^{239}Np – Comments on evaluation of decay data by V.P. Chechev and N.K. Kuzmenko

This evaluation was completed in June 2006. The literature available by May 2006 was included.

1. Decay Scheme

Decay scheme has been taken from 2003Br12.

2. Nuclear Data

Q^- value is from 2003Au03.

The evaluated half-life of ^{239}Np is based on the experimental results given in Table 1.

Table 1. Experimental values of the ^{239}Np half-life (in days)

Reference	Author(s)	Value
1956Wi25	Wish	2,346 (4)
1959Co63	Connor and Fairweather	2,34 (2)
1959Co93	Cohen *et al.*	2,366 (3)
1966Qa01	Qaim	2,354 (8)
1969Bi12	Bigham *et al.*	2,346 (4)
1990Ab06	Abzouzi *et al.*	2,3565 (4)

The weighted average of 2,3564 for this discrepant data set of the 6 values is dominated by the very accurate value of 1990Ab06. The LWEIGHT computer program, which uses a limitation of relative statistical weights (LRSW method), has increased the 1990Ab06 uncertainty from 0,0004 to 0,0020 and used a weighted average and an external uncertainty having led to 2,356 (3) as a recommended value.

Thus, the adopted value of the ^{239}Np half-life is **2,356 (3) days**.

2.1. Beta Transitions

The energies of β^- transitions have been calculated from the Q^- value and the level energies given in Table 2 from 2003Br12 where they have been deduced from a least squares fit to gamma-ray energies (see also 1996FiZX).

Table 2. ^{239}Pu levels populated in the ^{239}Np β^--decay

Level	Energy (keV)	Spin and parity	Half-life	Probability of β^--transition (%)
0	0	1/2+	24100 (11) a	-
1	7,861 (2)	3/2+	36 (3) ps	6,5 (10)
2	57,276 (2)	5/2+	101 (5) ps	0,4 (72)
3	75,706 (3)	7/2+	83 (8) ps	-
4	163,76 (2)	9/2+	73 (4) ps	-
5	285,460 (2)	5/2+	1,12 (5) ns	43,0 (22)
6	330,125 (4)	7/2+		9,4 (14)
7	387,41 (2)	9/2+		-
8	391,586 (3)	7/2-	193 (4) ns	38,8 (9)
9	469,8 (4)	(1/2-)		0,0027

Level	Energy (keV)	Spin and parity	Half-life	Probability of β^--transition (%)
10	492,2 (3)	3/2-		0,02
11	505,2	(5/2-)		0,0074
12	511,81 (6)	7/2+		1,56 (16)
13	556,2	(7/2-)		0,0026

The probabilities of β^--transitions have been deduced from the P(γ+ce) balance for each level of ^{239}Np. Measured and evaluated β^--transition probabilities are given in Table 3.

Table 3. Measured and evaluated probabilities (%) of β^- -transitions

	1952Fr25	1956Ba95	1959SCo63	Adopted
$\beta_{0,8}$	52	45	28	38,8 (9)
$\beta_{0,6}$	10	27	13,5	9,4 (14)
$\beta_{0,5}$	31	21	48	43,0 (22)
$\beta_{0,2}$	1,7	}	4	0,4 (72)
$\beta_{0,1}$	4,8	}7	6,5	6,5 (10)

2.2. Gamma-ray Transitions and Internal Conversion Coefficients

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

The gamma-ray transition probabilities, P(γ+ce), have been calculated from the gamma-ray emission probabilities and the total internal conversion coefficients (ICC's). Multipolarities of gamma-ray transitions have been taken from 2003Br12 (see also 1996FiZX). ICC's have been interpolated from the BrIcc package. The relative uncertainties of α_K, α_L, $\alpha_{M,}$ α_T for pure multipolarities have been taken as 2 %. The transition $\gamma_{8,5}$ is anomalously converted, ICC's for this transition have been taken from the measurements of 1959Ew90.

P($\gamma_{1,0}$ +ce)(7,86-keV) has been deduced from the intensity balance for the ground state assuming that there is no beta-feeding to the ''0''-level. P($\gamma_{3,2}$ +ce) (18,43-keV) has been deduced from the intensity balance for the level ''3'' (75,70-keV) assuming that there is no beta-feeding to the ''3''-level.

The mixing ratios (d) for gamma-ray transitions have been taken from 2003Br12 based on measurements of 1959Ew90, 1972Kr07, 1990Si12 and 1991Sh06.

3. Atomic Data

3.1. Fluorescence yields

The fluorescence yield data are from 1996Sc06 (Schönfeld and Janßen).

3.2. X Radiations

The LX-ray energies are from 1996FiZX. The KX-ray energies and the relative KX-ray emission probabilities are from 1999Schönfeld .

The ratios P(KLX)/P(KLL), P(KXY)/P(KLL) are from 1996Sc06.

4. Electron Emissions

The energies of the conversion electrons have been calculated from the gamma transition energies and the electron binding energies.

The emission probabilities of the conversion electrons have been calculated using evaluated P_γ and ICC values.

The absolute emission probabilities of K and L Auger electrons have been calculated using the EMISSION computer program.

β^- average energies have been calculated using the LOGFT computer program.

5. Photon Emissions

5.1. X-Ray Emissions

The absolute emission probabilities of Pu KX- and LX-rays have been calculated using the EMISSION code.

Measured and calculated absolute emission probabilities of Pu KX-rays are given in Tables 4.

Table 4. Measured and calculated absolute emission probabilities (%) of Pu KX-rays.

	1972Ah02	1982Ah04	Calculated
$K\alpha_2$ (Pu)	14,4 (6)	12,8 (4)	13,5 (4)
$K\alpha_1$ (Pu)	22,2 (6)	20,4 (6)	21,4 (6)
$K\beta'_1$ (Pu)	-	7,3 (3)	7,84 (25)
$K\beta'_2$ (Pu)	2,8 (1)	2,6 (1)	2,72 (10)

5.2. Gamma-Ray Emissions

The gamma ray energies, Eγ, for $\gamma_{1,0}$ (7,86-keV) , $\gamma_{2,1}$ (49,4-keV) and $\gamma_{4,2}$ (106,5-keV) were calculated from the level energies. The gamma ray energies with Eγ > 334,3 keV have been taken from 1974HeYW. The other gamma energies were adopted from 2003Br12 based on experimental data of 1959Ew90, 1965Ma17, 1972Po04, 1979Bo30 and 1982Ah04.

P($\gamma_{1,0}$)(7,86-keV) has been deduced from P($\gamma_{1,0}$ +ce) (7,86-keV) and the adopted α_T.

P($\gamma_{3,2}$)(18,43-keV) has been deduced from P($\gamma_{3,1}$) (67,84-keV) and the ratio of P($\gamma_{3,2}$ +ce) (18,43-keV)/P($\gamma_{3,1}$) (67,88-keV) < 0,2 from 1996FiZX.

P($\gamma_{2,0}$)(57,273-keV) = 0,12 (3) % has been deduced from P($\gamma_{2,1}$) (49,41-keV) and P($\gamma_{2,1}$) (49,41-keV)/ P($\gamma_{2,0}$)(57,27-keV) = 0,85 (12) from 1996FiZX.

P($\gamma_{7,6}$)(57,29-keV) ~ 0,012 % has been deduced from P($\gamma_{7,6}$)(57,3-keV) + P($\gamma_{2,0}$)(57,273 -keV) = 0,135 (7) % and P($\gamma_{2,0}$)(57,273-keV).

P($\gamma_{8,6}$)(61,88-keV) and P($\gamma_{3,1}$)(67,84-keV) have been taken from 1974HeYW.

P($\gamma_{7,5}$)(101,96-keV) has been taken from ^{239}Am e decay (see 2003Br02).

P($\gamma_{8,4}$)(227,83-keV) has been taken from the decay scheme (see 2003Br02).

P($\gamma_{6,1}$)(322,3-keV) has been deduced from the Pγ branching in ^{239}Am e decay and ^{243}Cm a decay (see 2003Br02).

P($\gamma_{4,3}$)(88,06-keV), P($\gamma_{4,2}$)(106,50-keV) and P($\gamma_{6,4}$)(166,39-keV) have been calculated from the conversion data of 1959Ew90 and the adopted α_T.

P($\gamma_{7,3}$)(311,70-keV) = 0,002 (2) % has been deduced from P($\gamma_{7,3}$)(311,70-keV)/P($\gamma_{7,6}$)(57,29-keV) = 0,34 (14) from 1996FiZX.

The absolute emission probabilities of the other gamma-rays have been evaluated from experimental data (Table 5).

6. References

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Table 5. Experimental and evaluated absolute emission probabilities (%) for gamma-rays in the decay of ^{239}Np.

E $_{\gamma}$(keV)	1972Ah02	1974Yu04	1974HeYW	1977St35 1991Po17	1979Mo25	1982Ah04	1984Va41	1986Ch17	1986Wo05	1992Ha02	Adopted
44,66						0,13 (1)					0,13 (1)
49,41			0,18 (3)			0,11 (1)					0,145 (35)
57,273						0,135 (7)					0,12 (3)
57,3											~0,012
61,46						1,29 (6)	1,29 (2)		1,40 (7)	1,27 (3)	1,29 (2)
106,12	27,8 (9)			26,6 (10)		26,4 (8)	27,50 (40)	26,08 (38)	25,23 (28)	25,6 (2)	25,9 (3)
181,69	0,075 (8)					0,083 (4)	0,07 (1)		0,085 (5)	0,088 (2)	0,086 (2)
209,75	3,42 (10)			3,36 (14)		3,30 (10)	3,46 (5)	3,28 (5)	3,43 (7)	3,47 (3)	3,42 (3)
226,38				0,24 (3)		0,290 (16)	0,28 (2)		0,230 (14)	0,25 (1)	0,255 (14)
228,18	11,4 (3)			11,78 (44)		11,2 (3)	11,21 (18)	11,05 (14)	10,91 (16)	11,54 (5)	11,32 (22
254,41	0,11 (1)					0,110 (6)	0,12 (1)		0,1078 (27)	0,113 (4)	0,110 (3)
272,84	0,08 (1)					0,077 (4)	0,08 (1)		0,0762 (24)		0,077 (3)
277,60	14,5 (5)	14,1 (4)		15,0 (4)	14,30 (24)	14,5 (4)	14,38 (21)	14,21 (13)	14,53 (17)	14,46 (10)	14,4 (1)
285,46	0,76 (2)			0,93 (6)		0,790 (25)	0,77 (2)	0,765 (9)	0,797 (10)	0,80 (1)	0,78 (1)
315,88	1,52 (5)			1,63 (7)		1,60 (5)	1,60 (3)	1,55 (2)	1,604 (20)	1,60 (1)	1,59 (1)
334,31	1,95 (7)			2,1 (1)		2,06 (6)	2,08 (3)	1,99 (2)	2,050 (25)	2,05 (2)	2,04 (2)
392,4			0,0016								0,0016
429,5			0,0039								0,0039
434,7			0,013								0,013
447,6			0,00026								0,00026
454,2			0,00082								0,00082
461,9			0,0016								0,0016
469,8			0,0011								0,0011
484,3			0,001								0,001
492,3			0,006								0,006
497,8			0,0032								0,0032
498,7			0,001								0,001
504,2			0,00078								0,00078