73[e]	0	10^{-10}		x
92238.15	^{238}U	uranium	*ENDF/B-IV	1.2×10^{7}			x
92238.20	^{238}U	uranium	*ENDF/B-IV	6×10^{5}			x

TABLE I (cont)

ZAID	Chemical Symbol	Element Name	Evaluation Source	Temperature (K)	Lowest Energy (MeV)	Highest Energy (MeV)	Negative Heating
92238.30	^{238}U	uranium	*ENDL-76[c]	0	10^{-10}		
94239.01	^{239}Pu	plutonium	*ENDL-73[e]	0	10^{-10}		x
94239.15	^{239}Pu	plutonium	*ENDF/B-IV	1.2×10^{7}			
94239.16	^{239}Pu	plutonium	*ENDF/B-IV	0			
94239.17	^{239}Pu	plutonium	*ENDF/B-IV	300			
94239.18	^{239}Pu	plutonium	*ENDF/B-IV	3000			
94239.20	^{239}Pu	plutonium	*ENDF/B-IV	6×10^{5}			
94240.01	^{240}Pu	plutonium	*ENDL-73[e]	0	10^{-10}		x

*The asterisk indicates those evaluations for which photon production data are included.

[a]The photon production data were taken from ENDF/B-IV.

[b]The photon production data were taken from a local evaluation by R. E. Seamon described in a memorandum dated June 8, 1973.

[c]The photon production data were taken from a source other than that from which the neutron cross sections came. The source for the photon production data is not readily identifiable.

[d]The photon production data were taken from ENDF/B-III.

[e]The photon production data were prepared by L. Stewart and R. Hunter in December, 1972.

TABLE II

KEY TO THE CURVES IN FIGURE 1

ZAID	Curve Label
92235.01	U-235a
92235.30	U-235b
92238.01	U-238a
92238.30	U-238b
94239.01	Pu-239
94240.01	Pu-240

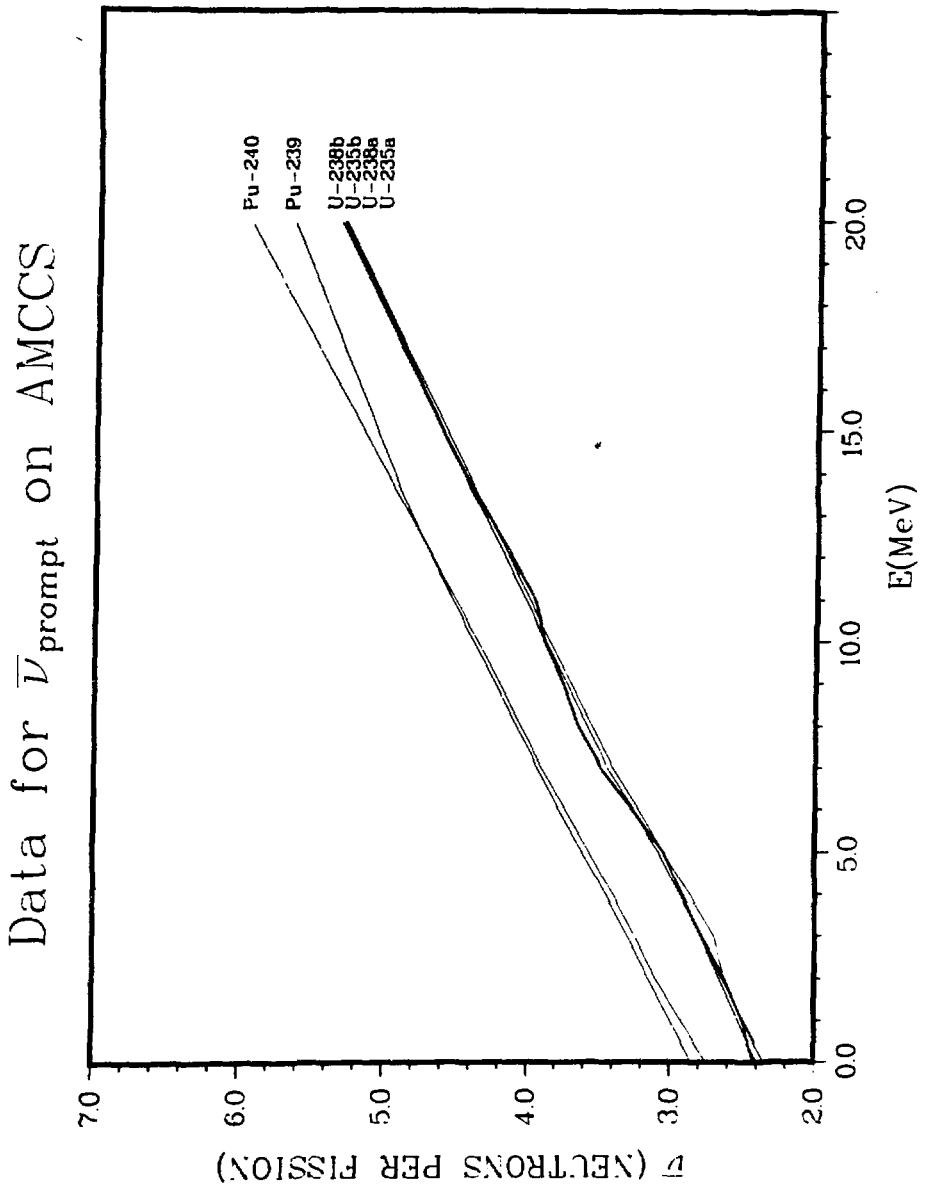

Figure 1.

Data for prompt $\bar{\nu}$ on AMCCS.