LA-UR-04-4520

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Title: MCNP Neutron Library T16_2003

Author(s): Robert C. Little

Submitted to: Reference document for nuclear data library T16_2003.

Los Alamos
NATIONAL LABORATORY

memorandum

Applied Physics Division
Diagnostics Applications Group (X-5)

To/MS: Distribution
From/MS: Robert C. Little, X-5, MS F663
Phone/Fax: 5-3487/5-3046
E-mail: rcl@lanl.gov
Symbol: X-5:04-39 (U)
Date: June 28, 2004

Subject: MCNP Neutron Library T16_2003

Executive Summary

A new MCNP continuous-energy neutron library has been created. The library is named T16_2003, and includes data for 15 target isotopes based on recent evaluations performed by the LANL Nuclear Physics Group T-16. Data are provided for ^{3}H, ^{232}U, ^{233}U, ^{234}U, ^{235}U, ^{236}U, ^{237}U, ^{238}U, ^{239}U, ^{240}U, ^{241}U, ^{237}Np, ^{239}Pu, ^{241}Am, and ^{243}Am. Room-temperature tables have been created for each of the 15 isotopes (ZAID endings of ".69c"), tables at 3000 K have been created for each isotope except ^{3}H and ^{237}Np (ZAID endings of ".68c"), and 77 K tables have been created for ^{235}U, ^{238}U, and ^{239}Pu (ZAID endings of ".67c"). As of 09/07/2004 the data tables on T16_2003 will become the defaults for these 15 isotopes for Monte Carlo users of the ICN or X-Division LAN computing systems at Los Alamos.

Background

Several MCNP [Ref. 1] neutron libraries based on ENDF/B-VI evaluations have been made available by Group X-5 at Los Alamos. The most recent are named ENDF66 and ACTI. ENDF66 [Ref. 2] is based on ENDF/B-VI Release 6 and provides data for 173 nuclides. ACTI [Ref. 3] is based on ENDF/B-VI Release 8 and provides data for 41 nuclides.

Release 8 was the final release of ENDF/B-VI (finalized by CSEWG in October 2001). The next release of ENDF is planned to be ENDF/B-VII. Current plans are for ENDF/B-VII to be distributed by CSEWG in December 2005.

In the interim between ENDF/B-VI Release 8 and ENDF/B-VII, various organizations have developed updated evaluations intended to be tested as candidates for ENDF/B-VII. Los Alamos has been a leading participant in this activity, primarily focusing on actinides. It is largely from this work that the data on T16_2003 have been gathered. One must be aware that there is no guarantee that the evaluations represented on T16_2003 will actually be identical to those released in ENDF/B-VII (in fact, Los Alamos Group T-16 has already worked on refined versions of U-235, U-238, and Pu-239 beyond those provided on T16_2003).

Isotopes Available on T16_2003

Data are provided for 15 target isotopes on T16_2003. Table 1 lists the isotopes, the ZAID(s) for each isotope, and a reference to the original evaluated data.

Table 1. Data Tables Available on T16_2003 Library

Isotope	Evaluation Reference	Processing Temperature (K)	ZAID
H-3	4	293.6	1003.69c
U-232	5, 6	293.6	92232.69c
		3000.0	92232.68c
U-233	6, 7	293.6	92233.69c
		3000.0	92233.68c
U-234	5, 6	293.6	92234.69c
		3000.0	92234.68c
U-235	6	77.0	92235.67c
		293.6	92235.69c
		3000.0	92235.68c
U-236	6	293.6	92236.69c
		3000.0	92236.68c
U-237	6, 8	293.6	92237.69c
		3000.0	92237.68c
U-238	6	77.0	92238.67c
		293.6	92238.69c
		3000.0	92238.68c
U-239	6, 8	293.6	92239.69c
		3000.0	92239.68c
U-240	6	293.6	92240.69c
		3000.0	92240.68c
U-241	6, 8	293.6	92241.69c
		3000.0	92241.68c
Np-237	9	293.6	93237.69c
Pu-239	9, 10	77.0	94239.67c
		293.6	94239.69c
		3000.0	94239.68c

Isotope	Evaluation Reference	Processing Temperature (K)	ZAID
Am-241	11	293.6	95241.69c
		3000.0	95241.68c
Am-243	12	293.6	95243.69c
		3000.0	95243.68c

Relative to ENDF/B-VI, the recent H-3 evaluation features a substantial increase in the elastic scattering cross section below ~ 1 MeV and a substantial reduction in the (n,2n) cross section.

The uranium data have resulted from a comprehensive re-evaluation for these isotopes. Several changes have been made relative to ENDF/B-VI. A good overview of the updated uranium evaluations and data testing results may be found in Reference 5.

The updated Np-237 evaluation differs from the ENDF/B-VI evaluation only through a small increase in the fission cross section in the fast energy range (~ 1-5 MeV) and a more substantial fission cross-section increase above 15 MeV.

The Pu-239 evaluation *does* include the (n,2n) cross section resulting from the now famous GEANIE measurements and GNASH modeling [Ref. 10], although the current evaluation specifies a lower value of the (n,2n) cross section from threshold to 6.5 MeV. In addition there have been modest but important updates to the fission cross section, fission nubar, and fission neutron energy spectrum relative to the ENDF/B-VI evaluation.

The Am-241 evaluation was performed in 2003, and focused on the (n,2n), fission, and capture reaction (cross section and branching) channels.

The Am-243 evaluation is actually from ENDF/B-VI Release 5. It was performed by T-16 back in 1996. The data table 95243.69c on T16_2003 is actually identical to the data set 95243.66c previously released as part of ENDF66. We have chosen to include data for Am-243 on the T16_2003 MCNP library for consistency with a recently-released multigroup data library [Ref. 13].

For additional details on the updates in the evaluations, see the References or contact us.

Data Available on T16_2003

All of the most recent MCNP neutron physics enhancements are supported by data on T16_2003. These enhancements include detailed delayed-neutron spectra, unresolved-resonance probability tables, and tabular angular distributions. See Appendix A for the MCNP Table G.2 listing regarding the data tables on T16_2003. A full listing for all current MCNP data is available at http://www-xdiv.lanl.gov/PROJECTS/DATA/nuclear/doc/Appendix_G.html

The processing and verification strategy for T16_2003 is essentially identical to that described in Ref. 2. Appendix B includes detailed information of the creation of these libraries needed for X-5 archiving purposes.

T16_2003 Library Availability

The T16_2003 library will be made available to (open and secure) ICN and X-Division LAN users at Los Alamos on 09/07/2004. Los Alamos users who would like to test the new data before that date should contact us. The library will be sent to RSICC for external distribution later during the summer of 2004.

The Los Alamos xsdir file will be updated at the time of the release of T16_2003 such that the data tables therein contained will become the default data tables for these 15 isotopes. Those users who do not fully specify ZAIDs will therefore see differences in results for problems containing any of the 15 isotopes provided on T16_2003. All users, of course, may request data tables from T16_2003 by specifying full ZAIDs according to Table I; e.g., 92235.69c.

Summary

The continuous-energy MCNP neutron library T16_2003 based upon recent Los Alamos Group T-16 evaluations for 15 isotopes has been created and made available. The majority of the evaluations represented on T16_2003 are intended to be tested as candidates for ENDF/B-VII, although there is no guarantee that the evaluations represented on T16_2003 will actually be identical to those released in ENDF/B-VII. As of 09/07/2004 the data tables on T16_2003 will become the defaults for the 15 isotopes for Monte Carlo users of the ICN or X-Division LAN computing systems at Los Alamos.

References:

1. X-5 Monte Carlo Team, "MCNP – A General Monte Carlo N-Particle Transport Code, Version 5. Volume I: Overview and Theory," LA-UR-03-1987 (April 2003).
2. Joann M. Campbell, Stephanie C. Frankle, and Robert C. Little, "ENDF66 – A Continuous-Energy Neutron Data Library for MCNP4C," *Proc. 12th Biennial Top. Mtg. Radiation Protection and Shielding Div.*, Santa Fe, New Mexico, April 2002, American Nuclear Society (2002).
3. S. C. Frankle, R. C. Reedy, and P. G. Young, "ACTI – An MCNP Data Library for Prompt Gamma-ray Spectroscopy," *Proc. 12th Biennial Top. Mtg. Radiation Protection and Shielding Div.*, Santa Fe, New Mexico, April 2002, American Nuclear Society (2002).
4. G.M. Hale, D.C. Dodder, J.D. Seagrave, B.L. Berman, and T.W. Philips, "Neutron-triton cross sections and scattering lengths obtained from p-3He scattering," Phys. Rev. C 42, 438 (1990).
5. Phillip G. Young, Mark B. Chadwick, R. E. MacFarlane, and Patrick Talou, "Neutron Reactions on 232U and 234U: Analysis and Evaluation," LA-UR-03-3205 (2003).

6. R. E. MacFarlane, et al., “New Suite of Evaluated Nuclear Cross Sections for Uranium Isotopes and Impacts in Simulations (U),” LACP-03-0789 submitted to Proceedings of NEDPC 2003 (2003).
7. Phillip G. Young, Mark B. Chadwick, R. E. MacFarlane, and Patrick Talou, “Analysis of Neutron Reactions on 233U,” LA-UR-03-1617 (2003).
8. P. G. Young and M. B. Chadwick, “237, 239, 241U + n Evaluations,” T-16:NW-2/10-00 (October 19, 2000).
9. Mark Chadwick, private communication (March 26, 2003).
10. M. B. Chadwick, P. G. Young, and D. McNabb, “Evaluation of the 239Pu(n,2n) Cross Section,” T-16-MBC00/10 (October 2, 2000).
11. T. Kawano, et al., “Americium Cross Sections for Delta-A Diagnostics and Attribution,” LA-UR-03-8983 submitted to Proceedings of NEDPC 2003 (2003).
12. V. McLane, C. L. Dunford, and P. F. Rose, Editors, “Data Formats and Procedures for the Evaluated Nuclear Data File ENDF-6,” BNL-NCS-44945 Revised (November 1995).
13. Robert C. Little, “NDI Multigroup Neutron Library T16_2003,” X-5:04-8 (February 24, 2004).

Appendix A – "MCNP Manual Appendix G" Information for T16_2003

ZAID	AWR	Library Name	Source	Date	Temp (K)	Total Length	Num En	Max En	GPD	NU	CP	DN	UR
Z = 1 ********** Hydrogen **********													
** H-3 **													
1003.69c	2.9896	t16_2003	LANL/T16	2001	293.6	11206	468	20.0	no	no	no	no	no
Z = 92 ********** Uranium **********													
** U-232 **													
92232.68c	230.0438	t16_2003	LANL/T16	2003	3000.	183542	5757	30.0	yes	both	no	no	yes
92232.69c	230.0438	t16_2003	LANL/T16	2003	293.6	197150	7269	30.0	yes	both	no	no	yes
** U-233 **													
92233.68c	231.0377	t16_2003	LANL/T16	2003	3000.	323539	11206	30.0	yes	both	no	yes	yes
92233.69c	231.0377	t16_2003	LANL/T16	2003	293.6	441295	24290	30.0	yes	both	no	yes	yes
** U-234 **													
92234.68c	232.0304	t16_2003	LANL/T16	2003	3000.	286070	16719	30.0	yes	both	no	yes	yes
92234.69c	232.0304	t16_2003	LANL/T16	2003	293.6	344651	23228	30.0	yes	both	no	yes	yes
** U-235 **													
92235.67c	233.0250	t16_2003	LANL/T16	2003	77.0	1119233	111037	20.0	yes	both	no	yes	yes
92235.68c	233.0250	t16_2003	LANL/T16	2003	3000.	337079	24131	20.0	yes	both	no	yes	yes
92235.69c	233.0250	t16_2003	LANL/T16	2003	293.6	726320	67380	20.0	yes	both	no	yes	yes
** U-236 **													
92236.68c	234.0178	t16_2003	LANL/T16	2003	3000.	276138	15549	30.0	yes	both	no	yes	yes
92236.69c	234.0178	t16_2003	LANL/T16	2003	293.6	328212	21335	30.0	yes	both	no	yes	yes
** U-237 **													
92237.68c	235.0124	t16_2003	LANL/T16	2000	3000.	120768	6401	30.0	yes	both	no	yes	yes
92237.69c	235.0124	t16_2003	LANL/T16	2000	293.6	135303	8016	30.0	yes	both	no	yes	yes
** U-238 **													
92238.67c	236.0058	t16_2003	LANL/T16	2003	77.0	1099087	103664	30.0	yes	both	no	yes	yes
92238.68c	236.0058	t16_2003	LANL/T16	2003	3000.	547675	42396	30.0	yes	both	no	yes	yes
92238.69c	236.0058	t16_2003	LANL/T16	2003	293.6	874492	78709	30.0	yes	both	no	yes	yes
** U-239 **													
92239.68c	237.0007	t16_2003	LANL/T16	2000	3000.	111013	6340	30.0	yes	both	no	yes	yes
92239.69c	237.0007	t16_2003	LANL/T16	2000	293.6	125557	7956	30.0	yes	both	no	yes	yes
** U-240 **													
92240.68c	237.9944	t16_2003	LANL/T16	2003	3000.	243398	11524	30.0	yes	both	no	yes	yes
92240.69c	237.9944	t16_2003	LANL/T16	2003	293.6	276968	15254	30.0	yes	both	no	yes	yes
** U-241 **													
92241.68c	238.9890	t16_2003	LANL/T16	2000	3000.	117572	6309	30.0	yes	both	no	yes	yes
92241.69c	238.9890	t16_2003	LANL/T16	2000	293.6	132260	7941	30.0	yes	both	no	yes	yes
Z = 93 ********** Neptunium **********													

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**   Np-237  **
   93237.69c    235.0118   t16_2003     LANL/T16          2003     293.6    255036   18967    20.0  yes  both    no   yes  no

Z  =  94  **************   Plutonium  ****************************************

**   Pu-239  **
   94239.67c    236.9986   t16_2003     LANL/T16          2003      77.0    887458   83969    20.0  yes  both    no   yes  yes
   94239.68c    236.9986   t16_2003     LANL/T16          2003     3000.    395617   29320    20.0  yes  both    no   yes  yes
   94239.69c    236.9986   t16_2003     LANL/T16          2003     293.6    706549   63868    20.0  yes  both    no   yes  yes

Z  =  95  **************   Americium  ****************************************

**   Am-241  **
   95241.68c    238.9860   t16_2003     LANL/T16          2003     3000.    163034    8020    30.0  yes  both    no   yes  yes
   95241.69c    238.9860   t16_2003     LANL/T16          2003     293.6    267605   19639    30.0  yes  both    no   yes  yes
**   Am-243  **
   95243.68c    240.9734   t16_2003     ENDF/B-VI.5       1996     3000.    160276   10268    30.0  yes  both    no   yes  yes
   95243.69c    240.9734   t16_2003     ENDF/B-VI.5       1996     293.6    308812   26772    30.0  yes  both    no   yes  yes
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Appendix B – Details of Processing Required for X-5 Archiving

The name of the evaluated file used as the source for processing is provided in Table B-1.

Table B-1. Evaluated Files Used for Processing

Isotope	File
H-3	h3gdh (originally transmitted as attachment to Hale 12/18/02 e-mail; updated by Little to include mf4/mt16 and mf5/mt16 from ENDF/B-VI)
U-232	u232la2 (originally transmitted as attachment to Chadwick 03/26/03 e-mail; actually used slightly updated version from http://t2.lanl.gov/data/data/preVii-neutron/U/232l dated 04/15/03 -- this version differed from the original only with the inclusion of the necessary title card)
U-233	u233la8a transmitted as attachment to Chadwick 03/26/03 e-mail
U-234	u234la4 transmitted as attachment to Chadwick 03/26/03 e-mail
U-235	u235la9d (originally transmitted as attachment to Chadwick 03/26/03 e-mail; actually used slightly updated version from http://t2.lanl.gov/data/data/preVii-neutron/U/235l dated 06/20/03 -- this version differed from the original only with an updated fission neutron energy spectrum at 1.e-5 eV incident energy)
U-236	u236la2d transmitted as attachment to Chadwick 11/26/03 e-mail
U-237	u237la4b transmitted as attachment to Chadwick 03/26/03 e-mail
U-238	u238la8h transmitted as attachment to Chadwick 03/26/03 e-mail
U-239	u239la2b transmitted as attachment to Chadwick 03/26/03 e-mail
U-240	u240la4d transmitted as attachment to Chadwick 11/26/03 e-mail
U-241	u241la2b transmitted as attachment to Chadwick 03/26/03 e-mail
Np-237	np237la1b transmitted as attachment to Chadwick 03/26/03 e-mail
Pu-239	pu239la7d transmitted as attachment to Chadwick 03/26/03 e-mail
Am-241	am241 (from file named Am241.lanl-final attached to 08/04/03 Kawano e-mail)
Am-243	am243e (file obtained from /cfs/endf/6u/neutron/am/243e)

The version of NJOY used in all processing was NJOY 99.50.1.

Most files associated with this job have been archived on open HPSS under the /hpss/nucldata/archive/mc_data/Libs/t16_2003 subdirectory. The pendf processing files are archived on open HPSS under the /hpss/nucldata/archive/sn_data /t16_2003 subdirectory.

RCL:rcl