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The Influence of the Basic Evaluated Data Files on Thermal Lattice Integral Parameters

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Abstract

The applicability of relatively simple calculations with the deterministic lattice cell code `WIMS-D/4` to study the relative influence of the changes in the nuclear data on the thermal lattice integral parameters is demonstrated. The metal uranium TRX lattices, uranium dioxide BAPL lattices and the recently measured DIMPLE-S01A lattice are considered. Whenever possible, comparison to detailed results with Monte-Carlo codes is made. The original WIMS-D library and the data from ENDF/B-IV, ENDF/B-V, ENDF/B-VI Rev.2, ENDF/B-VI Rev.3 and JEF-2.2 are considered.

1 Introduction

The ENDF/B-IV and ENDF/B-V data libraries have been extensively analysed [1, 2] for thermal reactor applications. The results of Monte-Carlo calculations can serve as numerical benchmarks for the validation of other deterministic methods. In this way the data processing methods for generating a WIMS-D library were validated [3, 4]. The same data processing methods were applied to generate WIMS-D libraries based on different basic evaluated data files. Using the same physical models to represent a selection of thermal lattice experiments, the differences in the calculated integral parameters should originate purely from the differences in the nuclear data.

2 Methods

The metal uranium TRX-1 and TRK-2 lattices, uranium dioxide BAPL-1, BAPL-2 and BAPL-3 lattices [5] and the recently measured DIMPLE-S01A lattice were considered. The `WIMS-D/4` inputs as prepared within the WIMS-D Library Update Project [3] of the International Atomic Energy Agency were used to model the lattices. In addition to the original WIMS-D library, special libraries were prepared with new data based on ENDF/B-IV, ENDF/B-V, ENDF/B-VI Rev.2, ENDF/B-VI Rev.3 and JEF-2.2 data for hydrogen bound in water, oxygen, aluminium and the uranium isotopes. The following integral parameters were considered:

Table 1: Definitions of some of the parameters

k_{eff}	effective multiplication factor,
ρ^{28}	ratio of epithermal to thermal ^{238}U capture reaction rate,
δ^{25}	ratio of epithermal to thermal ^{235}U fission reaction rate,
δ^{28}	ratio of ^{238}U fission to ^{235}U fission reaction rate,
δ^{29}	ratio of ^{239}Pu fission to ^{235}U fission reaction rate,
C^*	ratio of ^{238}U capture to ^{235}U fission reaction rate.

In Tables 5-10 the integral parameters calculated with `WIMS-D/4` are compared to the measured values. In braces the per-cent uncertainty is quoted for the measured values and the per-cent difference from the measurements for the calculated values. An average over all the lattices is also given: the average per-cent uncertainty in the integral parameters is given for the measured values and the average per-cent difference from the measurements and the associated variance (in braces) for the calculated values.

The calculated integral parameters can be compared to the results of detailed Monte-Carlo calculations, which are reported in the literature [1, 2]. The results for ENDF/B-IV and ENDF/B-V data are shown in Tables 11-12, respectively. They indicate the accuracy in absolute terms with which the integral parameters can be calculated using simple models and the same basic nuclear data. The discussion of the results can be found elsewhere [3] and will not be repeated here. Instead, the relative differences between the results using different libraries is investigated. In Table 2 the differences are given for all lattices, between the effective multiplication factor calculated from multigroup libraries based different evaluated data files. The differences between the ENDF/B-IV and ENDF/B-V data, between ENDF/B-V and ENDF/B-VI Rev.2 and between JEF-2.2 and ENDF/B-VI Rev.2 are considered. The results of the `WIMS-D/4` calculations are compared to the differences in the reference values from the literature and to the `MCNP4A` calculations [6].

Table 2: Differences in k_{eff} (expressed as $\Delta k_{eff} \times 10^5$) for thermal reactor lattices due to the use of different evaluated data files.

		TRX-1	TRX-2	BAPL-1	BAPL-2	BAPL-3	DIMP1A
E5-E4	Ref.	790	480	1199	1036	1099	-
	WIMS	847	690	947	858	779	850
E6-E5	MCNP	-	-	-	-	-	309
	WIMS	-175	-254	-285	-314	-329	-118
F2-E6	WIMS	278	177	307	287	239	284

MCNP - refers to `MCNP4A` calculation.
WIMS - refers to `WIMS-D/4` calculation.
E4 - refers to results based on ENDF/B-IV data.
E5 - refers to results based on ENDF/B-V data.
E6 - refers to results based on ENDF/B-VI Rev.2 data.
F2 - refers to results based on JEF-2.2 data.

The results of the `WIMS-D/4` calculations show very good consistency with the reference results [1, 2], comparing ENDF/B-IV and ENDF/B-V data. Note that the quoted reference results for the two libraries were not calculated with the same set of codes and hence the differences may include a contribution from the systematic discrepancies in the results produced by different codes.

The results for the DIMPLE-S01A core calculated with `MCNP4A` and ENDF/B-VI data [6] are shown in Table 3. If the `WIMS-D/4` based differences in Table 2 are valid, the equivalent result for the multiplication factor with the JEF-2.2 data would be 0.99941.

Table 3: Comparison of measurement and calculation for the DIMPLE-S01A core using `MCNP4A` code and data based ENDF/B-V and ENDF/B-VI evaluated data files.

	K-eff	Del29	Del28	ConvR
Measured	1.00000(~.30)	2.189(~0.9)	0.00302(~3.4)	0.0203(~0.5)
ENDF/B-V	0.99348(-.65)	2.16 (-1.7)	0.00274(-9.3)	0.0196(-3.4)
ENDF/B-VI	0.99657(-.34)	2.16 (-1.7)	0.00273(-9.6)	0.0196(-3.4)

There exists a shadow of doubt on the reliability of the relative differences in the

MCNP4A results based on ENDF/B-V and ENDF/B-VI data, because they are not consistent with the differences predicted by WIMS-D/4. One must bear in mind that the WIMS-D/4 calculations are rather crude, but the possibility that the discrepancy arises from the MCNP4A calculation can not be entirely excluded. It is well known that MCNP4A can not take self-shielding into account in the unresolved resonance region. The resolved and the unresolved resonance ranges for different ENDF/B libraries are shown in Table 4. Note that the unresolved resonance range extends down to $2250\,eV$ for ^{235}U and down to $10\,keV$ for ^{238}U in ENDF/B-VI, but as far down as $82\,eV$ for ^{235}U and $4\,keV$ for ^{238}U in ENDF/B-V.

Table 4: Resolved and unresolved resonance ranges in ENDF/B libraries for the uranium isotopes.

	Uranium-235			Uranium-238		
	Resolved	—	Unresolved	Resolved	—	Unresolved
ENDF/B-IV	$1\,eV$	$82\,eV$	$25\,keV$	$1\,eV$	$4\,keV$	$45\,keV$
ENDF/B-V	$1\,eV$	$82\,eV$	$25\,keV$	$1\,eV$	$4\,keV$	$149\,keV$
ENDF/B-VI	$10^{-5}\,eV$	$2250\,eV$	$25\,keV$	$10^{-5}\,eV$	$10\,keV$	$149\,keV$

3 Conclusions

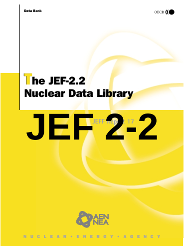
Integral parameters for a number of thermal lattices were calculated with WIMS-D/4 and multigroup cross section libraries based on various evaluated data files. Comparison of the relative differences between ENDF/B-IV and ENDF/B-V results relative to differences predicted by more detailed Monte-Carlo calculations using the same basic data indicate, that simple deterministic methods can be used to investigate the effect of some changes in the data on integral parameters.

From a reference Monte-Carlo calculation for the DIMPLE-S01A core based on ENDF/B-VI data and the relative differences calculated with WIMS/D-4 it seems that an equivalent detailed calculation using JEF-2.2 data would predict the the multiplication factor very close to one.

The difference in the results of the reference Monte-Carlo calculation for the DIMPLE-S01A core using ENDF/B-V and ENDF/B-VI data is not consistent with the difference calculated by WIMS-D/4. There exists a possibility that this inconsistency is due to self-shielding in the unresolved resonance range, which is not accounted for in MCNP4A.

References

[1] CSEWG Thermal Reactor Data Testing Subcommittee: *Benchmark Testing of ENDF/B Data for Thermal Reactors*, Archival Volume, National Nuclear Data Center, BNL, Upton, New York, USA, BNL-NCS-29891, (ENDF-313), Jul.1981.



[2] *Benchmark Data Testing of ENDF/B-V*, Brookhaven National Laboratory, Upton, New York, USA, BNL-NCS-31531, (ENDF-313), Aug.1982.

[3] S.Ganesan (Compil.): *Update of the WIMS-D/4 Nuclear Data Library*, Status Report of the IAEA WIMS Library Update Project, Internatinal Atomic Energy Agency, INDC(NDS)-290, Dec.1993.

[4] A.Trkov, D.L.Aldama: *Parametric Study of the NJOY Input Options in the Frame of the WIMS Library Update Project*, Institute Jožef Stefan, Ljubljana, Slovenia, IJS-DP-7049, (1994).

[5] Cross Section Evaluation Working Group, *Benchmark Specifications*, BNL 19302 (ENDF-202) with Supplements (1986).

[6] M.Maučec: *Description of DIMPLE S01A model developed with Monte Carlo Computer Code MCNP4A*, Institute Jožef Stefan, Ljubljana, Slovenia, Private communication.

Table 5: WIMS-D/4 and measurements comparison.

SMRDIF Integral parameter comparison

Reference file :[ANDREJ.WLUP2]REFEXP.SMR
Compared file :BNCWD4.SMR

LATTICE	K-eff	Rho28	Del25	Del28	ConvR
TRX-1	1.00000(~.30)	1.320(~1.6)	0.0987(~1.0)	0.0946(~4.3)	0.797(~1.0)
	1.00150(+.15)	1.280(-3.0)	0.0990(+.34)	0.0966(+2.1)	0.780(-2.1)
TRX-2	1.00000(~.10)	0.837(~1.9)	0.0614(~1.3)	0.0693(~5.1)	0.647(~.93)
	0.99570(-.43)	0.809(-3.4)	0.0610(-.60)	0.0696(+.38)	0.636(-1.7)
BAPL-1	1.00000(~.10)	1.390(~.72)	0.0840(~2.4)	0.0780(~5.1)	0.000
	1.00232(+.23)	1.358(-2.3)	0.0841(+.07)	0.0755(-3.2)	0.800
BAPL-2	1.00000(~.10)	1.120(~.89)	0.0680(~1.5)	0.0700(~5.7)	0.000
	0.99982(-.02)	1.134(+1.2)	0.0687(+1.0)	0.0653(-6.7)	0.732
BAPL-3	1.00000(~.10)	0.906(~1.1)	0.0520(~1.9)	0.0570(~5.3)	0.000
	0.99741(-.26)	0.894(-1.3)	0.0529(+1.8)	0.0539(-5.5)	0.657
DIMP1A	1.00000(~.10)	0.000	0.0000	0.0962(~3.3)	0.647(~.46)
	1.00809(+.80)	3.825	0.2375	0.0852(- 11)	0.633(-2.2)
Average	0.15	1.32	1.69	4.86	0.83
	0.08(~0.39)	-1.76(~1.65)	0.52(~0.81)	-4.07(~4.51)	-1.99(~0.24)

Table 6: ENDF/B-IV and measurements comparison.

SMRDIF Integral parameter comparison

Reference file :[andrej.wlup2]refexp.smr
Compared file :BNCE4.SMR

LATTICE	K-eff	Rho28	Del25	Del28	ConvR
TRX-1	1.00000(~.30)	1.320(~1.6)	0.0987(~1.0)	0.0946(~4.3)	0.797(~1.0)
	0.98327(-1.7)	1.405(+6.4)	0.1002(+1.6)	0.0924(-2.3)	0.812(+1.9)
TRX-2	1.00000(~.10)	0.837(~1.9)	0.0614(~1.3)	0.0693(~5.1)	0.647(~.93)
	0.98676(-1.3)	0.881(+5.3)	0.0615(+.18)	0.0656(-5.3)	0.653(+.97)
BAPL-1	1.00000(~.10)	1.390(~.72)	0.0840(~2.4)	0.0780(~5.1)	0.000
	0.99162(-.85)	1.441(+3.6)	0.0843(+.42)	0.0712(-8.7)	0.818
BAPL-2	1.00000(~.10)	1.120(~.89)	0.0680(~1.5)	0.0700(~5.7)	0.000
	0.99203(-.81)	1.200(+7.2)	0.0688(+1.2)	0.0613(- 12)	0.746
BAPL-3	1.00000(~.10)	0.906(~1.1)	0.0520(~1.9)	0.0570(~5.3)	0.000
	0.99278(-.73)	0.945(+4.3)	0.0529(+1.7)	0.0502(- 12)	0.666
DIMP1A	1.00000(~.10)	0.000	0.0000	0.0962(~3.3)	0.647(~.46)
	0.99265(-.74)	4.081	0.2401	0.0812(- 16)	0.658(+1.7)
Average	0.15	1.32	1.69	4.86	0.83
	-1.03(~0.37)	5.36(~1.31)	1.01(~0.61)	-9.37(~4.50)	1.53(~0.41)

Table 7: ENDF/B-V and measurements comparison.

SMRDIF Integral parameter comparison

Reference file : [ANDREJ.WLUP2]REFEXP.SMR
Compared file : BNCE5.SMR

LATTICE	K-eff	Rho28	Del25	Del28	ConvR
TRX-1	1.00000(~.30)	1.320(~1.6)	0.0987(~1.0)	0.0946(~4.3)	0.797(~1.0)
	0.99174(-.84)	1.377(+4.3)	0.0997(+1.0)	0.0965(+2.0)	0.805(+1.1)
TRX-2	1.00000(~.10)	0.837(~1.9)	0.0614(~1.3)	0.0693(~5.1)	0.647(~.93)
	0.99366(-.64)	0.863(+3.1)	0.0613(-.23)	0.0684(-1.3)	0.649(+.31)
BAPL-1	1.00000(~.10)	1.390(~.72)	0.0840(~2.4)	0.0780(~5.1)	0.000
	1.00109(+.11)	1.407(+1.2)	0.0839(-.13)	0.0740(-5.1)	0.809
BAPL-2	1.00000(~.10)	1.120(~.89)	0.0680(~1.5)	0.0700(~5.7)	0.000
	1.00061(+.06)	1.172(+4.6)	0.0685(+.69)	0.0637(-9.1)	0.738
BAPL-3	1.00000(~.10)	0.906(~1.1)	0.0520(~1.9)	0.0570(~5.3)	0.000
	1.00057(+.06)	0.922(+1.8)	0.0527(+1.3)	0.0522(-8.5)	0.660
DIMP1A	1.00000(~.10)	0.000	0.0000	0.0962(~3.3)	0.647(~.46)
	1.00115(+.11)	3.988	0.2384	0.0846(- 12)	0.648(+.19)
Average	0.15	1.32	1.69	4.86	0.83
	-0.19(~0.39)	3.01(~1.35)	0.53(~0.61)	-5.66(~4.80)	0.52(~0.38)

Table 8: ENDF/B-VI Rev.2 and measurements comparison.

SMRDIF Integral parameter comparison

Reference file :[ANDREJ.WLUP2]REFEXP.SMR
Compared file :BNCE6.SMR

LATTICE	K-eff	Rho28	Del25	Del28	ConvR
TRX-1	1.00000(~.30)	1.320(~1.6)	0.0987(~1.0)	0.0946(~4.3)	0.797(~1.0)
	0.98999(-1.0)	1.368(+3.7)	0.0984(-.28)	0.0966(+2.1)	0.804(+.93)
TRX-2	1.00000(~.10)	0.837(~1.9)	0.0614(~1.3)	0.0693(~5.1)	0.647(~.93)
	0.99112(-.90)	0.859(+2.6)	0.0605(-1.5)	0.0685(-1.1)	0.649(+.28)
BAPL-1	1.00000(~.10)	1.390(~.72)	0.0840(~2.4)	0.0780(~5.1)	0.000
	0.99824(-.18)	1.401(+.76)	0.0828(-1.4)	0.0742(-4.8)	0.809
BAPL-2	1.00000(~.10)	1.120(~.89)	0.0680(~1.5)	0.0700(~5.7)	0.000
	0.99747(-.25)	1.167(+4.2)	0.0676(-.54)	0.0638(-8.8)	0.738
BAPL-3	1.00000(~.10)	0.906(~1.1)	0.0520(~1.9)	0.0570(~5.3)	0.000
	0.99728(-.27)	0.919(+1.4)	0.0520(+.06)	0.0523(-8.2)	0.661
DIMP1A	1.00000(~.10)	0.000	0.0000	0.0962(~3.3)	0.647(~.46)
	0.99997(-.00)	3.959	0.2349	0.0847(- 12)	0.646(-.11)
Average	0.15	1.32	1.69	4.86	0.83
	-0.44(~0.38)	2.53(~1.31)	-0.73(~0.61)	-5.48(~4.80)	0.37(~0.43)

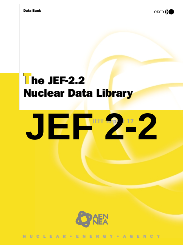


Table 9: ENDF/B-VI Rev.3 and measurements comparison.

SMRDIF Integral parameter comparison

Reference file :[ANDREJ.WLUP2]REFEXP.SMR
Compared file :BNCE6R3X.SMR

LATTICE	K-eff	Rho28	Del25	Del28	ConvR
TRX-1	1.00000(~.30) 0.98910(-1.1)	1.320(~1.6) 1.369(+3.7)	0.0987(~1.0) 0.0977(-1.0)	0.0946(~4.3) 0.0965(+2.0)	0.797(~1.0) 0.804(+.93)
TRX-2	1.00000(~.10) 0.99083(-.93)	0.837(~1.9) 0.859(+2.6)	0.0614(~1.3) 0.0600(-2.2)	0.0693(~5.1) 0.0684(-1.3)	0.647(~.93) 0.649(+.25)
BAPL-1	1.00000(~.10) 0.99753(-.25)	1.390(~.72) 1.401(+.79)	0.0840(~2.4) 0.0822(-2.1)	0.0780(~5.1) 0.0740(-5.2)	0.000 0.809
BAPL-2	1.00000(~.10) 0.99705(-.30)	1.120(~.89) 1.167(+4.2)	0.0680(~1.5) 0.0671(-1.3)	0.0700(~5.7) 0.0636(-9.1)	0.000 0.738
BAPL-3	1.00000(~.10) 0.99710(-.29)	0.906(~1.1) 0.919(+1.4)	0.0520(~1.9) 0.0516(-.69)	0.0570(~5.3) 0.0522(-8.5)	0.000 0.661
DIMP1A	1.00000(~.10) 0.99692(-.31)	0.000 3.964	0.0000 0.2334	0.0962(~3.3) 0.0849(- 12)	0.647(~.46) 0.647(+.02)
Average	0.15 -0.53(~0.35)	1.32 2.55(~1.31)	1.69 -1.45(~0.60)	4.86 -5.61(~4.73)	0.83 0.40(~0.39)

Table 10: JEF-2.2 and measurements comparison.

SMRDIF Integral parameter comparison

Reference file :[ANDREJ.WLUP2]REFEXP.SMR
Compared file :BNCF2.SMR

LATTICE	K-eff	Rho28	Del25	Del28	ConvR
TRX-1	1.00000(~.30) 0.99277(-.73)	1.320(~1.6) 1.363(+3.3)	0.0987(~1.0) 0.0982(-.50)	0.0946(~4.3) 0.0955(+.99)	0.797(~1.0) 0.806(+1.1)
TRX-2	1.00000(~.10) 0.99289(-.72)	0.837(~1.9) 0.857(+2.3)	0.0614(~1.3) 0.0604(-1.6)	0.0693(~5.1) 0.0681(-1.7)	0.647(~.93) 0.651(+.59)
BAPL-1	1.00000(~.10) 1.00131(+.13)	1.390(~.72) 1.394(+.30)	0.0840(~2.4) 0.0826(-1.7)	0.0780(~5.1) 0.0736(-5.6)	0.000 0.811
BAPL-2	1.00000(~.10) 1.00034(+.03)	1.120(~.89) 1.162(+3.8)	0.0680(~1.5) 0.0675(-.79)	0.0700(~5.7) 0.0634(-9.4)	0.000 0.740
BAPL-3	1.00000(~.10) 0.99967(-.03)	0.906(~1.1) 0.915(+1.0)	0.0520(~1.9) 0.0519(-.13)	0.0570(~5.3) 0.0521(-8.6)	0.000 0.663
DIMP1A	1.00000(~.10) 1.00281(+.28)	0.000 3.945	0.0000 0.2344	0.0962(~3.3) 0.0838(- 13)	0.647(~.46) 0.647(+.00)
Average	0.15 -0.17(~0.40)	1.32 2.14(~1.31)	1.69 -0.93(~0.59)	4.86 -6.20(~4.70)	0.83 0.57(~0.46)

Table 11: ENDF/B-IV comparison of WIMS-D/4 results and reference.

SMRDIF Integral parameter comparison
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Reference file :[ANDREJ.WLUP2]REFE4.SMR
Compared file :BNCE4.SMR

LATTICE	K-eff	Rho28	Del25	Del28	ConvR
TRX-1	0.98760(~.32)	1.382(~.43)	0.0994(~.50)	0.0955(~.63)	0.806(~.25)
	0.98327(-.45)	1.405(+1.6)	0.1002(+.84)	0.0924(-3.2)	0.812(+.79)
TRX-2	0.99350(~.31)	0.863(~.58)	0.0609(~.49)	0.0676(~.44)	0.647(~.31)
	0.98676(-.69)	0.881(+2.1)	0.0615(+1.0)	0.0656(-2.9)	0.653(+.97)
BAPL-1	0.99140(~.30)	1.433(~2.0)	0.0835(~1.6)	0.0735(~.95)	0.817(~1.3)
	0.99162(+.02)	1.441(+.52)	0.0843(+1.0)	0.0712(-3.1)	0.818(+.13)
BAPL-2	0.99320(~.09)	1.188(~1.3)	0.0678(~1.8)	0.0631(~.79)	0.742(~.81)
	0.99203(-.12)	1.200(+1.0)	0.0688(+1.5)	0.0613(-2.9)	0.746(+.47)
BAPL-3	0.99395(~.21)	0.936(~1.7)	0.0522(~.38)	0.0516(~.78)	0.664(~1.1)
	0.99278(-.12)	0.945(+.92)	0.0529(+1.3)	0.0502(-2.6)	0.666(+.32)
Average	0.26	1.35	1.11	0.74	0.86
	-0.27(~0.26)	1.25(~0.57)	1.13(~0.24)	-2.96(~0.20)	0.54(~0.31)

Table 12: ENDF/B-V comparison of WIMS-D/4 results and reference.

SMRDIF Integral parameter comparison
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Reference file :[ANDREJ.WLUP2]REFE5.SMR
Compared file :BNCE5.SMR

LATTICE	K-eff	Rho28	Del25	Del28	ConvR
TRX-1	0.99550(~.28)	1.362(~.81)	0.1002(~.80)	0.0989(~.71)	0.799(~.50)
	0.99174(-.38)	1.377(+1.1)	0.0997(-.50)	0.0965(-2.4)	0.805(+.80)
TRX-2	0.99830(~.18)	0.846(~.59)	0.0614(~1.1)	0.0698(~1.0)	0.642(~.31)
	0.99366(-.47)	0.863(+2.0)	0.0613(-.23)	0.0684(-2.0)	0.649(+1.1)
BAPL-1	1.00339(~.08)	1.406(~.85)	0.0843(~.47)	0.0762(~.13)	0.807(~.50)
	1.00109(-.23)	1.407(+.04)	0.0839(-.49)	0.0740(-2.8)	0.809(+.29)
BAPL-2	1.00356(~.06)	1.166(~.86)	0.0685(~.88)	0.0653(~.15)	0.735(~.54)
	1.00061(-.29)	1.172(+.51)	0.0685(-.04)	0.0637(-2.5)	0.738(+.44)
BAPL-3	1.00492(~.08)	0.911(~.55)	0.0527(~.57)	0.0535(~.37)	0.655(~.31)
	1.00057(-.43)	0.922(+1.2)	0.0527(-.06)	0.0522(-2.5)	0.660(+.84)
Average	0.16	0.74	0.81	0.58	0.44
	-0.36(~0.09)	0.98(~0.68)	-0.26(~0.20)	-2.46(~0.26)	0.69(~0.29)

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The Influence of the Basic Evaluated Data Files on Thermal Lattice Integral Parameters

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The Influence of the Basic Evaluated Data Files on Thermal Lattice Integral Parameters

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Abstract

The applicability of relatively simple calculations with the deterministic lattice cell code `WIMS-D/4` to study the relative influence of the changes in the nuclear data on the thermal lattice integral parameters is demonstrated. The metal uranium TRX lattices, uranium dioxide BAPL lattices and the recently measured DIMPLE-S01A lattice are considered. Whenever possible, comparison to detailed results with Monte-Carlo codes is made. The original WIMS-D library and the data from ENDF/B-IV, ENDF/B-V, ENDF/B-VI Rev.2, ENDF/B-VI Rev.3 and JEF-2.2 are considered.

1 Introduction

The ENDF/B-IV and ENDF/B-V data libraries have been extensively analysed [1, 2] for thermal reactor applications. The results of Monte-Carlo calculations can serve as numerical benchmarks for the validation of other deterministic methods. In this way the data processing methods for generating a WIMS-D library were validated [3, 4]. The same data processing methods were applied to generate WIMS-D libraries based on different basic evaluated data files. Using the same physical models to represent a selection of thermal lattice experiments, the differences in the calculated integral parameters should originate purely from the differences in the nuclear data.

2 Methods

The metal uranium TRX-1 and TRK-2 lattices, uranium dioxide BAPL-1, BAPL-2 and BAPL-3 lattices [5] and the recently measured DIMPLE-S01A lattice were considered. The `WIMS-D/4` inputs as prepared within the WIMS-D Library Update Project [3] of the International Atomic Energy Agency were used to model the lattices. In addition to the original WIMS-D library, special libraries were prepared with new data based on ENDF/B-IV, ENDF/B-V, ENDF/B-VI Rev.2, ENDF/B-VI Rev.3 and JEF-2.2 data for hydrogen bound in water, oxygen, aluminium and the uranium isotopes. The following integral parameters were considered:

Table 1: Definitions of some of the parameters

k_{eff}	effective multiplication factor,
ρ^{28}	ratio of epithermal to thermal ^{238}U capture reaction rate,
δ^{25}	ratio of epithermal to thermal ^{235}U fission reaction rate,
δ^{28}	ratio of ^{238}U fission to ^{235}U fission reaction rate,
δ^{29}	ratio of ^{239}Pu fission to ^{235}U fission reaction rate,
C^*	ratio of ^{238}U capture to ^{235}U fission reaction rate.

In Tables 5-10 the integral parameters calculated with `WIMS-D/4` are compared to the measured values. In braces the per-cent uncertainty is quoted for the measured values and the per-cent difference from the measurements for the calculated values. An average over all the lattices is also given: the average per-cent uncertainty in the integral parameters is given for the measured values and the average per-cent difference from the measurements and the associated variance (in braces) for the calculated values.

The calculated integral parameters can be compared to the results of detailed Monte-Carlo calculations, which are reported in the literature [1, 2]. The results for ENDF/B-IV and ENDF/B-V data are shown in Tables 11-12, respectively. They indicate the accuracy in absolute terms with which the integral parameters can be calculated using simple models and the same basic nuclear data. The discussion of the results can be found elsewhere [3] and will not be repeated here. Instead, the relative differences between the results using different libraries is investigated. In Table 2 the differences are given for all lattices, between the effective multiplication factor calculated from multigroup libraries based different evaluated data files. The differences between the ENDF/B-IV and ENDF/B-V data, between ENDF/B-V and ENDF/B-VI Rev.2 and between JEF-2.2 and ENDF/B-VI Rev.2 are considered. The results of the WIMS-D/4 calculations are compared to the differences in the reference values from the literature and to the MCNP4A calculations [6].

Table 2: Differences in k_{eff} (expressed as $\Delta k_{eff} \times 10^5$) for thermal reactor lattices due to the use of different evaluated data files.

		TRX-1	TRX-2	BAPL-1	BAPL-2	BAPL-3	DIMP1A
E5-E4	Ref.	790	480	1199	1036	1099	-
	WIMS	847	690	947	858	779	850
E6-E5	MCNP	-	-	-	-	-	309
	WIMS	-175	-254	-285	-314	-329	-118
F2-E6	WIMS	278	177	307	287	239	284

MCNP - refers to MCNP4A calculation.
WIMS - refers to WIMS-D/4 calculation.
E4 - refers to results based on ENDF/B-IV data.
E5 - refers to results based on ENDF/B-V data.
E6 - refers to results based on ENDF/B-VI Rev.2 data.
F2 - refers to results based on JEF-2.2 data.

The results of the WIMS-D/4 calculations show very good consistency with the reference results [1, 2], comparing ENDF/B-IV and ENDF/B-V data. Note that the quoted reference results for the two libraries were not calculated with the same set of codes and hence the differences may include a contribution from the systematic discrepancies in the results produced by different codes.

The results for the DIMPLE-S01A core calculated with MCNP4A and ENDF/B-VI data [6] are shown in Table 3. If the WIMS-D/4 based differences in Table 2 are valid, the equivalent result for the multiplication factor with the JEF-2.2 data would be 0.99941.

Table 3: Comparison of measurement and calculation for the DIMPLE-S01A core using MCNP4A code and data based ENDF/B-V and ENDF/B-VI evaluated data files.

```
                 K-eff          Del29          Del28           ConvR
==================================================================
Measured   1.00000(~.30)  2.189(~0.9)  0.00302(~3.4)  0.0203(~0.5)
ENDF/B-V   0.99348(-.65)  2.16 (-1.7)  0.00274(-9.3)  0.0196(-3.4)
ENDF/B-VI  0.99657(-.34)  2.16 (-1.7)  0.00273(-9.6)  0.0196(-3.4)
```

There exists a shadow of doubt on the reliability of the relative differences in the

MCNP4A results based on ENDF/B-V and ENDF/B-VI data, because they are not consistent with the differences predicted by WIMS-D/4. One must bear in mind that the WIMS-D/4 calculations are rather crude, but the possibility that the discrepancy arises from the MCNP4A calculation can not be entirely excluded. It is well known that MCNP4A can not take self-shielding into account in the unresolved resonance region. The resolved and the unresolved resonance ranges for different ENDF/B libraries are shown in Table 4. Note that the unresolved resonance range extends down to $2250\,eV$ for ^{235}U and down to $10\,keV$ for ^{238}U in ENDF/B-VI, but as far down as $82\,eV$ for ^{235}U and $4\,keV$ for ^{238}U in ENDF/B-V.

Table 4: Resolved and unresolved resonance ranges in ENDF/B libraries for the uranium isotopes.

	Uranium-235			Uranium-238		
	Resolved	—	Unresolved	Resolved	—	Unresolved
ENDF/B-IV	$1\,eV$	$82\,eV$	$25\,keV$	$1\,eV$	$4\,keV$	$45\,keV$
ENDF/B-V	$1\,eV$	$82\,eV$	$25\,keV$	$1\,eV$	$4\,keV$	$149\,keV$
ENDF/B-VI	$10^{-5}\,eV$	$2250\,eV$	$25\,keV$	$10^{-5}\,eV$	$10\,keV$	$149\,keV$

3 Conclusions

Integral parameters for a number of thermal lattices were calculated with WIMS-D/4 and multigroup cross section libraries based on various evaluated data files. Comparison of the relative differences between ENDF/B-IV and ENDF/B-V results relative to differences predicted by more detailed Monte-Carlo calculations using the same basic data indicate, that simple deterministic methods can be used to investigate the effect of some changes in the data on integral parameters.

From a reference Monte-Carlo calculation for the DIMPLE-S01A core based on ENDF/B-VI data and the relative differences calculated with WIMS/D-4 it seems that an equivalent detailed calculation using JEF-2.2 data would predict the the multiplication factor very close to one.

The difference in the results of the reference Monte-Carlo calculation for the DIMPLE-S01A core using ENDF/B-V and ENDF/B-VI data is not consistent with the difference calculated by WIMS-D/4. There exists a possibility that this inconsistency is due to self-shielding in the unresolved resonance range, which is not accounted for in MCNP4A.

References

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[2] *Benchmark Data Testing of ENDF/B-V*, Brookhaven National Laboratory, Upton, New York, USA, BNL-NCS-31531, (ENDF-313), Aug.1982.

[3] S.Ganesan (Compil.): *Update of the WIMS-D/4 Nuclear Data Library*, Status Report of the IAEA WIMS Library Update Project, Internatinal Atomic Energy Agency, INDC(NDS)-290, Dec.1993.

[4] A.Trkov, D.L.Aldama: *Parametric Study of the NJOY Input Options in the Frame of the WIMS Library Update Project*, Institute Jožef Stefan, Ljubljana, Slovenia, IJS-DP-7049, (1994).

[5] Cross Section Evaluation Working Group, *Benchmark Specifications*, BNL 19302 (ENDF-202) with Supplements (1986).

[6] M.Maučec: *Description of DIMPLE S01A model developed with Monte Carlo Computer Code MCNP4A*, Institute Jožef Stefan, Ljubljana, Slovenia, Private communication.

Table 5: WIMS-D/4 and measurements comparison.

```
SMRDIF Integral parameter comparison
====================================

Reference file :[ANDREJ.WLUP2]REFEXP.SMR
Compared  file :BNCWD4.SMR
```

LATTICE	K-eff	Rho28	Del25	Del28	ConvR
TRX-1	1.00000(~.30)	1.320(~1.6)	0.0987(~1.0)	0.0946(~4.3)	0.797(~1.0)
	1.00150(+.15)	1.280(-3.0)	0.0990(+.34)	0.0966(+2.1)	0.780(-2.1)
TRX-2	1.00000(~.10)	0.837(~1.9)	0.0614(~1.3)	0.0693(~5.1)	0.647(~.93)
	0.99570(-.43)	0.809(-3.4)	0.0610(-.60)	0.0696(+.38)	0.636(-1.7)
BAPL-1	1.00000(~.10)	1.390(~.72)	0.0840(~2.4)	0.0780(~5.1)	0.000
	1.00232(+.23)	1.358(-2.3)	0.0841(+.07)	0.0755(-3.2)	0.800
BAPL-2	1.00000(~.10)	1.120(~.89)	0.0680(~1.5)	0.0700(~5.7)	0.000
	0.99982(-.02)	1.134(+1.2)	0.0687(+1.0)	0.0653(-6.7)	0.732
BAPL-3	1.00000(~.10)	0.906(~1.1)	0.0520(~1.9)	0.0570(~5.3)	0.000
	0.99741(-.26)	0.894(-1.3)	0.0529(+1.8)	0.0539(-5.5)	0.657
DIMP1A	1.00000(~.10)	0.000	0.0000	0.0962(~3.3)	0.647(~.46)
	1.00809(+.80)	3.825	0.2375	0.0852(- 11)	0.633(-2.2)
Average	0.15	1.32	1.69	4.86	0.83
	0.08(~0.39)	-1.76(~1.65)	0.52(~0.81)	-4.07(~4.51)	-1.99(~0.24)

Table 6: ENDF/B-IV and measurements comparison.

```
SMRDIF Integral parameter comparison
====================================

Reference file :[andrej.wlup2]refexp.smr
Compared  file :BNCE4.SMR
```

LATTICE	K-eff	Rho28	Del25	Del28	ConvR
TRX-1	1.00000(~.30)	1.320(~1.6)	0.0987(~1.0)	0.0946(~4.3)	0.797(~1.0)
	0.98327(-1.7)	1.405(+6.4)	0.1002(+1.6)	0.0924(-2.3)	0.812(+1.9)
TRX-2	1.00000(~.10)	0.837(~1.9)	0.0614(~1.3)	0.0693(~5.1)	0.647(~.93)
	0.98676(-1.3)	0.881(+5.3)	0.0615(+.18)	0.0656(-5.3)	0.653(+.97)
BAPL-1	1.00000(~.10)	1.390(~.72)	0.0840(~2.4)	0.0780(~5.1)	0.000
	0.99162(-.85)	1.441(+3.6)	0.0843(+.42)	0.0712(-8.7)	0.818
BAPL-2	1.00000(~.10)	1.120(~.89)	0.0680(~1.5)	0.0700(~5.7)	0.000
	0.99203(-.81)	1.200(+7.2)	0.0688(+1.2)	0.0613(- 12)	0.746
BAPL-3	1.00000(~.10)	0.906(~1.1)	0.0520(~1.9)	0.0570(~5.3)	0.000
	0.99278(-.73)	0.945(+4.3)	0.0529(+1.7)	0.0502(- 12)	0.666
DIMP1A	1.00000(~.10)	0.000	0.0000	0.0962(~3.3)	0.647(~.46)
	0.99265(-.74)	4.081	0.2401	0.0812(- 16)	0.658(+1.7)
Average	0.15	1.32	1.69	4.86	0.83
	-1.03(~0.37)	5.36(~1.31)	1.01(~0.61)	-9.37(~4.50)	1.53(~0.41)

Table 7: ENDF/B-V and measurements comparison.

```
SMRDIF Integral parameter comparison
====================================

Reference file :  [ANDREJ.WLUP2]REFEXP.SMR
Compared  file :  BNCE5.SMR
```

LATTICE	K-eff	Rho28	Del25	Del28	ConvR
TRX-1	1.00000(~.30)	1.320(~1.6)	0.0987(~1.0)	0.0946(~4.3)	0.797(~1.0)
	0.99174(-.84)	1.377(+4.3)	0.0997(+1.0)	0.0965(+2.0)	0.805(+1.1)
TRX-2	1.00000(~.10)	0.837(~1.9)	0.0614(~1.3)	0.0693(~5.1)	0.647(~.93)
	0.99366(-.64)	0.863(+3.1)	0.0613(-.23)	0.0684(-1.3)	0.649(+.31)
BAPL-1	1.00000(~.10)	1.390(~.72)	0.0840(~2.4)	0.0780(~5.1)	0.000
	1.00109(+.11)	1.407(+1.2)	0.0839(-.13)	0.0740(-5.1)	0.809
BAPL-2	1.00000(~.10)	1.120(~.89)	0.0680(~1.5)	0.0700(~5.7)	0.000
	1.00061(+.06)	1.172(+4.6)	0.0685(+.69)	0.0637(-9.1)	0.738
BAPL-3	1.00000(~.10)	0.906(~1.1)	0.0520(~1.9)	0.0570(~5.3)	0.000
	1.00057(+.06)	0.922(+1.8)	0.0527(+1.3)	0.0522(-8.5)	0.660
DIMP1A	1.00000(~.10)	0.000	0.0000	0.0962(~3.3)	0.647(~.46)
	1.00115(+.11)	3.988	0.2384	0.0846(- 12)	0.648(+.19)
Average	0.15	1.32	1.69	4.86	0.83
	-0.19(~0.39)	3.01(~1.35)	0.53(~0.61)	-5.66(~4.80)	0.52(~0.38)

Table 8: ENDF/B-VI Rev.2 and measurements comparison.

```
SMRDIF Integral parameter comparison
====================================

Reference file :[ANDREJ.WLUP2]REFEXP.SMR
Compared  file :BNCE6.SMR
```

LATTICE	K-eff	Rho28	Del25	Del28	ConvR
TRX-1	1.00000(~.30)	1.320(~1.6)	0.0987(~1.0)	0.0946(~4.3)	0.797(~1.0)
	0.98999(-1.0)	1.368(+3.7)	0.0984(-.28)	0.0966(+2.1)	0.804(+.93)
TRX-2	1.00000(~.10)	0.837(~1.9)	0.0614(~1.3)	0.0693(~5.1)	0.647(~.93)
	0.99112(-.90)	0.859(+2.6)	0.0605(-1.5)	0.0685(-1.1)	0.649(+.28)
BAPL-1	1.00000(~.10)	1.390(~.72)	0.0840(~2.4)	0.0780(~5.1)	0.000
	0.99824(-.18)	1.401(+.76)	0.0828(-1.4)	0.0742(-4.8)	0.809
BAPL-2	1.00000(~.10)	1.120(~.89)	0.0680(~1.5)	0.0700(~5.7)	0.000
	0.99747(-.25)	1.167(+4.2)	0.0676(-.54)	0.0638(-8.8)	0.738
BAPL-3	1.00000(~.10)	0.906(~1.1)	0.0520(~1.9)	0.0570(~5.3)	0.000
	0.99728(-.27)	0.919(+1.4)	0.0520(+.06)	0.0523(-8.2)	0.661
DIMP1A	1.00000(~.10)	0.000	0.0000	0.0962(~3.3)	0.647(~.46)
	0.99997(-.00)	3.959	0.2349	0.0847(- 12)	0.646(-.11)
Average	0.15	1.32	1.69	4.86	0.83
	-0.44(~0.38)	2.53(~1.31)	-0.73(~0.61)	-5.48(~4.80)	0.37(~0.43)

Table 9: ENDF/B-VI Rev.3 and measurements comparison.

SMRDIF Integral parameter comparison

Reference file :[ANDREJ.WLUP2]REFEXP.SMR
Compared file :BNCE6R3X.SMR

LATTICE	K-eff	Rho28	Del25	Del28	ConvR
TRX-1	1.00000(~.30)	1.320(~1.6)	0.0987(~1.0)	0.0946(~4.3)	0.797(~1.0)
	0.98910(-1.1)	1.369(+3.7)	0.0977(-1.0)	0.0965(+2.0)	0.804(+.93)
TRX-2	1.00000(~.10)	0.837(~1.9)	0.0614(~1.3)	0.0693(~5.1)	0.647(~.93)
	0.99083(-.93)	0.859(+2.6)	0.0600(-2.2)	0.0684(-1.3)	0.649(+.25)
BAPL-1	1.00000(~.10)	1.390(~.72)	0.0840(~2.4)	0.0780(~5.1)	0.000
	0.99753(-.25)	1.401(+.79)	0.0822(-2.1)	0.0740(-5.2)	0.809
BAPL-2	1.00000(~.10)	1.120(~.89)	0.0680(~1.5)	0.0700(~5.7)	0.000
	0.99705(-.30)	1.167(+4.2)	0.0671(-1.3)	0.0636(-9.1)	0.738
BAPL-3	1.00000(~.10)	0.906(~1.1)	0.0520(~1.9)	0.0570(~5.3)	0.000
	0.99710(-.29)	0.919(+1.4)	0.0516(-.69)	0.0522(-8.5)	0.661
DIMP1A	1.00000(~.10)	0.000	0.0000	0.0962(~3.3)	0.647(~.46)
	0.99692(-.31)	3.964	0.2334	0.0849(- 12)	0.647(+.02)
Average	0.15	1.32	1.69	4.86	0.83
	-0.53(~0.35)	2.55(~1.31)	-1.45(~0.60)	-5.61(~4.73)	0.40(~0.39)

Table 10: JEF-2.2 and measurements comparison.

SMRDIF Integral parameter comparison

Reference file :[ANDREJ.WLUP2]REFEXP.SMR
Compared file :BNCF2.SMR

LATTICE	K-eff	Rho28	Del25	Del28	ConvR
TRX-1	1.00000(~.30)	1.320(~1.6)	0.0987(~1.0)	0.0946(~4.3)	0.797(~1.0)
	0.99277(-.73)	1.363(+3.3)	0.0982(-.50)	0.0955(+.99)	0.806(+1.1)
TRX-2	1.00000(~.10)	0.837(~1.9)	0.0614(~1.3)	0.0693(~5.1)	0.647(~.93)
	0.99289(-.72)	0.857(+2.3)	0.0604(-1.6)	0.0681(-1.7)	0.651(+.59)
BAPL-1	1.00000(~.10)	1.390(~.72)	0.0840(~2.4)	0.0780(~5.1)	0.000
	1.00131(+.13)	1.394(+.30)	0.0826(-1.7)	0.0736(-5.6)	0.811
BAPL-2	1.00000(~.10)	1.120(~.89)	0.0680(~1.5)	0.0700(~5.7)	0.000
	1.00034(+.03)	1.162(+3.8)	0.0675(-.79)	0.0634(-9.4)	0.740
BAPL-3	1.00000(~.10)	0.906(~1.1)	0.0520(~1.9)	0.0570(~5.3)	0.000
	0.99967(-.03)	0.915(+1.0)	0.0519(-.13)	0.0521(-8.6)	0.663
DIMP1A	1.00000(~.10)	0.000	0.0000	0.0962(~3.3)	0.647(~.46)
	1.00281(+.28)	3.945	0.2344	0.0838(- 13)	0.647(+.00)
Average	0.15	1.32	1.69	4.86	0.83
	-0.17(~0.40)	2.14(~1.31)	-0.93(~0.59)	-6.20(~4.70)	0.57(~0.46)

Table 11: ENDF/B-IV comparison of WIMS-D/4 results and reference.

```
SMRDIF Integral parameter comparison
====================================

Reference file :[ANDREJ.WLUP2]REFE4.SMR
Compared  file :BNCE4.SMR
```

LATTICE	K-eff	Rho28	Del25	Del28	ConvR
TRX-1	0.98760(~.32)	1.382(~.43)	0.0994(~.50)	0.0955(~.63)	0.806(~.25)
	0.98327(-.45)	1.405(+1.6)	0.1002(+.84)	0.0924(-3.2)	0.812(+.79)
TRX-2	0.99350(~.31)	0.863(~.58)	0.0609(~.49)	0.0676(~.44)	0.647(~.31)
	0.98676(-.69)	0.881(+2.1)	0.0615(+1.0)	0.0656(-2.9)	0.653(+.97)
BAPL-1	0.99140(~.30)	1.433(~2.0)	0.0835(~1.6)	0.0735(~.95)	0.817(~1.3)
	0.99162(+.02)	1.441(+.52)	0.0843(+1.0)	0.0712(-3.1)	0.818(+.13)
BAPL-2	0.99320(~.09)	1.188(~1.3)	0.0678(~1.8)	0.0631(~.79)	0.742(~.81)
	0.99203(-.12)	1.200(+1.0)	0.0688(+1.5)	0.0613(-2.9)	0.746(+.47)
BAPL-3	0.99395(~.21)	0.936(~1.7)	0.0522(~.38)	0.0516(~.78)	0.664(~1.1)
	0.99278(-.12)	0.945(+.92)	0.0529(+1.3)	0.0502(-2.6)	0.666(+.32)
Average	0.26	1.35	1.11	0.74	0.86
	-0.27(~0.26)	1.25(~0.57)	1.13(~0.24)	-2.96(~0.20)	0.54(~0.31)

Table 12: ENDF/B-V comparison of WIMS-D/4 results and reference.

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SMRDIF Integral parameter comparison
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Reference file :[ANDREJ.WLUP2]REFE5.SMR
Compared  file :BNCE5.SMR
```

LATTICE	K-eff	Rho28	Del25	Del28	ConvR
TRX-1	0.99550(~.28)	1.362(~.81)	0.1002(~.80)	0.0989(~.71)	0.799(~.50)
	0.99174(-.38)	1.377(+1.1)	0.0997(-.50)	0.0965(-2.4)	0.805(+.80)
TRX-2	0.99830(~.18)	0.846(~.59)	0.0614(~1.1)	0.0698(~1.0)	0.642(~.31)
	0.99366(-.47)	0.863(+2.0)	0.0613(-.23)	0.0684(-2.0)	0.649(+1.1)
BAPL-1	1.00339(~.08)	1.406(~.85)	0.0843(~.47)	0.0762(~.13)	0.807(~.50)
	1.00109(-.23)	1.407(+.04)	0.0839(-.49)	0.0740(-2.8)	0.809(+.29)
BAPL-2	1.00356(~.06)	1.166(~.86)	0.0685(~.88)	0.0653(~.15)	0.735(~.54)
	1.00061(-.29)	1.172(+.51)	0.0685(-.04)	0.0637(-2.5)	0.738(+.44)
BAPL-3	1.00492(~.08)	0.911(~.55)	0.0527(~.57)	0.0535(~.37)	0.655(~.31)
	1.00057(-.43)	0.922(+1.2)	0.0527(-.06)	0.0522(-2.5)	0.660(+.84)
Average	0.16	0.74	0.81	0.58	0.44
	-0.36(~0.09)	0.98(~0.68)	-0.26(~0.20)	-2.46(~0.26)	0.69(~0.29)