Corrigendum

Stable Isotope Capture Cross Sections from the Oak Ridge Electron Linear Accelerator

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In November 1979, we discovered that there was an error in the computer codes that transform measured neutron capture yields taken on the Oak Ridge Electron Linear Accelerator (ORELA) Flight Path 7 to effective capture cross sections. (By effective capture cross section is meant the nuclear neutron cross section as modified by energy resolution, sample thickness, and temperature effects.) The coding error was finally traced in August 1980 to a subroutine that calculated and applied corrections for small changes in detector efficiency due to nonstandard sample size and to gain shifts. The latter correction was made only if the detector gain had drifted up or down by more than 0.4% from the set point at the time of a particular measurement. This subroutine correctly calculated the required correction factor but did *not* apply the factor to the capture yield and associated uncertainty estimates as was intended. Rather the correction was erroneously applied twice to the useful range of the neutron monitor data. As the effective cross section comes from dividing the yield by the monitor data, an error about three times the intended correction is thereby introduced. Since the correction factors are usually near unity, the effects of the error are typically small (<5%). However, in the three extreme cases (^{106,108,110}Pd), the net errors introduced are large (~25%). Table I lists all publications since 1972 for which nonunity correction factors are required to obtain correctly normalized effective cross sections. (References appear on p. 111.) Also listed in Table I are the required correction factors.

Further processing of the erroneously normalized effective cross-section data to remove sample thickness effects and to derive resonance parameters (resonance capture areas, neutron and/or radiation widths) leads to errors that are *not* linearly dependent on the correction factors (Table I). In fact, these errors are neutron-width dependent and are a superposition of the smooth energy dependence of neutron penetrabilities and the Porter-Thomas width fluctuations. Our experience so far indicates that for individual resonances the percentage correction to be applied to resonance capture areas can differ by as much as one-third of the percentage correction indicated in Table I. This implies that the factors shown in Table I can be used to correct resonance capture areas and radiation widths (except for the three extreme cases mentioned above) with an uncertainty of not more than ~5%. In those few cases (e.g., ^{232}Th) for which nuclear data needs dictate greater precision, we are undertaking a systematic analysis of the corrected data to obtain corrected resonance parameters.

A similar situation pertains in the case of *averaged* capture cross sections, which are important for reactor calculations. Here, the finite sample and Doppler broadening corrections are calculated using strength functions that describe the data.

TABLE I

Effective Neutron Capture Cross Sections Requiring Corrections to Reported Data

Isotope	Factor[a]	Reference	Isotope	Factor[a]	Reference
^{24}Mg	0.9325	1	^{103}Ru	0.9507	12,13
^{25}Mg	0.9325	1	^{104}Pd	0.7999	13,14
^{26}Mg	0.9325	1	^{105}Pd	1.1131	13,14
^{32}S	1.1131	2	^{106}Pd	0.7734	13,14
^{33}S	0.9850	3	^{108}Pd	0.7480	13,14
^{51}V	1.0360	4	^{110}Pd	0.7480	13,14
^{55}Mn	0.9507	5	^{159}Tb	1.0737	15
^{63}Cu	0.9507	6	^{165}Ho	1.1131	16
^{65}Cu	0.9507	6	^{169}Tm	1.0737	17
^{64}Zn	0.9850	7	^{186}Os[b]	0.899[c]	18
^{66}Zn	0.9507	8	^{187}Os[b]	0.943[c]	18
^{68}Zn	0.9507	8	^{188}Os[b]	0.970[c]	18
^{93}Nb	1.0737	9	^{197}Au[b]	1.0001	19
^{92}Mo	0.9507	10	^{203}Tl	0.9507	20
^{100}Mo	0.9507	11	^{206}Pb	1.0360	21
^{100}Ru	0.9850	12,13	^{207}Pb	0.9655	22
^{101}Ru	0.9850	12,13	^{209}Bi	1.0360	23
^{102}Ru	0.9850	12,13	^{232}Th	1.1131	24
^{104}Ru	0.9850	12,13			

[a]While the correction factor by which the effective cross-section data should be multiplied is known precisely, the corrections for finite sample effects may range up to several percent.

[b]Average of more than one run under different conditions.

[c]The factors of osmium show a very mild (0.5% variation over 300 keV) dependence due to unscrambling the yields from the isotopic mixtures represented by the samples.

TABLE II

Average Capture Cross Section (mb)

Energy Range (keV)	^{104}Pd	^{105}Pd	^{106}Pd	^{108}Pd	^{110}Pd	^{165}Ho	^{232}Th
3-4	481.4	2594.0	843.1	713.8	545.0	5140.9	1139.6
4-6	825.3	2514.1	671.4	597.4	525.7	4137.1	1051.0
6-8	667.7	2127.0	673.3	476.7	458.9	3222.5	906.9
8-10	688.5	1915.3	529.5	520.4	479.7	2573.6	793.5
10-15	485.2	1782.7	413.3	390.4	284.0	2222.1	700.0
15-20	408.0	1580.1	416.7	330.2	246.7	1811.6	597.9
20-30	332.2	1343.4	311.9	260.4	166.5	1516.1	527.1
30-40	270.5	1148.7	256.0	203.0	151.1	1278.2	456.3
40-60	215.3	976.0	188.4	166.6	121.6	1077.5	389.0
60-80	167.9	809.4	154.3	138.8	90.6	924.7	289.4
80-100	142.5	701.9	132.9	119.0	83.1	820.1	231.6
100-150	125.4	603.9	119.4	102.8	76.8	677.0	195.3
150-200	116.0	509.8	109.3	100.0	73.6	561.5	177.2
200-300	113.7	445.4	108.0	98.1	72.6	472.3	158.8
300-400	110.2	316.4	106.4	98.7	67.5	388.3	146.7
400-500	118.7	232.5	116.3	85.2	45.8	330.6	150.9
500-600	115.3	185.5	95.1	66.1		267.2	156.1
600-700	89.9	161.7	84.6			222.4	168.3

Table II lists in histogram form recalculated average cross sections for palladium, holmium, and thorium. These results incorporate the ENDF/B-V flux monitor recalibration[25] and the effects of any other upgrading of our data analysis system reported since the original publications.

We are working with the Brookhaven National Center for Neutron Cross Section Data to have all cross sections and resonance parameters reported by us since 1972 brought up to date. Users who are uncertain about appropriate corrections for any particular data set that we have published are encouraged to contact us directly.

Some of the analysis of capture data obtained at ORELA Flight Path 7 was performed by B. J. Allen, A. R. de L. Musgrove, and others at the Australian Atomic Energy Commission, Lucas Heights, and unfortunately their analysis codes contain the same error discovered at ORELA. Users who have questions concerning the corrections appropriate for work published by the Australian group should contact them directly.

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REFERENCES

[1]H. WEIGMANN, R. L. MACKLIN, and J. A. HARVEY, *Phys. Rev. C*, **14**, 1328 (1976).

[2]J. HALPERIN et al., *Phys. Rev. C*, **21**, 545 (1980).

[3]G. F. AUCHAMPAUGH et al., *Phys. Rev. C*, **12**, 1126 (1975).

[4]R. R. WINTERS, R. L. MACKLIN, and J. HALPERIN, *Phys. Rev. C*, **18**, 2092 (1978).

[5]J. B. GARG, R. L. MACKLIN, and J. HALPERIN, *Phys. Rev. C*, **18**, 2079 (1978).

[6]M. S. PANDEY et al., *Phys. Rev. C*, **15**, 615 (1977).

[7]V. K. TIKKU et al., *Phys. Rev. C*, **23**, 683 (1981).

[8]V. K. TIKKU et al., *Proc. Third Int. Symp. Neutron Capture Gamma Ray Spectroscopy*, Upton, New York, September 18-22, 1978, p. 778, Plenum Press, New York (1979).

[9]R. L. MACKLIN, *Nucl. Sci. Eng.*, **59**, 12 (1976).

[10]O. A. WASSON et al., *Phys. Rev. C*, **7**, 1532 (1973).

[11]H. WEIGMANN et al., *Phys. Rev. C*, **20**, 115 (1979).

[12]R. L. MACKLIN and J. HALPERIN, *Nucl. Sci. Eng.*, **73**, 174 (1980).

[13]R. L. MACKLIN, R. R. WINTERS, and J. HALPERIN, *Proc. Specialists' Mtg. Neutron Cross Sections of Fission Product Nuclei*, Bologna, Italy, p. 103, International Atomic Energy Agency (1979).

[14]R. L. MACKLIN, J. HALPERIN, and R. R. WINTERS, *Nucl. Sci. Eng.*, **71**, 182 (1979).

[15]M. MIZUMOTO, R. L. MACKLIN, and J. HALPERIN, *Phys. Rev. C*, **17**, 522 (1978).

[16]R. L. MACKLIN, *Nucl. Sci. Eng.*, **59**, 231 (1976).

[17]R. L. MACKLIN, D. M. DRAKE, and J. J. MALANIFY, "Fast Neutron Capture Cross Sections of ^{169}Tm, ^{191}Ir, ^{193}Ir, and ^{175}Lu for $3 \leqslant E_n \leqslant 2000$ keV," LA-7479-MS, Los Alamos Scientific Laboratory (1978).

[18]R. R. WINTERS, R. L. MACKLIN, and J. HALPERIN, *Phys. Rev. C*, **21**, 563 (1980).

[19]R. L. MACKLIN, J. HALPERIN, and R. R. WINTERS, *Phys. Rev. C*, **11**, 1270 (1975).

[20]R. L. MACKLIN and R. R. WINTERS, *Astrophys. J.*, **208**, 812 (1976).

[21]M. MIZUMOTO et al., *Phys. Rev. C*, **19**, 335 (1979).

[22]S. RAMAN, M. MIZUMOTO, and R. L. MACKLIN, *Phys. Rev. Lett.*, **39**, 598 (1977).

[23]R. L. MACKLIN and J. HALPERIN, *Phys. Rev. C*, **14**, 1389 (1976).

[24]R. L. MACKLIN and J. HALPERIN, *Nucl. Sci. Eng.*, **64**, 849 (1977).

[25]R. L. MACKLIN, R. W. INGLE, and J. HALPERIN, *Nucl. Sci. Eng.*, **71**, 205 (1979).