^{237}Np – Comments on evaluation of decay data by V. P. Chechev and N.K. Kuzmenko

This evaluation was done originally in October 2007 and then updated in April 2009 with a literature cut-off by the same date. The Saisinuc software (2002Be) and associated supporting programs were used in assembling the data following the established protocol within DDEP.

1. DECAY SCHEME

Decay scheme is based on 2005Si15. It cannot be considered complete since the α-feedings measured directly in ^{237}Np α-decay and those deduced from the level gamma-ray intensity balances are not always in good agreement as shown in Table 1 (see also 2005Si15).

Table 1. Comparison of the prominent α-feedings ($P_\alpha \times 100$) measured directly in ^{237}Np α-decay with those deduced from the level gamma-ray intensity balances

Level	Level energy (keV)	$P_\alpha \times 100$ Adopted from measurements	$P_\alpha \times 100$ Deduced from γ-ray intensity balance
0	0	}2.92 (4)	1 (3)
1	6.654 (25)		
2	57.101 (14)	2.430 (17)	8 (4)
3	70.510 (25)	2.02 (2)	1.4 (3)
4	86.469 (9)		
6	103.636 (20)	}80.1 (5)	}79.1 (24)
7	109.04 (5)		
13	212.342 (18)	3.46 (3)	2.8 (9)
14	237.895 (13)	6.43 (3)	5.1 (7)

2. NUCLEAR DATA

Q(α) value is from 2003Au03.

The recommended half-life of ^{237}Np is based on the experimental results given in Table 2.

Table 2. Experimental values of ^{237}Np half-life (in 10^6 years)

Reference	Author(s)	Value	Comments and method
1949Ma01	Magnusson and LaChapelle	2.20 (11)	First isolation of the element 93 and a determination of ^{237}Np half-life
1960Br12	Brauer et al.	2.14 (1)	Specific activity
1992Lo03	Lowles et al.	2.144 (7)	Specific activity, many sources, known geometry gas flow proportional counters for α-particle counting

The weighted mean of the 3 values is 2.143 with the internal uncertainty of 0.0057 and external uncertainty of 0.0025 and χ^2/ν = 0.19. The unweighted mean is 2.161 (19). *

The recommended value of ^{237}Np half-life of 2.144 (7) × 10^6 years has been adopted from the most accurate measurement of 1992Lo03.

The recommended ^{237}Np spontaneous fission half-life $T_{1/2}$(SF) ≥ 1×10^{18} years is from 1961Dr04. The theoretical values of $T_{1/2}$(SF) are about 10^{18} yr (1988Io05) and 10^{14} yr (1992Gr16).

2.1 Alpha Transitions

The energies of the alpha transitions have been deduced from the Q value and the level energies given in Table 3 from 2005Si15 where they were deduced from a least squares fit to gamma-ray energies. The energies of the gamma rays adopted from 2005Si15 are given below, in Table 7.

Table 3. ^{233}Pa levels populated in ^{237}Np α-decay

Level	Level energy (keV)	Spin and parity	Half-life	Energy of α-particles (keV)	Probability of alpha transition (%)
0	0	$3/2^-$	26.98 (2) d	4872.7 (14)	2.41 (3)
1	6.654 (25)	$1/2^-$		4866.4 (14)	0.51 (3)
2	57.101 (14)	$7/2^-$		4816.8 (10)	2.430 (17)
3	70.510 (25)	$5/2^-$		4803.5 (10)	2.02 (2)
4	86.469 (9)	$5/2^+$	35.8 (4) ns	4788.0 (9)	47.64 (6)
5	94.645 (16)	$3/2^+$			
6	103.636 (20)	$7/2^+$		4771.4 (8)	23.0 (3)
7	109.04 (5)	$9/2^+$		4766.5 (8)	9.5 (3)
8	133.2 (10)	$(11/2^+)$		4741.3 (20)	0.019
9	163.34 (10)	$(11/2^-)$		4712.3 (20)	1.174 (13)
10	169.152 (20)	$1/2^+$		4708.3 (20)	
11	179.1 (4)	$(9/2^-)$		4698.2 (8)	0.535 (10)
12	201.594 (19)	$3/2^+$		4676.4	0.38 (2)
13	212.342 (18)	$5/2^+$		4665.0 (9)	3.46 (3)
14	237.895 (13)	$5/2^+$		4640.0 (10)	6.43 (3)
15	257.1 (4)	$5/2^-$		4619.7 (21)	0.032 (8)
16	279.71 (3)	$(7/2^+)$		4599.1 (18)	0.37 (1)
17	300.48 (3)	$7/2^+$		4578.6 (14)	0.39 (2)
18	303.59 (7)	$(9/2^+)$		4573 (3)	0.048 (23)
19	306.05 (10)	$(7/2^+)$			
20	365.93 (8)	$9/2^+$		4515.1 (19)	0.038 (4)

The recommended α-transition probabilities have been obtained by averaging the experimental results (see Table 4). The probabilities of the $\alpha_{0,8}$ - and $\alpha_{0,12}$ - transitions have been deduced from the decay scheme. The α-decay hindrance factors have been calculated using the ALPHAD computer program from the ENSDF evaluation package with r_0 = 1.517 (4) fm (see 2005Si15).

New α-transition with energy of 4550.5 (22) keV and intensity of 0.011 (3) % unplaced in ^{237}Np decay scheme was seen by 2002Wo03 (also 2000Si02).

Table 4. Experimental and recommended probabilities of α-transitions (×100) from ^{237}Np α-decay

Level	Level energy (keV)	Energy of α-particles (keV)	1961Ba44	1969Br12	1990Bo44	2002Wo03	Recommended $P_{\alpha}\times 100$
0	0	4872.7 (14)	0.925	2.6 (2)	2.43 (3)	2.39 (4)	2.41 (3)
1	6.654 (25)	4866.4 (14)	0.24		0.49 (3)	0.53 (4)	0.51 (3)
2	57.101 (14)	4816.8 (10)		2.5 (4)	2.47 (2)	2.430 (17)	2.430 (17)
3	70.510 (25)	4803.5 (10)	2.014 (17)		2.06 (5)		2.014 (17)
4	86.469 (9)	4788.0 (9)		47 (9)	47.75 (20)	47.64 (6)	47.64 (6)
5	94.645 (16)						
6	103.636 (20)	4771.4 (8)		25 (6)	22.7 (4)	23.2 (3)	23.0 (3)
7	109.04 (5)	4766.5 (8)		8 (3)	9.7 (3)	9.3 (3)	9.5 (3)
8	133.2 (10)	4741.3 (20)					0.019
9	163.34 (10)	4712.3 (20)				< 1.17	< 1.17
10	169.152 (20)	4708.3 (20)				< 1.17	< 1.17
11	179.1 (4)	4698.2 (8)		0.48 (20)	0.54 (4)	0.535 (10)	0.535 (10)
12	201.594 (19)	4676.4					0.38 (2)
13	212.342 (18)	4665.0 (9)		3.32 (10)	3.43 (4)	3.478 (24)	3.46 (3)
14	237.895 (13)	4640.0 (10)		6.18 (12)	6.45 (4)	6.43 (3)	6.43 (3)
15	257.1 (4)	4619.7 (21)				0.032 (8)	0.032 (8)
16	279.71 (3)	4599.1 (18)		0.34 (4)	0.39 (2)	0.371 (9)	0.373 (9)
17	300.48 (3)	4578.6 (14)		0.40 (4)	0.41 (2)	0.369 (23)	0.393 (23)
18	303.59 (7)	4573 (3)	0.048 (23)				0.048 (23)
19	306.05 (10)						
		4550.5 (22)				0.011 (3)	0.011 (3)
20	365.93 (8)	4515.1 (19)		0.04 (2)	0.041 (4)	0.035 (4)	0.038 (4)

2.2. Gamma Transitions and Internal Conversion Coefficients

The energies of the gamma-ray transitions are virtually the same as the gamma-ray energies because nuclear recoil is negligible.

The gamma-ray transition probabilities have been deduced from their gamma-ray emission probabilities and total internal conversion coefficients (ICCs) deduced with a computer program supplied with the Saisinuc software (2002Be). The ICCs have been interpolated using the BrIcc package with the so called "*Frozen Orbital*" approximation (2008Ki07, see also 2002Ba85). The multipolarities and admixture coefficients δ have been taken from 2005Si15. The uncertainties in the ICCs for pure multipolarities have been taken as 2 %.

ICCs for the anomalously converted E1 gamma-ray transition $\gamma_{4,0}$ (86.477 keV) have been adopted from 1988Wo01 (see also 1960As02 and 1969Br12).

The conversion electron data of 1988Wo01 indicate that the gamma-transition $\gamma_{4,2}$ (29.374 keV) may be an anomalous E1. However the evaluators have been adopted the theoretical ICCs since the detector efficiency was not completely reliable for such energy as pointed out in 1988Wo01.

3. Atomic Data

The atomic data (fluorescence yields, X-ray energies and relative probabilities, and Auger electrons energies and relative probabilities) are from Schönfeld and Janβen (1996Sc06).

4. Alpha Emissions

The alpha particle energies have been taken from 2002Wo03 (see also 2000Si02). They are somewhat different (in limits of uncertainties) from those obtained from alpha transition energies taking into account nuclear recoil for ^{233}Pa.

Details of alpha transition probability evaluation are given in Section 2.1.

5. Photon Emissions

5.1. X-Ray Emissions

The absolute X-ray emission probabilities (per 100 disintegrations) have been evaluated using the experimental data, see Tables 5, 6.

Table 5. Experimental and recommended absolute Pa KX- ray emission probabilities (×100)

	1984Va27	2000Sc04	2002Lu01	2004Sh07	2008De10	Recommended
$K\alpha_2$	1.90 (10)	1.82 (5)	1.80 (20)	1.80 (3)	1.813 (20)	1.813 (20)
$K\alpha_1$	3.00 (15)	2.98 (7)	2.89 (2)	2.89 (4)	2.932 (30)	2.906 (20)
$K'\beta_1$	1.03 (5)	0.86 (2)	1.06 (2)	1.02 (4)	1.154 (14)	1.06 (10)
$K'\beta_2$	0.35 (2)		0.373 (10)	0.38 (2)	0.380 (9)	0.380 (9)

Table 6. Experimental and recommended absolute Pa LX- ray emission probabilities (×100)

	2000Sc04	2004Sh07	2008De10	Recommended
Ll	1.55 (8)	1.31 (20)	1.33 (27)	1.32 (8)
Lα	26 (3)	23.3 (24)	23.1 (47)	24.0 (24)
Lβ	29.5 (20)[a]	24.3 (31)[b]	28 (6)	28.0 (20)
Lη	0.64 (6)	0.50 (4)		0.54 (4)
Lγ	5.8 (4)[c]	5.4 (8)[d]	7.8 (16)	5.8 (4)

[a] Obtained by the evaluators from the sum absolute intensity (Pa Lβ + U Lβ) of 47.5 (19) % using the intensities of Pa Lβ-components measured in 2000Sc04 and the U Lβ-intensity of 18.0 (6) % from ^{233}Pa decay data evaluation (2006Ch39) revised in April 2009.

[b] Obtained by the evaluators from the sum absolute intensity (Pa Lβ + U Lβ) of 42.3 (30) % using the intensities of Pa Lβ-components measured in 2000Sc04 and the U Lβ-intensity of 18.0 (6) % from ^{233}Pa decay data evaluation (2006Ch39) revised in April 2009.

[c] Obtained by the evaluators from the sum absolute intensity (Pa Lγ + U Lγ) of 10.0 (4) % using the intensities of Pa Lγ-components measured in 2000Sc04 and the U Lβ-intensity of 4.18 (13) % from ^{233}Pa decay data evaluation (2006Ch39) revised in April 2009.

[d] Obtained by the evaluators from the sum absolute intensity (Pa Lγ + U Lγ) of 9.6 (8) % using the intensities of Pa Lγ-components measured in 2000Sc04 and the U Lβ-intensity of 4.18 (13) % from ^{233}Pa decay data evaluation (2006Ch39) revised in April 2009.

5.2. Gamma-Ray Emissions

Energies

The gamma-ray energies have been adopted from 2005Si15. The gamma ray energy for $\gamma_{7,6}$ (5.18 keV) has been adopted from 1990Lo04. The energies for $\gamma_{1,0}$ (6.65 keV), $\gamma_{5,4}$ (8.22 keV) and $\gamma_{7,4}$ (17.4 keV) are from ^{233}Th decay. For $\gamma_{13,12}$ (10.7 keV) and $\gamma_{8,7}$ (21.4 keV) the energies are from 1979Go12. The gamma-ray energies of $\gamma_{6,5}$ (9.0 keV) and $\gamma_{7,4}$ (22.6 keV) have been deduced from ^{233}Pa level scheme (details of information of these and other gamma-ray transitions see in 2005Si15). Table 7 contains the experimental and adopted energies of the remaining gamma rays.

Table 7. Experimental and adopted energies (in keV) of gamma rays from ^{237}Np decay

1969Br12	1969HoXY	1971Cl03	1974HeYW	1976Sk01	1979Go12	1988Wo01 (Ge-detector)	1988Wo01 (LEPS-detector)	Adopted
29.29 (10)	29.30 (5)	29.38 (2)	29.375 (20)	29.373 (10)	29.374 (20)	29.5 (17)	29.18 (21)	29.374 (20)
46.46 (10)	46.6 (1)	-	46.60 (10)	46.53 (4)	46.53 (6)	46.7 (11)	46.28 (18)	46.53 (6)
57.15 (10)	57.1 (1)	57.11 (2)	57.112 (20)	57.15 (4)	57.104 (20)	57.15 (80)	56.88 (17)	57.104 (20)
	62.9	-	62.5 (5)					62.59 (10)
			63.92 (8)					63.90 (10)
	71.0		70.75 (10)					70.49 (10)
86.49 (10)	86.40 (5)	86.49 (2)	86.486 (10)	86.503 (20)	86.477 (10)	86.50 (48)	86.26 (14)	86.477 (10)
		-		88.04 (16)				87.99 (3)
			94.66 (10)	94.66 (5)				94.64 (5)
106.22 (10)	106.30 (8)	106.30 (20)	106.15 (25)	106.12 (5)		106.17 (48)		106.15 (25)
				108.6				108.7
				115.45 (20)	115.40 (35)			115.40 (35)
117.65 (7)	117.5 (1)	117.72 (2)	117.718 (20)	117.681 (30)	117.702 (20)	117.72 (50)	117.41 (15)	117.702 (20)
131.11 (7)	131.2 (1)	131.11 (2)	131.11 (2)	131.11 (7)	131.101 (25)	131.09 (52)	130.62 (15)	131.101 (25)
134.23 (7)	134.4 (1)	134.28 (2)	134.28 (3)	134.23 (4)	134.285 (20)	134.27 (53)		134.285 (20)
				140.60 (10)	-			139.9 (1)
143.26 (7)	143.35 (5)	143.25 (1)	143.254 (10)	143.208 (25)	143.249 (20)	143.27 (56)	142.96 (16)	143.249 (20)
151.31 (7)	151.5 (1)	151.41 (1)	151.410 (15)	151.37 (4)	151.414 (20)	151.42 (60)	151.06 (17)	151.414 (20)
				153.52				153.37 (10)
155.20 (7)	155.4 (1)	155.25 (2)	155.25 (2)	155.22 (4)	155.239 (20)	155.28 (63)		155.239 (20)
162.38 (7)	162.7 (1)	162.52 (3)	162.52 (3)	162.50 (6)	162.41 (8)	162.45 (68)		162.41 (8)
169.09 (7)	169.4 (1)	169.16 (3)	169.16 (3)	169.17 (5)	169.156 (20)	169.18 (73)		169.156 (20)
170.56 (10)	171.2 (3)	170.64 (5)	170.64 (5)	170.63 (8)	170.59 (6)			170.59 (6)
175.93 (10)	176.1 (1)	176.06 (5)	176.06 (5)	176.09 (7)	176.12 (6)	176.17 (80)		176.12 (6)
180.66 (10)	180.8 (1)	180.78 (5)	180.78 (5)	180.80 (8)	180.81 (10)	180.87 (85)		180.81 (10)
186.86 (30)				186.8 (5)	186.86 (35)			186.86 (35)
191.34 (10)		191.42 (3)	191.42 (3)	191.45 (6)	191.46 (5)	191.46 (97)		191.46 (5)
193.05 (10)		193.22 (3)	193.22 (3)	193.26 (4)	193.26 (5)	193.24 (98)		193.26 (5)
				194.67 (20)				194.67 (20)
194.91 (7)	195.00 (5)	194.97 (2)	194.97 (2)	195.096 (20)	194.95 (3)	195.1 (10)		194.95 (3)
196.81 (10)	-	196.80 (10)	196.80 (10)	196.84 (6)	196.86 (5)	196.9 (10)		196.86 (5)
			199.9 (1)	200.17 (10)	199.95 (6)			199.95 (6)
201.68 (8)	201.75 (10)	201.67 (20)	201.670 (25)	201.72 (5)	201.62 (5)	201.8 (11)		201.62 (5)
			202.9 (2)	202.69 (25)				202.9 (2)
209.07 (8)	209.1 (2)	209.18 (3)	209.18 (3)	209.25 (5)	209.19 (5)	209.2 (12)		209.19 (5)
212.28 (7)	212.4 (1)	212.33 (2)	212.33 (2)	212.42 (5)	212.29 (5)	212.4 (12)		212.29 (5)
213.92 (10)	-	213.96 (4)	213.96 (4)	214.09 (5)	214.01 (5)	214.1 (12)		214.01 (5)
				222.52 (25)				222.6 (2)
229.84 (10)	229.9 (1)	229.90 (10)	229.90 (10)	230.01 (10)	229.94 (5)			229.94 (5)
237.91 (7)	238.2 (1)	237.91 (2)	237.908 (10)	238.04 (4)	237.862 (60)	238.0 (14)		237.86 (2)
248.6 (4)	248.8 (1)	248.8 (5)	248.8 (5)	248.9 (1)	248.95 (10)			248.95 (10)
257.14 (40)	257.3 (2)	257.15 (50)	257.15 (50)	257.20 (20)	257.09 (20)			257.09 (20)
262.48 (40)	262.6 (2)	262.42 (50)	262.42 (50)	262.44 (15)	262.44 (20)			262.44 (20)

Emission Probabilities

The value $P\gamma_{14,12}$ (36.32 keV) of 0.000 05 (1) has been adopted from 1990Lo04. The values $P\gamma_{-1,1}$ (21.5 keV)) of 0.003 56 (13) and $P\gamma_{-1,2}$ (27.7 keV) of 0.008 4 (7) have been adopted from 2004Sh07. The values $P\gamma_{17,14}$ (62.59 keV) of 0.000 06 (2), $P\gamma_{3,1}$ (63.9 keV) of 0.000 108 (4) and $P\gamma_{10,5}$ (74.54 keV) of 0.000 12 (3) have been adopted from 1981Ba68. The value $P\gamma_{9,2}$ (106.15 keV) of 0.000 49 (1) has been adopted from 2002Lu01. For absolute gamma-ray emission probabilities see 1981Ba68, 1984Va27, 2000Sc04, 2000Wo01, 2002Wo03, 2004Sh07. The remaining relative emission probabilities are listed in Table 9. These have been renormalized by the evaluators to $P\gamma$ (86.48 keV) = 12.26 (12) % obtained as a weighted average of 1984Banham, 1984Va27, 2000Sc04, 2000Wo01, 2002Wo03, 2002Lu01, 2004Sh07, 2008De10.

There are significant unexplained (as stated in 2002Wo03) discrepancies in the intensities of several gamma rays with the following energies: 29.4, 46.5, 88.0, 117.7, 169.2, 193.3, 195.0, 257.1 and 279.6 keV.

The value of $P\gamma_{4,0}$ (86.48 keV) used for normalization of the decay scheme is itself discrepant since this gamma ray and the gamma ray with the energy 86.6 keV from the decay of its daughter ^{233}Pa become apparent as a complex peak, and the separated intensities in various studies are not always in good agreement. Table 8 contains the experimental and evaluated values of the absolute emission probability of gamma ray $\gamma_{4,0}$ (86.48 keV). The results of 2000Sc04, 2002Lu01 and 2004Sh07 given in Table 8 have been corrected taking into account the intensity of gamma ray with the energy 86.6 keV from the decay of ^{233}Pa: Pγ (^{233}Pa, 86.6 keV) = 1.99 (11) %, see 2006Ch39.

Table 8. Experimental and recommended values of the 86.48 keV γ ray emission probability

1984Banham	1984Va27	2000Wo01 2002Wo03	2000Sc04	2002Lu01	2004Sh07	2008De10	Recommended
12.20 (12)	12.44 (33)	12.86 (21)	12.1 (3)	12.02 (12)#	11.6 (5)	12.38 (13)	12.26 (12)

Although the $P\gamma_{4,0}$ (86.48 keV) =11.40 (24) % is given in 2002Lu01, the evaluators used more accurate value of 14.01 (6) % measured in 2002Lu01 for Pγ (86.48+86.6 from ^{233}Pa decay) to deduce $P\gamma_{4,0}$ (86.48 keV)=12.02 (12) %.

The recommended values of the gamma ray emission probabilities given in Table 9 have been obtained by averaging experimental data using the LWEIGHT computer program. The uncertainty assigned in this evaluation to the recommended value is always greater than or equal to the smallest uncertainty in any of the experimental values used in the statistical processing.

The systematic uncertainties (1 %) of U KX-ray emission probability from 2008De10 have been added to statistic uncertainties measured in 2008De10.

The systematic uncertainties (20 %) of U LX-ray emission probability from 2008De10 have been added to statistic uncertainties measured in 2008De10.

Table 9 (part 1). Experimental and recommended emission probabilities of gamma rays in ^{237}Np decay

Eγ	1969Br12	1976Sk01	1979Go12	1981Ba68 1984Banham	1984Va27	1988Wo01 (Ge-detector)	1988Wo01 (LEPS-detector)
29.37	13.7 (20)	16.2 (9)	10.1 (10)	15.4 (2)	15.03 (40)	-	19.2 (9)
46.53	0.137 (20)	0.12 (2)	0.10 (1)	0.104 (6)	0.10 (1)	0.12 (1)	0.14 (2)
57.10	0.412 (38)	0.433 (25)	0.37 (4)	0.373 (11)	0.39 (1)	0.34 (1)	0.43 (3)
62.6		0.012		0.006 (2)			
63.9				0.0108 (4)			
86.48	12.6	12.3	12.3	12.20 (12)	12.44 (33)	12.3	12.3
87.99	0.157 (20)	0.14 (4)	0.12 (1)	0.138 (3)	0.14 (1)	-	-
94.64		0.62 (4)	0.54 (5)				
106.15		0.044 (9)	0.05 (5)				
108.7							
115.40		0.26 (8)					
117.70	0.167 (20)	0.180 (12)	0.148 (15)	0.175 (2)	0.168 (5)	0.16 (7)	0.15 (2)
131.1	0.087 (9)	0.10 (1)	0.079 (8)	0.086 (1)	-	0.091 (5)	0.09 (2)
134.28	0.069 (8)	0.081 (16)	0.062 (6)	0.071 (1)	-	0.080 (5)	
143.25	0.412 (40)	0.462 (28)	0.40 (4)	0.430 (4)	0.434 (10)	0.43 (1)	0.42 (3)
151.41	0.244 (30)	0.249 (16)	0.223 (23)	0.236 (2)	0.232 (6)	0.248 (7)	0.20 (3)
153.4		0.007 (2)					

155.24	0.095 (9)	0.097 (7)	0.085 (9)	0.0917 (10)	-	0.086 (6)	-
162.4		0.041 (7)	0.027 (4)			0.032 (4)	-
169.16	0.074 (8)	0.082 (9)	0.072 (7)	0.0711 (7)	-	0.057 (4)	-
170.59		0.016 (2)	0.024 (5)				
176.12		0.017 (3)				0.02 (4)	-
180.8		0.022 (5)	0.021 (4)			0.015 (2)	-
186.86		0.003 (3)					
191.46		0.017 (3)	0.026 (5)			0.014 (5)	-
193.26		0.043 (4)	0.05 (5)			0.049 (3)	-
194.67		0.05 (2)					
194.95	0.206 (20)	0.169 (21)	0.16 (2)	0.184 (2)	0.188 (5)	0.191 (6)	-
196.86		0.023 (3)	0.019 (4)			0.021 (2)	-
201.6		0.044 (5)	0.044 (5)			0.041 (4)	-
209.2		0.019 (2)	0.016 (3)			0.010 (2)	-
212.3	0.157 (20)	0.166 (11)	0.157 (16)	0.150 (2)	0.155 (5)	0.156 (4)	
214.0		0.047 (4)	0.06 (4)			0.034 (1)	
222.6		0.002 (2)					
229.94		0.011 (3)	0.018 (4)				
237.86	0.067 (6)	0.075 (9)	0.062 (7)	0.0586 (12)	-	0.059 (3)	-
248.95		0.005 (2)	0.05 (1)				
257.09		0.007 (3)	0.019 (6)				
262.44		0.008 (2)	0.007 (1)				
279.65		0.002 (2)	0.011 (4)				
288.3							

Table 9 (part 2). Experimental and recommended emission probabilities of gamma rays in ^{237}Np decay

Eγ	1990Lo04	2000Sc04	2000Wo01	2002Lu01	2004Sh07	2008De10	Recommended
29.37	13.7 (1)	14.1 (15)	13.2 (4)	13.51 (16)	13.15 (36)	15.08 (16)	14.3 (6)
46.53	0.112 (1)	0.104 (4)	0.1067 (19)	0.163 (5)	0.100 (13)	0.114 (3)	0.109 (4)
57.10	0.360 (2)	0.354 (8)	0.360 (5)	0.366 (3)	0.356 (16)	0.458 (6)	0.381 (21)
62.6							0.006 (2)
63.9	0.0090 (9)						0.0107 (4)
86.48	12.3	14.1 (3)$^{\&}$	12.86 (21)	14.01 (6)$^{\&}$	13.6 (5)$^{\&}$	12.38 (13)$^{\&}$	12.26 (12)
87.99	0.143 (1)			0.167 (4)	0.134 (13)	0.144 (5)	0.143 (3)
94.64				0.615 (23)	0.575 (19)	0.730 (10)	0.66 (7)
106.15	0.048 (1)				0.0509 (26)	0.0573 (28)	0.0509 (29)
108.7		0.0864 (19)		0.070 (3)	0.0723 (36)		0.071 (3)
115.40	0.47 (11)*	0.332 (10)*					0.0026 (8)#
117.70	0.168 (1)	0.169 (4)	0.188 (3)	0.184 (12)	0.169 (17)	0.1660 (29)	0.171 (4)
131.1	0.079 (1)	0.0857 (22)		0.088 (3)	0.075 (5)		0.084 (5)
134.28	0.064 (1)	0.0670 (28)		0.075 (3)	0.073 (6)		0.069 (5)
143.25	0.387 (2)	0.443 (8)	0.439 (5)	0.428 (3)	0.394 (24)	0.423 (6)	0.42 (4)
151.41		0.232 (24)	0.228 (3)	0.244 (3)	0.223 (14)	0.234 (4)	0.234 (2)
153.4							0.007 (2)
155.24	0.080 (1)	0.0889 (18)		0.091 (6)	0.087 (6)		0.088 (8)
162.4		0.0327 (12)					0.033 (1)
169.16		0.0633 (19)		0.092 (11)			0.0672 (3)
170.59							0.020 (4)
176.12		0.012 (4)					0.015 (3)
180.8		0.0158 (10)					0.016 (1)
186.86							0.003 (3)
191.46		0.0192 (12)		0.015 (4)	0.023 (5)		0.019 (1)
193.26		0.0437 (10)		0.030 (5)	0.041 (8)		0.044 (1)
194.67	0.033 (1)			0.033 (8)	0.03 (1)		0.033 (1)

194.95	0.156 (2)	0.177 (5)	0.161 (4)	0.164 (7)	0.161 (34)		0.174 (20)
196.86		0.0208 (12)		0.024 (5)	0.020 (4)		0.0208 (1)
201.6		0.0393 (9)					
209.2		0.0142 (9)		0.019 (2)	< 0.02		0.0150 (15)
212.3		0.151 (3)	0.148 (3)	0.150 (4)			0.17 (1)
214.0	0.132 (2)	0.0362 (8)		0.039 (2)			0.037 (2)
222.6							0.002 (2)
229.94							0.014 (3)
237.86		0.0569 (6)		0.056 (3)	0.067 (4)		0.0573 (6)
248.95		0.0050 (14)		0.006 (3)			0.005 (1)
257.09							0.02 (1)
262.44		0.00471 (18)					0.0048 (2)
279.65		0.0109 (4)					0.0108 (4)
288.3		0.0164 (5)					0.0162 (5)

* Sum intensity of $\gamma_{12,14}$ and KX(Pa)
# Adopted from 2005Si15
& Measured Pγ86.48+86.6 keV from ^{233}Pa decay)

6. Electron Emissions

The energies of the conversion electrons have been obtained from the gamma transition energies and the electron binding energies. The emission probabilities of conversion electrons have been deduced from the evaluated P(γ) and ICC values.

The number of K- and L- Auger electrons per 100 disintegrations has been deduced using the evaluated XK- and XL- emission probabilities.

7. Consistency of recommended data

The most accurate Q value, Q(M), is taken from the atomic mass adjustment table of Audi et al. (2003Au03). Comparison of Q(eff) (deduced as the sum of average energies per disintegration ($\sum E_i \times P_i$) for all emissions accompanying ^{237}Np α- decay) with the tabulated decay energy Q(M) allows to check a consistency of the recommended decay-scheme parameters obtained in this evaluation.

Here E_i and P_i are the evaluated energies and emission probabilities of the i-th alpha particle, beta particle, gamma ray, X-ray, etc. Consistency (percentage deviation) is determined by {[Q(M)– Q(eff))]/ Q(M)} ×100. "Percentage deviations above 5 % would be regarded as high and imply a poorly defined decay scheme; a value of less than 5 % indicates the construction of a reasonably consistent decay scheme" (quoted from the article by A.L. Nichols in Appl. Rad. Isotopes 55 (2001) 23-70).

For the above ^{237}Np decay data evaluation we have Q(M) = 4958.3 (12) keV and Q(eff) = 4966 (21) keV, i.e. consistency is not superior, but better than 1 %.

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