BNL-107738-2015-JA

Nuclear Data Sheets for A = 239*

E. BROWNE

Guest appointment at
Lawrence Berkeley National Laboratory
under subcontract with National Nuclear Data Center,
Brookhaven National Laboratory
Upton, New York 11973–5000, USA

J. K. TULI

National Nuclear Data Center
Brookhaven National Laboratory
Upton, New York 11973–5000, USA

(Received November 8, 2013; Revised September 12, 2014)

Abstract: Spectroscopic data and level schemes from radioactive decay and nuclear reaction studies are presented here for all nuclei with mass number A=239.

In general, a relatively small amount of new data on this mass chain has been reported since the previous evaluation in 2003. However, special evaluations, such as "Database of prompt gamma rays from slow neutron–capture from elemental analysis" (2007ChZX), have provided additional precise data for levels in ^{239}U. Also, new Coulomb excitation measurements in ^{239}Pu have extended the knowledge of the 1/2[631] rotational band up to Jπ=(55/2+), and that of the octupole vibrational band up to Jπ=(53/2–).

For historical knowledge it is worth mentioning the report on the "Discovery of isotopes of the transuranium elements with 93<= Z <=98" (2013Fr02), where the information for elements Np, Pu, Am, and Cf with mass number A=239 is presented.

The alpha hindrance factors (HF) presented in this evaluation were calculated using values of the radius parameter (r_0) interpolated from those for even–even adjacent nuclei given by 1998Ak04.

Cutoff Date: All data received by June 2013 have been evaluated.

General Policies and Organization of Material: see http://www.nndc.bnl.gov/nds/NDSPolicies.pdf.

Acknowledgments: Thanks are due to B. Singh for his compilation of many experimental works into the Experimental Unevaluated Nuclear Data List (XUNDL), maintained and disseminated by the National Nuclear Data Center (NNDC) at the Brookhaven National Laboratory (BNL). Authors are extremely thankful to E. McCutchan for her thorough review.

General Comments: For nuclides not observed but theoretical results see 2011Sa40 (^{239}Es), 2008Kh10 (^{239}Fm), and 2008Do10 (^{239}No).

Notice: This manuscript has been co-authored by employees of Brookhaven Science Associates, LLC under Contract No.DE-SC0012704 with the U.S. Department of Energy. The publisher by accepting the manuscript for publication acknowledges that the United States Government retains a non-exclusive, paid-up, irrevocable, world-wide license to publish or reproduce the published form of this manuscript, or allow others to do so, for United States Government purposes.

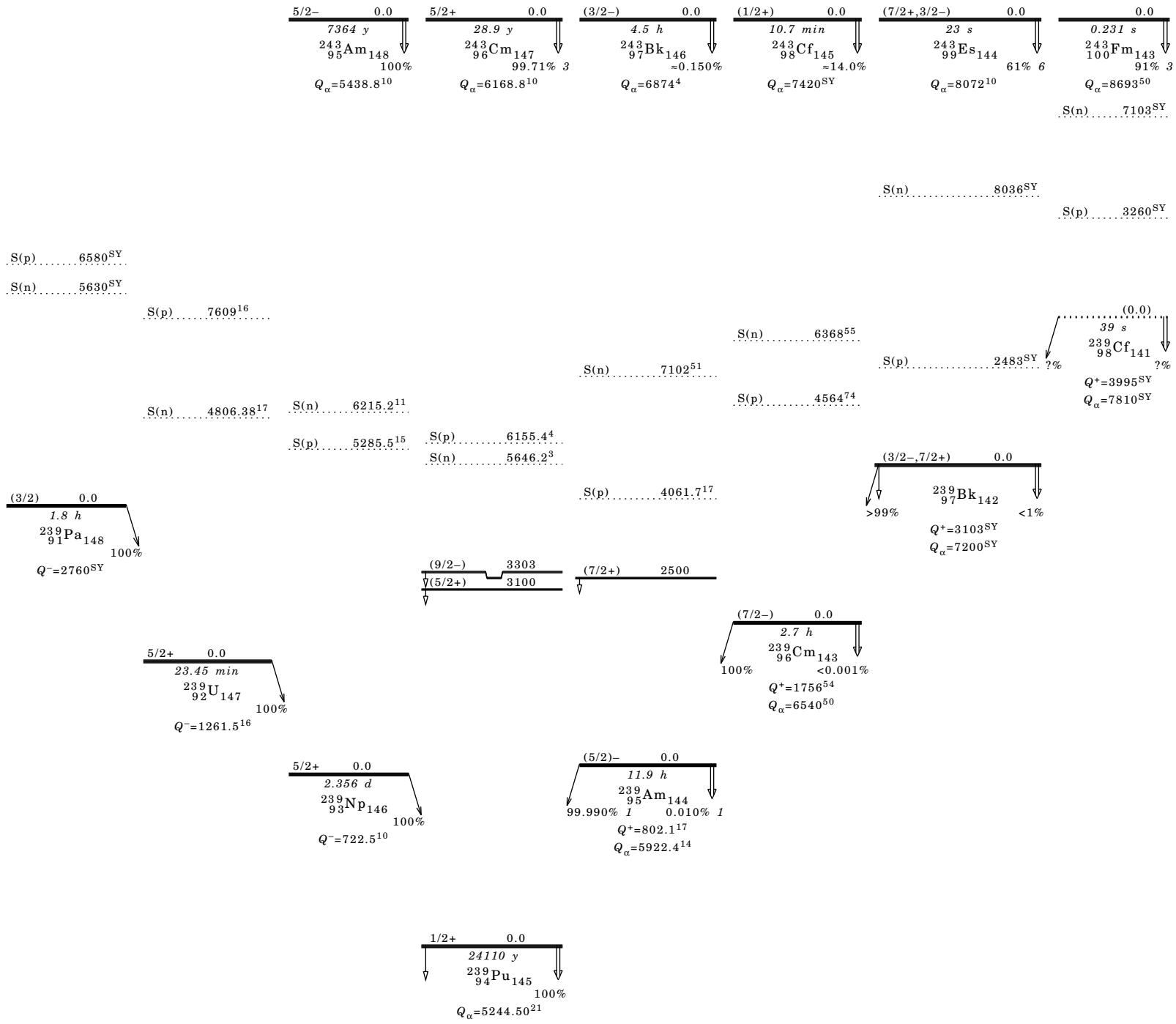
DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or any third party's use or the results of such use of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does *not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

Index for A = 239

Nuclide	Data Type	Page
	Skeleton Scheme for A=239	296
^{239}Pa	Adopted Levels	298
^{239}U	Adopted Levels, Gammas	299
	^{239}Pa β^- Decay	308
	^{238}U(n,γ) E=thermal	308
	^{238}U(n,γ) E=res: Av	313
	^{238}U(n,γ) E=res	315
	^{238}U(d,p)	316
^{239}Np	Adopted Levels, Gammas	318
	^{239}U β^- Decay	324
	^{243}Am α Decay	332
	^{238}U(^{3}He,d),(α,t)	335
^{239}Pu	Adopted Levels, Gammas	336
	^{239}Np β^- Decay	345
	Muonic Atom	348
	^{239}Am ε Decay	349
	^{243}Cm α Decay	351
	^{238}U(α,3nγ)	355
	^{238}Pu(n,γ) E=th	356
	^{238}Pu(d,p)	357
	^{239}Pu(γ,γ')	357
	^{239}Pu(n,n')	358
	^{239}Pu(d,d')	358
	Coulomb Excitation	359
^{239}Am	Adopted Levels, Gammas	361
	^{239}Cm ε Decay	362
	^{243}Bk α Decay	363
^{239}Cm	Adopted Levels	365
	^{243}Cf α Decay	365
^{239}Bk	Adopted Levels	366
	^{243}Es α Decay	366
^{239}Cf	Adopted Levels	368
	^{243}Fm α Decay	368

Skeleton Scheme for A=239



Ground-State and Isomeric-Level Properties for A=239

Nuclide	Level	Jπ	$T_{1/2}$	Decay Modes
^{239}Pa	0.0	(3/2)	1.8 h *5*	%β^-=100
^{239}U	0.0	5/2+	23.45 min *2*	%β^-=100
^{239}Np	0.0	5/2+	2.356 d *3*	%β^-=100
^{239}Pu	0.0	1/2+	24110 y *30*	%α=100; %SF=3.1×10^{-10} *6*
	3100	(5/2+)	7.5 μs *10*	%SF≤100
	3303	(9/2−)	2.6 ns *+40−12*	%SF≤100
^{239}Am	0.0	(5/2)−	11.9 h *1*	%ε=99.990 *1*; %α=0.010 *1*
	2500	(7/2+)	163 ns *12*	%SF≤100
^{239}Cm	0.0	(7/2−)	2.7 h *8*	%ε=100; %α<0.001
^{239}Bk	0.0	(3/2−,7/2+)		%ε>99; %SF<1; %α<1
^{239}Cf	0.0		39 s *+37−12*	%ε=?; %α=?
^{243}Am	0.0	5/2−	7364 y *22*	%α=100
^{243}Cm	0.0	5/2+	28.9 y *4*	%α=99.71 *3*; ...
^{243}Bk	0.0	(3/2−)	4.5 h *2*	%α=0.150; ...
^{243}Cf	0.0	(1/2+)	10.7 min *5*	%α=14.0; ...
^{243}Es	0.0	(7/2+,3/2−)	23 s *3*	%α=61 *6*; ...
^{243}Fm	0.0		0.231 s *9*	%α=91 *3*; ...

Adopted Levels

Q(β^-)=2760 *SY*; S(n)=5630 *SY*; S(p)=6580 *SY*; Q(α)=3560 *SY* 2012Wa38.
ΔQ(β^-)=200, ΔS(n)=200, ΔS(p)=340, ΔQ(α)=200.
^{239}Pa activity was produced by bombarding a uranium target with 900–MeV ^{18}O projectiles. Protactinium was chemically separated and its genetic relation to its daughter nuclide ^{239}U was established. The half–life of ^{239}Pa was measured by following the growth and subsequent decay of the known 74.6–keV γ ray from ^{239}U β^- decay (1995Yu01,1996Yu06).

^{239}Pa Levels

E(level)	Jπ	$T_{1/2}$	Comments
0.0	(3/2)	1.8 h *5*	$T_{1/2}$: From 1995Yu01, 1996Yu06. Jπ: Assigned by evaluator, based on its β^- decay to the 715– (3/2+), 784– (5/2–), and 815–keV (1/2–) levels in ^{239}U. %β^-=100.

Adopted Levels, Gammas

Q(β⁻)=1261.5 *16*; S(n)=4806.38 *17*; S(p)=7609 *16*; Q(α)=4131 *13* 2012Wa38.
2013Fr03: Discovery of ^{239}U.
Other measurements, calculations, and compilations.
^{238}U(n,γ).
2013De19: ^{238}U(n,γ), E<20 MeV. Analyzed data.
2013He11: ^{238}U(n,γ), E<20 MeV. Deduced σ.
2012Br11: ^{238}U(n,γ), E=0 – 30 MeV. Calculated neutron yields.
2012Le17: ^{238}U(n,γ), E<20 MeV. Deduced σ.
2012Na16: ^{238}U(n,γ), E=3.7 MeV. Measured Eγ, Iγ. Deduced σ.
2012Pr13: ^{238}U(n,γ), E=Thermal. σ compilation.
2012Tu03: ^{238}U(n,γ), E=0.01 – 50 MeV. Deduced σ.
2011Go05: ^{238}U(n,γ), E≤20 MeV. Deduced σ.
2011Go28: ^{238}U(n,γ), E=0.001 – 30 MeV. Deduced σ.
2011Ro44: ^{238}U(n,γ), E=0.1 – 20 MeV. Deduced σ.
2011Ul01: ^{238}U(n,γ), E=10 eV – 100 keV. Deduced σ.
2010Ad13: ^{238}U(n,γ), E=th – 1 GeV. Measured Eγ, Iγ. Deduced σ.
2010Co02: ^{238}U(n,γ), E=0.001 – 1 MeV. Measured Eγ, Iγ. Deduced σ.
2009Ch04: ^{238}U(n,γ), E<1.0 MeV. Deduced σ.
2009De04: ^{238}U(n,γ), 0 – 20 keV. Deduced σ.
2009Go05: ^{238}U(n,γ), 0.01 – 30 MeV. Deduced Fission σ.
2008Ha01: ^{238}U(n,γ), E=0.003 – 11 MeV. Deduced σ.
2008Mu23: ^{238}U(n,γ), E<1 MeV. Analyzed σ.
2008Re07: ^{238}U(n,γ), E=low. Measured Eγ, Iγ.
2007Bo19: ^{238}U(n,γ), 0 – 20 keV. Deduced σ.
2004Ko23: ^{238}U(n,γ), E=reactor. Measured Eγ, Iγ.
2004St02: ^{238}U(n,γ), 0 – 20 keV. Deduced σ.
Nuclear Structure.
2011Ad15: Calculated single–particle states.
2009Mi28: Calculated fission barrier; level energies.
2006Sh19: Rotational bands.
2006Fr21: Level densities.
2005Pa73: Single–particle states.
2004Fr11: Fission fragment yields.
2004Sa55: Calculated masses.
2002Be89: Calculated level densities.
2011He12: Compilation.
Radioactivity.
2012Ro34: Theory.
2012Sa31: ^{239}U(^{20}O) cluster decay.
2004Fr11: β⁻ decay. Evaluated data.

^{239}U Levels

All levels populated in (n,γ) reactions (from thermal or resonance neutron capture states with Jπ=1/2+) have spins 1/2, 3/2, or 5/2. Band assignments presented here have been based on the energy systematics of Nilsson orbital configurations, and on the systematics of rotational band parameters (1978Bo12,1972Bo16,1984Ch05). Jπ assignments to levels in the second potential well of the shape isomeric ground state are supported by tentative γ–ray multipolarities (1998Ob01,1995Ob01).

Chemical shift for the 6.67–eV n–resonance was measured, $\Delta\langle r^2\rangle/\langle r^2\rangle$=5% relative to ^{239}U g.s. was deduced, possibly caused by lack of deformation at 4.8 MeV (neutron binding energy) (1981Se14).

Cross Reference (XREF) Flags

A ^{238}U(n,γ) E=thermal
B ^{238}U(n,γ) E=res: Av
C ^{238}U(d,p)
D ^{238}U(n,γ) E=res
E ^{239}Pa β⁻ Decay

E(level)†	Jπ§	XREF	$T_{1/2}$	Comments
0.0#	5/2+	ABC E	23.45 min *2*	Jπ: from (n,γ) average resonance. $T_{1/2}$: weighted average of: 23.54 min *5* (1943Mi10), 23.5 min *7* (1947Fe05), 23.40 min *5* (1969Hu21), 23.44 min *2* (1989Ab05). %β⁻=100.
42.534# *7*	7/2+	A C		Jπ: 42.5γ E2(+M1) to 5/2+.
98.631# *16*	9/2+	A CD		Jπ: L=4 in (d,p).

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued)

^{239}U Levels (continued)

E(level)[†]	Jπ[§]	XREF	$T_{1/2}$	Comments
133.7991[@] *10*	1/2+	ABC E	0.78 μs *4*	Jπ: 133.8γ E2 to 5/2+. $T_{1/2}$: from (d,pγ) (1975Ya03).
145.767[@] *6*	3/2+	ABC E		Jπ: (n,γ) average resonance.
169.089?[&] *10*	(7/2+)	A		Jπ: possible 169.1γ γ to 5/2+.
193.985[@] *5*	5/2+	AB E		Jπ: 60.2γ E2 to 1/2+, (n,γ) average resonance.
222.25[@] *3*	(7/2+)	A E		Jπ: 562.0γ (E1) from 5/2−.
226.3[&] *15*	(9/2+)	C		Jπ: from cross−section signature in (d,p).
292.5872[f] *20*	(7/2−)	A		Jπ: 292.2γ to 5/2+, 193.9γ to 9/2+. Systematics of Nilsson orbital configurations (1972El21).
301.8[&] *20*	(11/2+)	C		Jπ: from cross−section signature in (d,p).
307.8[@] *15*	(9/2+)	C		Jπ: from cross−section signature in (d,p).
372.7[f] *20*	(11/2−)	C		Jπ: from cross−section signature in (d,p).
498.6[f] *15*	(15/2−)	C		Jπ: from cross−section signature in (d,p).
539.283[g] *9*	5/2−	AB		Jπ: 539.3γ E1 to 5/2+, 496.7γ E1 to 7/2+; (n,γ) average resonance.
687.854[a] *5*	(1/2)+	ABC		Jπ: 1/2+ or 3/2+ from 554.0γ M1 to 1/2+; band parameter syst suggests 1/2+ (see for example ^{249}Cm,^{251}Cf).
694.7 *5*	5/2	B		Jπ: from (n,γ) average resonance. 1984Ch05 suggest configuration=5/2[633].
702.5 *15*	(9/2+)	C		Jπ: from cross−section signature in (d,p). 1978Er03 suggest configuration=7/2[613].
715.835[a] *5*	3/2+	ABC E		Jπ: 521.8γ M1(+E2) to 5/2+, 582.0γ M1(+E2) to 1/2+.
726.108[c] *10*	(3/2)+	AB		Jπ: 580.3γ M1+E2 to 3/2+, 592.3γ M1+E2 to 1/2+, band syst suggests 3/2+.
734.65[a] *3*	(5/2+)	ABC		Jπ: from (n,γ) average resonance.
739.380[b] *6*	1/2−	ABC		Jπ: 605.5γ E1 to 1/2+; γ−ray polarization in (n,γ).
746.054[b] *4*	3/2−	ABC		Jπ: 612.2γ E1 to 1/2+, 552.1γ E1 to 5/2+.
757.151[c] *22*	(5/2)+	ABC		Jπ: 563.1γ M1+E2 to 5/2+; (n,γ) average resonance.
784.273[b] *14*	5/2−	ABC E		Jπ: 638.5γ E1 to 3/2+; (n,γ) average resonance.
795.9[b] *15*	(7/2−)	C		Jπ: from cross−section signature in (d,p).
815.155[h] *6*	1/2−	ABC E		Jπ: from cross−section signature in (d,p); γ−ray polarization in (n,γ).
823.708[h] *8*	3/2−	ABC		Jπ: 629.7γ E1 to 5/2+, 690.0γ E1 to 1/2+.
838.3 *15*		C		1978Er03 suggest 11/2− member of 1/2[750] rotational band.
853.23[e] *4*	(3/2)+	ABC		Jπ: 853.2γ M1+E2 to 5/2+; (n,γ) average resonance.
858.81[h] *10*	5/2−	B		Jπ: from (n,γ) average resonance.
874.0[c] *15*	(9/2+)	C		Jπ: from cross−section signature in (d,p).
888.1[e] *3*	5/2+	ABC		Jπ: from (n,γ) average resonance.
893.30 *10*	5/2+	AB		Jπ: 893.3γ M1+E2 to 5/2+; (n,γ) average resonance.
897.9 *15*		C		
932.90[d] *5*	(1/2)−	ABC		Jπ: 787.2γ (E1) to 3/2+; (n,γ) average resonance.
944.8[e] *20*	(7/2+)	C		Jπ: from cross−section signature in (d,p).
961.88[d] *14*	(3/2)−	ABC		Jπ: 768.0γ (E1) to 5/2+, 827.9γ (E1) to 1/2+; (n,γ) average resonance.
965.638[i] *19*	3/2+	AB		Jπ: 831.8γ M1+E2 to 1/2+.
982.9[d] *10*	5/2−	BC		Jπ: from (n,γ) average resonance.
988.20[i] *6*	(5/2)+	AB		Jπ: 794.2γ M1+E2 to 3/2+, 842.4γ M1+E2 to 5/2+.
990.495 *19*	3/2+,5/2+	AB D		Jπ: 990.2γ M1+E2 to 5/2+; (n,γ) average resonance.
996.1[e] *15*	(9/2+)	C		Jπ: from cross−section signature in (d,p).
1005.7 *5*	1/2+,3/2+,5/2+	AB		Jπ: from (n,γ) average resonance.
1018.6 *10*	5/2−	B		Jπ: from (n,γ) average resonance. 1984Ch05 suggest configuration=1/2[631]×2−.
1062.48[j] *6*	5/2+	AB		Jπ: 1062.5γ E0+M1+E2 to 5/2+; (n,γ) average resonance.
1066.81 *12*	1/2,3/2	ABC		Jπ: 1/2−,3/2− from (n,γ) average resonance; 3/2+,5/2+,7/2+ from 1066.8γ M1+E2 to 5/2+.
1115.0 *15*		C		
1146.74 *23*	5/2	B		Jπ: from (n,γ) average resonance.
1149.7 *3*		ABC		
1152.80 *4*	3/2+	AB		Jπ: 1007.0γ E0+M1+E2 to 3/2+.
1155.052[k] *22*	1/2+	AB		Jπ: 1021.3γ E0+M1 to 1/2+.
1167.02[k] *3*	3/2+	AB		Jπ: 1021.3γ E0+M1 to 3/2+; (n,γ) average resonance.
1194.63[l] *5*	(1/2)−	ABC		Jπ: 478.8γ (E1) to 3/2+; (n,γ) average resonance.
1201.02[k] *6*	5/2+	AB		Jπ: 1007.0γ E0+M1+E2 to 5/2+; (n,γ) average resonance.
1206.0 *10*	(5/2)	B		Jπ: from (n,γ) average resonance.

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued)

^{239}U Levels (continued)

E(level)†	Jπ§	XREF	$T_{1/2}$	Comments
1223.31[1] *3*	(3/2−)	AB		Jπ: (1/2+,3/2+) from 1089.6γ (M1) to 1/2+; 1/2−,3/2− from (n,γ) average resonance.
1225.5 *10*	1/2−	B		Jπ: 1/2−,3/2− from (n,γ) average resonance. 1984Ch05 suggest configuration=5/2[622]×2−.
1232.0 *7*		ABC		
1235.2 *5*		AB		
1237.7 *7*	1/2+,3/2+	ABC		Jπ: from (n,γ) average resonance.
1241.96 *6*	1/2−,3/2−	ABC		Jπ: 554.1γ E1 to 3/2+; (n,γ) average resonance.
1260.3 *3*	(1/2,3/2)	ABC		Jπ: from (n,γ) average resonance.
1265.3 *8*		A		
1270.6 *5*	(1/2,3/2)	ABC		Jπ: from (n,γ) average resonance.
1276.83 *21*	(1/2,3/2)	AB		Jπ: from (n,γ) average resonance.
1295.2 *10*	1/2,3/2,5/2	B		Jπ: from (n,γ) average resonance.
1306.22 *3*	1/2−,3/2−	AB		Jπ: 590.4γ E1 to 3/2+; (n,γ) average resonance. π=+.
1318.2 *3*		AB		
1320.5 *7*		AB		
1324.6 *3*	(1/2−,3/2−)	AB		Jπ: from (n,γ) average resonance.
1338.3 *10*	(1/2+,3/2+,5/2+)	BC		Jπ: from (n,γ) average resonance.
1360.97 *3*	(1/2−,3/2−)	ABC		Jπ: from (n,γ) average resonance.
1368.03 *21*		A		
1383.5 *4*		A		
1399.5 *8*		A		
1404.53 *21*		A		
1416.9 *6*		A		
1436.83 *21*		A C		XREF: C(1430).
1445.83 *21*		A		
1462.5 *3*		A		
1479.5 *5*		A C		XREF: C(1473).
1481.53 *21*		A		
1493.6 *5*	1/2,3/2	A		Jπ: from γ–ray polarization in (n,γ).
1494.9 *6*	1/2,3/2	A		Jπ: from γ–ray polarization in (n,γ).
1504.5 *3*		A		
1509.9 *3*	(1/2−,3/2−)	A		Jπ: from γ–ray polarization in (n,γ).
1512.9 *15*		A C		XREF: C(1515).
1520.33 *21*	1/2−,3/2−	A C		XREF: C(1524).
				Jπ: from γ–ray polarization in (n,γ).
1573.2 *5*	1/2,3/2+	A		Jπ: from γ–ray polarization in (n,γ).
1586.3 *5*	3/2	A		Jπ: from γ–ray polarization in (n,γ).
1609.2 *5*	1/2+,3/2+	A		Jπ: from γ–ray polarization in (n,γ).
1614.7 *5*	3/2,(1/2)	A		Jπ: from γ–ray polarization in (n,γ).
1631.2 *5*	1/2,3/2	A		Jπ: from γ–ray polarization in (n,γ).
1684.7 *5*	1/2,3/2	A		Jπ: from γ–ray polarization in (n,γ).
1692.2 *5*	3/2,(1/2)	A		Jπ: from γ–ray polarization in (n,γ).
0.0+x‡	(5/2+)	D	>0.25 μs	$T_{1/2}$: from delayed γγ coin (1994Ob01). Jπ: 708.2γ to 3/2+, 5/2+.
1717.0 *5*	3/2,(1/2)	A		Jπ: from γ–ray polarization in (n,γ).
1807.9 *5*	(3/2)	A		Jπ: from γ–ray polarization in (n,γ).
174.0+x‡		D		
477.8+x‡	(3/2−)	D		
1083.4+x‡	(1/2+,5/2+)	D		
1626.9+x‡	(1/2−,3/2−)	D		
1630.6+x‡	(3/2−)	D		
1767.5+x‡	(1/2−,3/2−)	D		
1776.5+x?‡		D		
1808.2+x?‡		D		
3107.0+x‡	(1/2+)	D		

† From least squares adjustment in (n,γ) thermal, unless otherwise specified.

‡ x=1699 keV, from (n,γ) E=res experiment (2008ObZZ). See also 1998Ob01. Levels are in the second potential well.

§ From rotational structure. Other supporting arguments, such as γ–ray multipolarities and reduced primary γ–ray intensities from (n,γ) resonance average reactions, are given with the individual levels.

(A): 5/2[622] Rotational parameter A=6.1 keV.

@ (B): 1/2[631] Rotational parameter A=6.8 keV, decoupling constant a=−0.41.

Footnotes continued on next page

Adopted Levels, Gammas (continued)

^{239}U Levels (continued)

[&] (C): 7/2[624] Rotational parameter A=6.9 keV.
[a] (D): 1/2[620] Rotational parameter A=6.5 keV, decoupling constant a=+0.42.
[b] (E): 1/2[761]? Rotational parameter A=4.9 keV, decoupling constant a=−0.55.
[c] (F): 3/2[631]? Rotational parameter A=6.2 keV.
[d] (G): 1/2[501] Rotational parameter A=6.9 keV, decoupling constant a=+0.39.
[e] (H): 3/2[622] Rotational parameter A=6.8 keV.
[f] (I): 7/2[743] Rotational parameter A=4.0 keV.
[g] (J): 5/2[622]×0− Octupole vibration.
[h] (K): 1/2[631]×0− Rotational parameter A=4.9 keV, decoupling constant a=−0.42. Octupole vibration.
[i] (L): 3/2[631]−2+? Rotational parameter A=4.5 keV. Gamma vibration.
[j] (M): 5/2[622]×0+? Beta vibration.
[k] (N): 1/2[631]×0+ Rotational parameter A=5.4 keV, decoupling constant a=−0.26. Beta vibration.
[l] (O): 1/2[750]? Rotational parameter A=6.0 keV, decoupling constant a=+0.59.

γ(^{239}U)

E(level)	Eγ†	Iγ†	Mult.†	α	Comments
42.534	42.540 *8*	100	E2(+M1)		
133.7991	133.799 *1*	100	E2	3.72	B(E2)(W.u.)=0.040 *3*.
145.767	11.978 *CA*	100			
169.089?	169.089# *10*	100			
193.985	48.230 *17*		[E2+M1]		
	60.185 *10*		E2	148	
292.5872	193.956 *15*	12 *6*			
	250.062# *7*	100 *40*			
	292.587 *2*	47 *18*			
539.283	496.753 *11*	34 *8*	E1	0.01367	
	539.278 *11*	100 *20*	E1	0.01163	
687.854	542.085 *12*	28 *7*			
	554.054 *8*	100 *24*	M1	0.189	
	687.853 *8*	33 *10*	(E2)		
715.835	521.849 *7*	100 *4*	M1(+E2)		
	582.034 *8*	22 *5*	M1(+E2)		
	673.307 *12*	14 *6*			
	715.832 *9*	30 *8*	(E2)		Mult.: E2,E1 from α, Δπ=no from level scheme.
726.108	580.340 *13*	96 *26*	M1+E2		
	592.309 *13*	100 *30*	M1+E2		
734.65	588.88 *3*	100			
739.380	593.612 *5*	100 *22*	E1	0.00966	
	605.581 *9*	49 *11*	E1	0.00930	
746.054	552.069 *6*	90 *2*	E1	0.01111	
	600.284 *10*	13 *4*	E1	0.00946	
	612.253 *5*	100 *22*	[E1]	0.00911	
757.151	563.17 *3*	100 *30*	M1+E2		
	611.38 *3*	100 *30*			
784.273	562.027 *22*	78 *24*	[E1]	0.01073	
	638.505 *12*	100 *29*	E1	0.00842	
815.155	127.301 *5*	83 *17*			
	669.385 *13*	33 *17*			
	681.355 *9*	100 *30*	E1‡		
823.708	629.722 *9*	100 *30*	E1	0.00864	
	689.907 *11*	59 *13*	E1	0.00728	
853.23	853.23 *4*	100	M1+E2		
893.30	893.30 *10*	100	M1+E2		
932.90	787.15 *7*	25 *8*	(E1)‡		
	799.12 *7*	100 *25*			
961.88	767.86 *21*	83 *25*	(E1)‡		
	828.04 *21*	100 *25*	(E1)‡		
965.638	819.868 *21*	19 *8*			
	831.837 *19*	100 *30*	M1+E2		
988.20	794.21 *8*	83 *25*	M1+E2		
	842.42 *8*	100 *25*	M1+E2		
990.495	451.213 *23*	100 *40*			
	990.49 *3*	100 *40*	M1+E2		

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued)

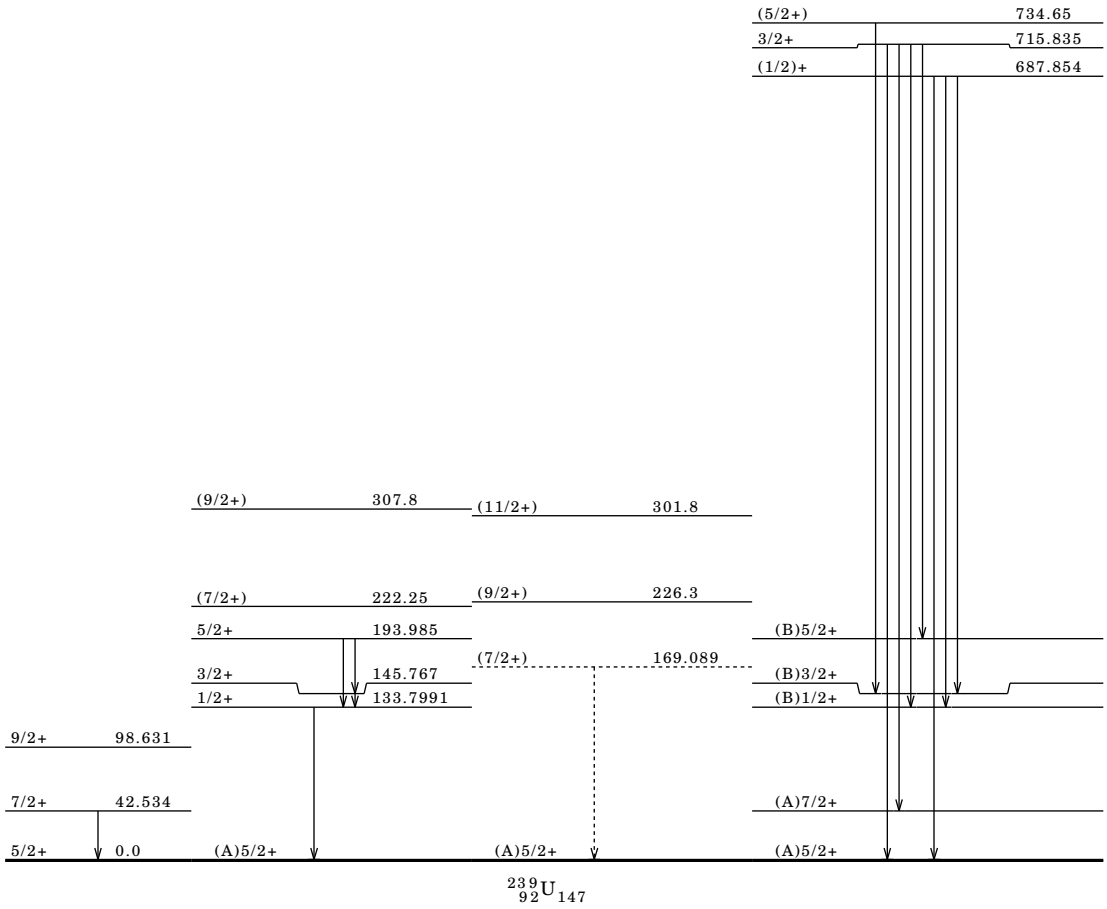
γ(^{239}U) (continued)

E(level)	Eγ†	Iγ†	Mult.†	α	Comments
1062.48	1062.48 *6*	100	E0+M1+E2		
1066.81	1066.82 *12*	100	M1+E2		
1149.7	1149.8 *3*	100			
1152.80	1007.03@ *6*	79@ *20*	E0+M1+E2		
	1110.27 *6*	100 *40*			
	1152.80 *6*	100 *40*			
1155.052	961.06 *4*	39 *10*			
	1021.25@ *4*	79@ *20*	E0+M1		
	1155.05 *4*	100 *40*			
1167.02	972.83 *25*				
	1021.25@ *4*	40@ *10*	E0+M1+E2		
	1167.01 *4*	100 *30*			
1194.63	478.79 *8*	75 *25*	(E1)‡		
	1048.85 *8*	75 *25*			
	1060.82 *8*	100 *25*			
1201.02	1007.03@ *6*	100@	E0+M1+E2		
1223.31	535.45 *5*	76 *16*	(E1)		Mult.: measured E1 or E2. Decay scheme requires E1.
	1029.32 *5*	100 *30*	(E1)		Mult.: measured E1 or E2. Decay scheme requires E1.
	1089.50 *5*	38 *11*	(E1)		Mult.: measured (M1). Decay scheme requires E1.
1241.96	554.10 *8*	100	E1	0.01108	
1306.22	590.39 *3*	100	E1	0.00977	
1360.97	537.26 *3*	100			
0.0+x	708.2§				
	1600.3§				
477.8+x	477.8§ *4*	100			
1083.4+x	605.6§ *5*	100			
1630.6+x	549.8§ *11*	100			
1776.5+x?	1298.8§# *10*	100			
3107.0+x	1298.8§# *10*	17 *4*			
	1339.5§# *10*	15 *2*			
	1476.4§ *11*	17 *2*			
	1480.1§# *11*	33 *4*			
	2933.0§ *21*	100 *20*			
	3107.0§ *23*				

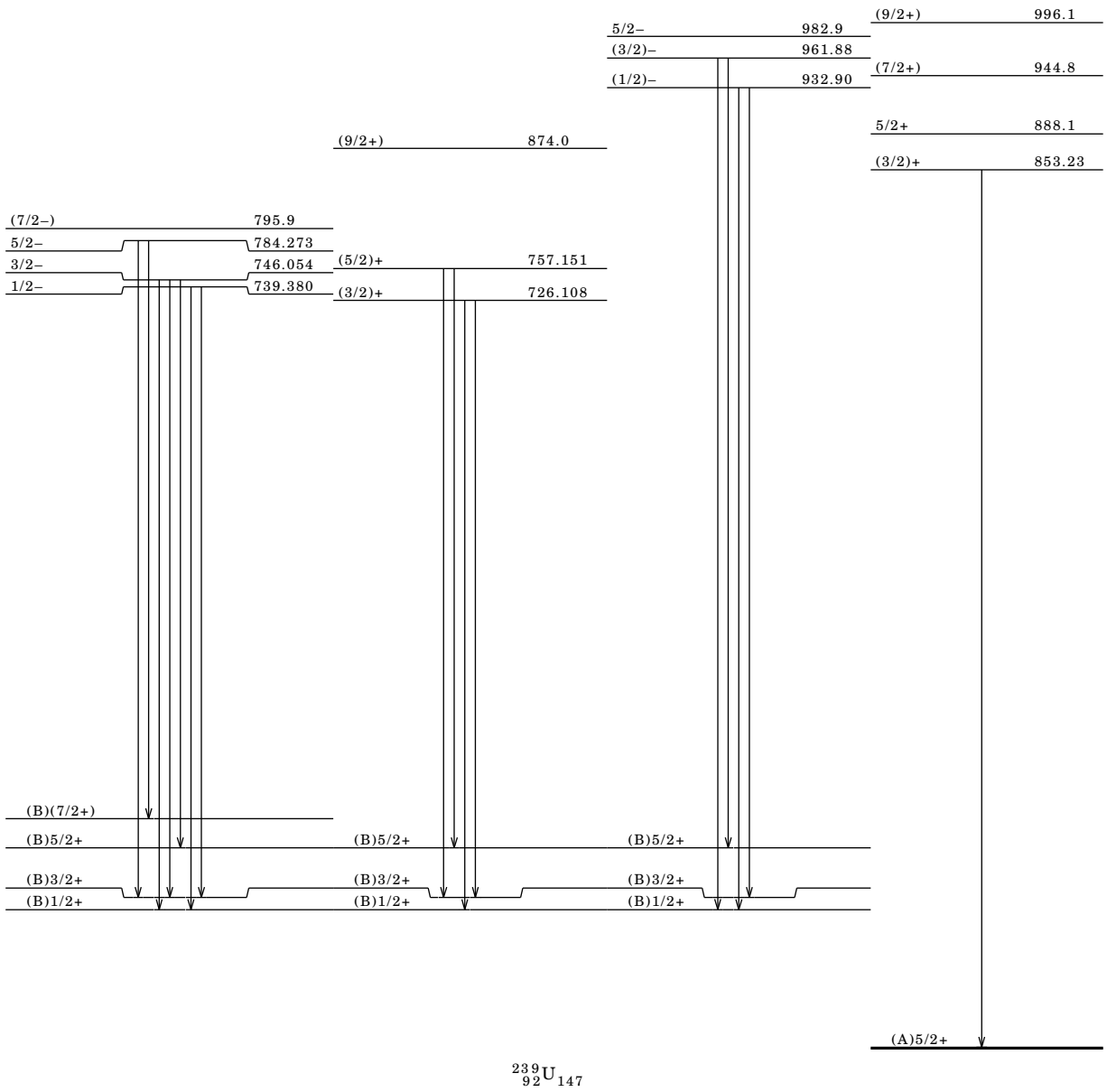
† From (n,γ) E=thermal.
‡ E1 or E2. Decay scheme requires E1.
§ γ rays de–excite levels in the second potential well.
# Placement of transition in the level scheme is uncertain.
@ Multiply placed; intensity suitably divided.

Adopted Levels, Gammas (continued)

(A) 5/2[622] **(B) 1/2[631]** **(C) 7/2[624]** **(D) 1/2[620]**



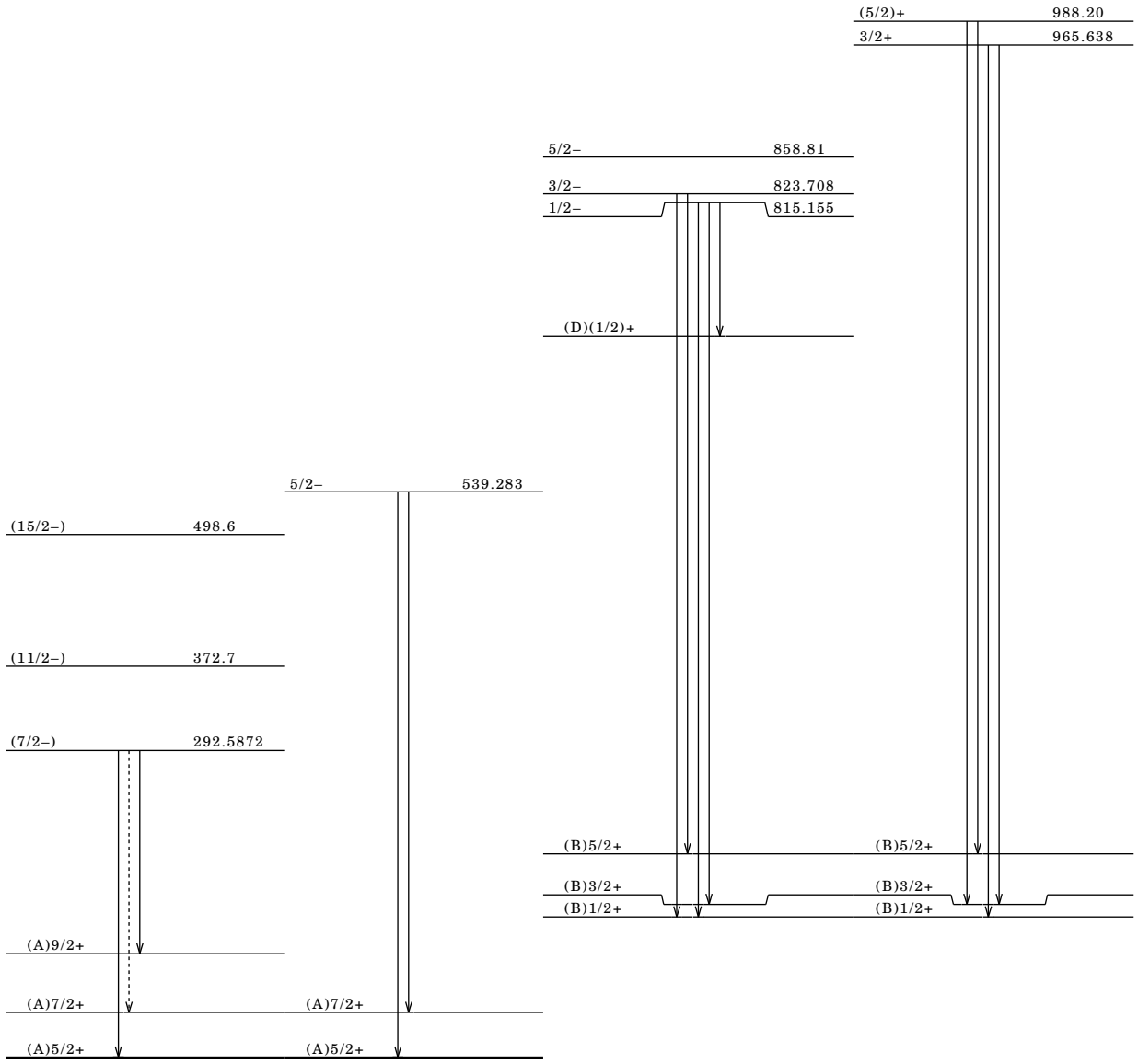
Adopted Levels, Gammas (continued)



$^{239}_{92}U_{147}$

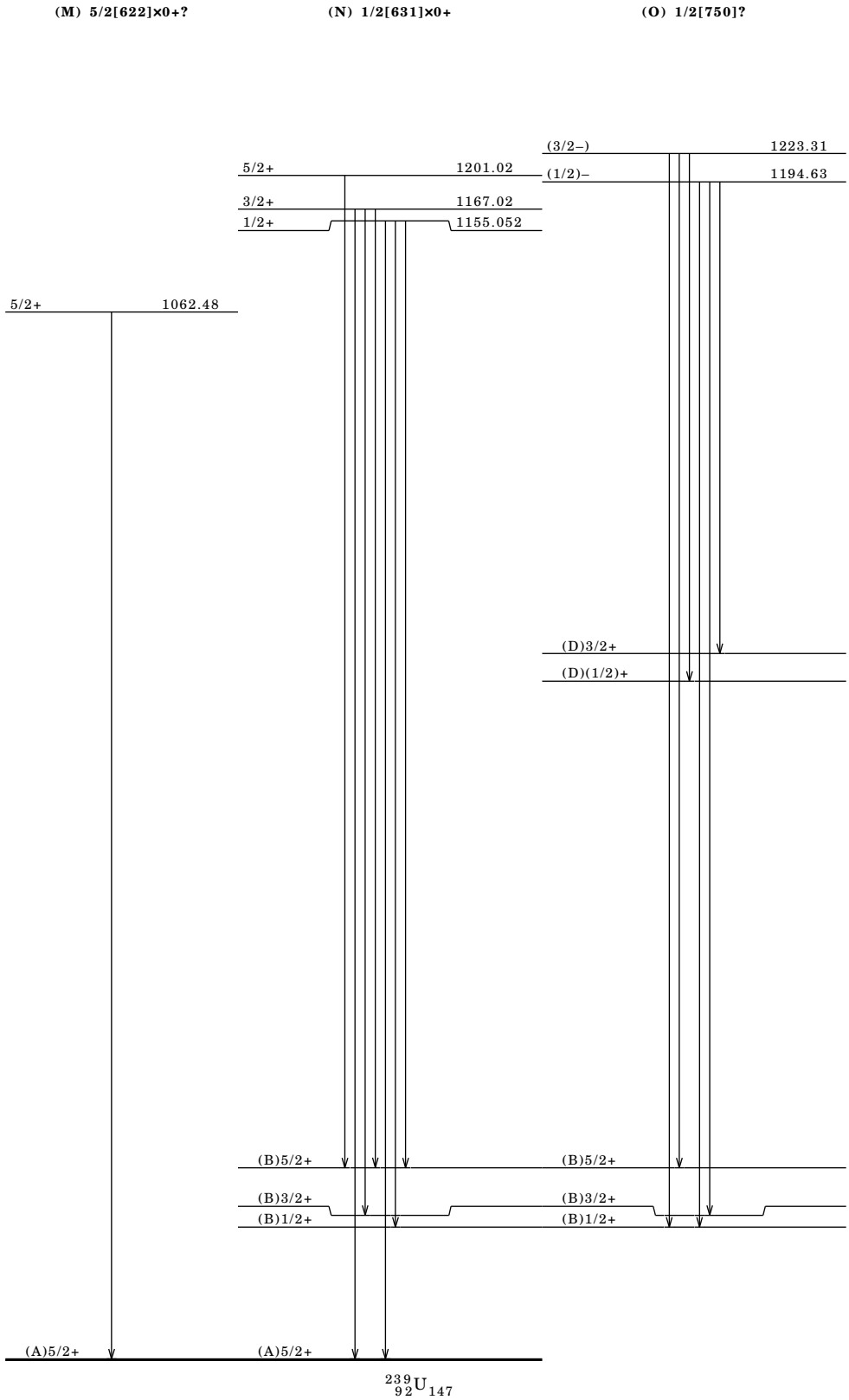
Adopted Levels, Gammas (continued)

(I) 7/2[743] **(J) 5/2[622]×0–** **(K) 1/2[631]×0–** **(L) 3/2[631]–2+?**



$^{239}_{92}U_{147}$

Adopted Levels, Gammas (continued)



^{239}Pa β⁻ Decay 1995Yu01,1996Yu06

Parent ^{239}Pa: E=0.0; Jπ=(3/2); $T_{1/2}$=1.8 h *5*; Q(g.s.)=2760 syst; %β⁻ decay=100.

Measured Eγ and γγ coin. Detectors: High–purity Ge. γ rays assigned to ^{239}Pa β⁻ decay had been previously seen in ^{238}U(n,γ) (1992Sc18).

^{239}U Levels

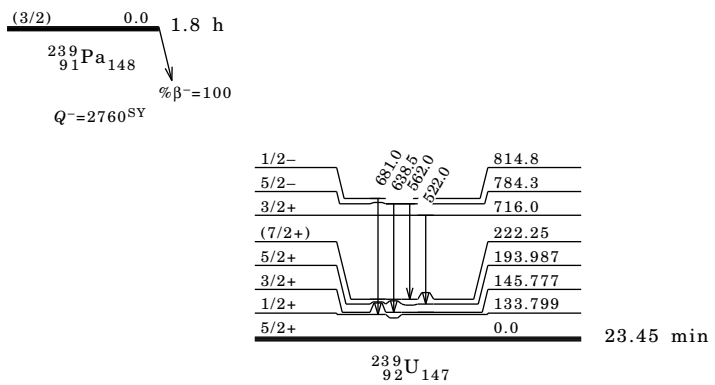
E(level)†	Jπ‡	$T_{1/2}$‡
0.0	5/2+	23.45 min *2*
133.799‡ *1*	1/2+	
145.777‡ *9*	3/2+	
193.987‡ *6*	5/2+	
222.25‡ *4*	(7/2+)	
716.0 *5*	3/2+	
784.3 *5*	5/2−	
814.8 *5*	1/2−	

† From γ–ray energies.
‡ From Adopted Levels.

γ(^{239}U)

Eγ	E(level)
522.0 *5*	716.0
562.0 *5*	784.3
638.5 *5*	784.3
681.0 *5*	814.8

Decay Scheme



^{238}U(n,γ) E=thermal 1978Bo12,1972Bo46,1984Ch05

1978Bo12: 99.98% depleted ^{238}U target. Measured Eγ, Iγ of secondary γ rays, γγ coin, conversion electrons. Detectors: curved–crystal spectrometer and Ge(Li) anti–Compton detector for γ rays, two Ge(Li) detectors for γγ coin measurements, and a magnetic spectrometer for detecting conversion electrons.

1972Bo46: >99.999% depleted ^{238}U target. Measured Eγ, Iγ (per 100 captured neutrons) of primary γ rays. Detector: Annihilation–pair Ge(Li) spectrometer.

1984Ch05: 99.999% depleted ^{238}U target. Polarized neutrons. Measured Eγ, Iγ (per 100 captured neutrons) of circularly polarized primary γ rays with Eγ=2400 – 4200 keV. Detectors: Ge(Li).

2007ChZX: Database of Prompt Gamma Rays from Slow Neutron Capture for Elemental Analysis. International Atomic Energy Agency. Evaluated Data.

^{238}U(n,γ) E=thermal 1978Bo12,1972Bo46,1984Ch05 (continued)

^{239}U Levels

E(level)‡	Jπ§
0.0	5/2+
42.534 *7*	7/2+
98.631 *16*	9/2+
133.7991 *10*	1/2+
145.767 *6*	3/2+
169.089? *10*	(7/2+)
193.985 *5*	5/2+
222.25? *3*	(7/2+)
292.5872 *20*	(7/2−)
539.283 *9*	(5/2)−
687.854 *5*	(1/2)+
715.835 *5*	3/2+
726.108 *10*	(3/2)+
734.65 *3*	(5/2+)
739.380 *6*	1/2−
746.054 *4*	3/2−
757.151 *22*	(5/2)+
784.273 *14*	5/2−
≈800?	
815.155 *6*	1/2−
823.708 *8*	3/2−
853.23 *4*	(3/2)+
888.1 *3*	5/2+
893.30 *10*	(5/2)+
932.90 *5*	(1/2)−
961.85 *13*	(3/2−)
965.637 *15*	3/2+
988.20 *6*	(5/2)+
990.495 *19*	(3/2+,5/2+)
1005.7 *5*	(1/2,3/2,5/2)+
1062.48 *6*	5/2+
1066.81 *12*	1/2,3/2
1149.7 *3*	(1/2+,3/2+)
1152.80 *4*	(3/2+,5/2)
1155.052 *22*	1/2+
1167.02 *3*	3/2+
1194.63 *5*	1/2−
1201.02 *6*	5/2+
1223.31 *3*	3/2
1232.0 *7*	(1/2+,3/2+)
1235.2 *5*	(1/2+,3/2+)
1237.7 *7*	1/2+,3/2+
1241.96 *6*	3/2−
1243.4† *5*	
1260.3 *3*	(1/2,3/2)+
1265.3 *8*	(5/2+)
1270.6 *5*	(1/2+,3/2+)
1276.83 *21*	(1/2+,3/2+)
1306.22 *3*	1/2−,3/2−
1318.2 *3*	1/2,3/2
1320.5 *7*	1/2,3/2
1324.6 *3*	(1/2,3/2)−
1360.97 *3*	1/2−,3/2−
1368.03 *21*	(1/2,3/2)+
1383.5 *4*	
1399.5 *8*	
1404.53 *21*	(1/2,3/2)+
1416.9 *6*	
1436.83 *21*	(1/2,3/2)+
1445.83 *21*	(1/2,3/2)+
1462.5 *3*	(1/2,3/2)+
1479.5 *5*	(1/2,3/2)+
1481.53 *21*	(1/2,3/2)−
1493.6 *5*	1/2,3/2
1494.9 *6*	1/2,3/2
1504.5 *3*	(1/2,3/2)−
1509.9 *3*	1/2−,3/2−
1512.9 *15*	(1/2,3/2)+
1520.33 *21*	1/2−,3/2−
1573.2 *5*	1/2,3/2+#
1586.3 *5*	3/2#
1609.2 *5*	1/2,3/2+#
1614.7 *5*	3/2,(1/2)#
1631.2 *5*	1/2,3/2#
1684.7 *5*	1/2,3/2#
1692.2 *5*	3/2,(1/2)#
1717.0 *5*	3/2,(1/2)#
1807.9 *5*	3/2#
4806.454 *21*	1/2+

† Not seen by 1984Ch05.
‡ From least–squares fit to Eγ.
§ From multipolarities of secondary γ rays (1978Bo12), and from the energy dependence of primary γ–ray intensities in average neutron resonance capture (1972Bo46), unless otherwise specified.
# From γ–ray circular polarization in ^{238}U(n,γ) E=thermal (1984Ch05).

γ(^{239}U)

For Iγ from average resonance capture, see 1971Wa12, 1972Bo46, 1984Ch05. Other measurements: 1999Ho33, 1995Ra25, 1991Ka34, 1977Li13, 1975BoZF, 1971Ar47, 1965Ma17, 1966Sh16.

Iγ normalization: From 100/σ_0=100/2.680 *19* b (2006MuZX), where σ_0 is the neutron radiative capture cross section measured at 2200 m/s.

Eγ‡	E(level)	Iγ‡&	Mult.†	α	I(γ+ce)&	Comments
(11.978 *CA*)	145.767				32 *CA*	I(γ+ce): from intensity balance.
42.540 *8*	42.534	@	E2(+M1)			Mult.: from ce(L2)=0.8 *2*, ce(L3)=0.6 *2* (1978Bo12).
48.230 *17*	193.985		[E2+M1]		13 *CA*	I(γ+ce): from intensity balance. ce(L2)=2.1 *5*.
60.185 *10*	193.985	0.0755@	E2	148.1		Mult.: from ce(L2):ce(M2):ce(M3)=4.5 *3*:2.1 *4*: 1.1 *2*: 1.0 *4* (1978Bo12).
127.301 *5*	815.155	0.0099 *20*				
133.799 *1*	133.7991	0.38 *8*	E2	3.72		Mult.: from α(L2)exp=1.6 *4*; ce(L1):ce(L2):ce(L3):ce(M1):ce(M2):ce(M3) : ce(N2):ce(N3):ce(O)= 2.6 *2*:30.0 *3*:18.5 *2*:0.9 *1* :5.7 *3*:5.1 *1*:2.0 *2*:1.4 *1*:0.60 *14* (1978Bo12).
169.089[a] *10*	169.089?	0.012 *4*				
193.956 *15*	292.5872	0.0039 *20*				
250.062[a] *7*	292.5872	0.034 *12*				
292.587 *2*	292.5872	0.016 *6*				
451.213 *23*	990.495	0.010 *4*				
x466.7§ *2*		0.0040§ *10*				

Continued on next page (footnotes at end of table)

^{238}U(n,γ) E=thermal 1978Bo12,1972Bo46,1984Ch05 (continued)

γ(^{239}U) (continued)

Eγ‡	E(level)	Iγ‡&	Mult.†	α	Comments
478.79 *8*	1194.63	0.012 *4*	(E1)		Mult.: E1,E2, but decay scheme requires E1.
x487.15§ *25*		0.028§ *8*	E1,E2		Mult.: from α(K)exp=0.022 *7* (1978Bo12).
496.753 *11*	539.283	0.034 *8*	E1#	0.01367	
521.849 *7*	715.835	0.073 *3*	M1(+E2)		Mult.: from α(K)exp=0.17 *5*; ce(K):ce(L1)=0.86 *9*:0.16 *2* (1978Bo12).
535.45 *5*	1223.31	0.028 *6*	E1,E2#		
537.26 *3*	1360.97	0.0079 *20*			
539.278 *11*	539.283	0.099 *20*	E1	0.01163	Mult.: from α(K)exp=0.006 *2* (1978Bo12).
542.085 *12*	687.854	0.024 *6*			
x542.338§ *11*		0.036§ *8*	M1(+E2)	0.12 *8*	Mult.: from α(L1)exp=0.027 *8* (1978Bo12).
552.069 *5*	746.054	0.207 *5*	E1	0.01111	Mult.: from α(K)exp=0.009 *3* (1978Bo12).
554.054 *8*	687.854	0.085 *20*	M1	0.189	Mult.: from α(K)exp=0.16 *4*; ce(K):ce(L1):ce(L2)=0.69 *7*: 0.14 *2*:0.040 *16* (1978Bo12).
554.10 *8*	1241.96	0.028 *6*	E1#	0.01103	
x558.50§ *15*		0.012§ *4*	M1+E2	0.11 *8*	Mult.: from α(K)exp=0.07 *4* (1978Bo12).
562.027 *22*	784.273	0.032 *10*	[E1]	0.01073	
563.17 *3*	757.151	0.014 *4*	M1+E2		Mult.: from α(K)exp=0.12 *7* (1978Bo12).
580.340 *13*	726.108	0.043 *10*	M1+E2		Mult.: from α(K)exp=0.10 *3* (1978Bo12).
582.034 *8*	715.835	0.016 *4*	M1(+E2)		Mult.: from α(K)exp=0.13 *4* (1978Bo12).
x586.90§ *11*		0.007§ *2*	M1	0.1618	Mult.: from α(K)exp=0.19 *6* (1978Bo12).
588.88 *3*	734.65	0.024 *6*			
590.39 *3*	1306.22	0.034 *12*	E1		Mult.: from α(K)exp=0.003 *3* (1978Bo12).
592.309 *13*	726.108	0.045 *12*	M1+E2		Mult.: from α(K)exp=0.095 *3* (1978Bo12).
593.612 *5*	739.380	0.108 *24*	E1#		
x600.28 *1*		0.030 *8*	E1,E2#		
600.284 *10*	746.054	0.030 *8*	E1		Mult.: from α(K)exp=0.013 *4* (1978Bo12).
605.581 *9*	739.380	0.053 *12*	E1#		
611.38 *3*	757.151	0.014 *4*			
612.253 *5*	746.054	0.23 *5*	[E1]		
x620.97[a]		@			ce(K)=0.05 *3*.
629.722 *9*	823.708	0.073 *20*	E1		Mult.: from α(K)exp=0.009 *5* (1978Bo12).
638.505 *12*	784.273	0.041 *12*	E1#		
x660.54 *25*		0.10 *3*			
x662.21 *14*		0.6 *2*			
669.385 *13*	815.155	0.0039 *20*			
673.307 *12*	715.835	0.010 *4*			
681.355 *9*	815.155	0.012 *4*	E1,E2#		
687.853 *8*	687.854	0.028 *8*	(E2)#		
689.907 *11*	823.708	0.043 *10*	E1#		
715.832 *9*	715.835	0.022 *6*	E2,E1#		
x723.95 *5*		1.0 *3*			
x726.23 *8*		1.7 *4*			
x735.8 *3*		0.2 *1*			
x751.67 *25*		0.4 *1*			
x754.20 *25*		0.3 *1*			
x757.11 *25*		0.50 *13*	M1(+E2)		Mult.: from α(K)exp=0.08 *4* (1978Bo12).
x758.92 *25*		0.3 *1*			
767.86 *21*	961.85	0.020 *6*	E1,E2#		
787.15 *7*	932.90	0.020 *6*	E1,E2#		
794.21 *8*	988.20	0.020 *6*	M1+E2		Mult.: from α(L1)exp=0.012 *4* (1978Bo12).
799.12 *7*	932.90	0.079 *20*			
819.868 *21*	965.637	0.010 *4*			
828.04 *21*	961.85	0.024 *6*	E1,E2#		
831.837 *19*	965.637	0.053 *12*	M1+E2		Mult.: from α(K)exp=0.024 *7* (1978Bo12).
842.42 *8*	988.20	0.024 *6*	M1+E2		Mult.: from α(K)exp=0.024 *8* (1978Bo12).
853.23 *4*	853.23	0.055 *12*	M1+E2		Mult.: from α(K)exp=0.026 *8* (1978Bo12).
x858.75 *25*		0.20 *5*			
x860.23 *25*		0.6 *2*	M1(+E2)		Mult.: from α(K)exp=0.050 *7* (1978Bo12).
x888.43 *9*		0.6 *2*			
893.30 *10*	893.30	0.016 *4*	M1+E2		Mult.: from α(K)exp=0.026 *13* (1978Bo12).
x921.68 *25*		0.10 *3*			
961.06 *4*	1155.052	0.0039 *20*			

Continued on next page (footnotes at end of table)

^{238}U(n,γ) E=thermal 1978Bo12,1972Bo46,1984Ch05 (continued)

γ(^{239}U) (continued)

Eγ‡	E(level)	Iγ‡&	Mult.†	α	Comments
972.83 *25*	1167.02				Eγ: From 1978Bo12.
x983.42 *7*		1.3 *3*			
990.49 *3*	990.495	0.010 *4*	M1+E2		Mult.: from α(K)exp=0.012 *10* (1978Bo12).
1007.03[b] *6*	1152.80	0.0079[b] *20*	E0+M1+E2		Mult.: from α(K)exp=0.19 *6* (1978Bo12).
	1201.02	0.0079[b] *20*	E0+M1+E2		Mult.: from α(K)exp=0.19 *6* (1978Bo12).
1021.25[b] *4*	1155.052	0.0079[b] *20*	E0+M1		Mult.: from α(K)exp=0.27 *8* (1978Bo12).
	1167.02	0.0079[b] *20*	E0+M1+E2		Mult.: from α(K)exp=0.27 *8* (1978Bo12).
1029.32 *5*	1223.31	0.037 *8*	E1,E2[#]		
1048.85 *8*	1194.63	0.012 *4*			
x1053.77 *25*		0.5 *2*			
1060.82 *8*	1194.63	0.016 *4*			
x1061.50 *25*		0.3 *1*	E0+M1+E2		Mult.: from α(K)exp=1.0 *5* (1978Bo12).
1062.48 *6*	1062.48	0.0079 *20*	E0+M1+E2		Mult.: from α(K)exp=0.24 *8* (1978Bo12).
1066.82 *12*	1066.81	0.030 *6*	M1+E2		Mult.: from α(K)exp=0.015 *5* (1978Bo12). Mult.: from av res (n,γ) the 1066.8 level is 1/2− or 3/2− in contradiction to the mult assignment of 1978Bo12.
x1069.41[a] *25*		0.20 *5*	E0+M1+E2		Mult.: from α(K)exp=0.22 *8* (1978Bo12).
1089.50 *5*	1223.31	0.014 *4*	M1	0.0313	Mult.: from α(K)exp=0.03 *1* (1978Bo12).
1110.27 *6*	1152.80	0.010 *4*			
x1139.22 *25*		0.30 *8*	M1	0.0278	Mult.: from α(K)exp=0.05 *3* (1978Bo12).
1149.8 *3*	1149.7	0.010 *4*			
1152.80 *6*	1152.80	0.010 *4*			
1155.05 *4*	1155.052	0.010 *4*			
x1158.13 *25*		0.30 *8*			
1167.01 *4*	1167.02	0.020 *6*			
x1172.03 *25*		0.40 *25*			
x1174.45 *25*		0.20 *5*			
x1189.94 *25*		0.40 *10*			
x1192.74 *25*		0.6 *2*			
x1196.50 *25*		0.8 *2*			
2998.5 *5*	4806.454	0.012 *4*			
3089.4 *5*	4806.454	0.0071 *24*			
3114.2 *5*	4806.454	0.007 *3*			
3121.7 *5*	4806.454	0.008 *3*			
3175.2 *5*	4806.454	0.0067 *22*			
3191.7 *5*	4806.454	0.0047 *16*			
3197.2 *5*	4806.454	0.016 *6*			
3220.1 *5*	4806.454	0.012 *4*			
3233.2 *5*	4806.454	0.010 *3*			
3286.1 *2*	4806.454	0.0040 *3*			
3293.5[§] *15*	4806.454	0.00028[§] *10*			
3296.5[§] *3*	4806.454	0.354[§] *18*			
3301.9[§] *3*	4806.454	0.0015[§] *1*			
3311.5[§] *6*	4806.454	0.0037[§] *10*			
3312.8 *5*	4806.454	0.0040 *10*			
3324.9[§] *2*	4806.454	0.00252[§] *14*			
3326.9[§] *5*	4806.454	0.00024[§] *8*			
3343.9[§] *3*	4806.454	0.00042[§] *6*			
3360.6[§] *2*	4806.454	0.00156[§] *12*			
3369.6[§] *2*	4806.454	0.00092[§] *10*			
3389.5[§] *6*	4806.454	0.00014[§] *6*			
3401.9[§] *2*	4806.454	0.0025[§] *2*			
3406.9[§] *8*	4806.454	<0.00008[§]			
3422.9[§] *4*	4806.454	0.00022[§] *8*			
3438.4[§] *2*	4806.454	0.00234[§] *12*			
3445.44 *6*	4806.454	0.0045 *3*			
3481.8[§] *3*	4806.454	0.00084[§] *10*			
3485.9[§] *7*	4806.454	0.00084[§] *18*			
3488.2[§] *3*	4806.454	0.00278[§] *14*			
3500.8[§] *3*	4806.454	0.00086[§] *8*			
3529.6[§] *2*	4806.454	0.00166[§] *10*			
3535.8[§] *5*	4806.454	0.00066[§] *14*			

Continued on next page (footnotes at end of table)

^{238}U(n,γ) E=thermal 1978Bo12,1972Bo46,1984Ch05 (continued)

γ(^{239}U) (continued)

Eγ‡	E(level)	Iγ‡&	Mult.†	Comments
3541.1§ *8*	4806.454	0.00054§ *14*		
3546.1§ *3*	4806.454	0.00094§ *18*		
3563.0 *5*	4806.454			
3564.45 *9*	4806.454	0.0042 *4*		
3568.7§ *7*	4806.454	0.00042§ *12*		
3571.2§ *5*	4806.454	0.00116§ *24*		
3574.4§ *7*	4806.454	0.00070§ *16*		
3583.10 *7*	4806.454	0.00053 *4*		
3611.78 *9*	4806.454	0.0146 *10*		
3639.39 *6*	4806.454	0.01228		
3651.36 *6*	4806.454	0.00695		
3653.9§ *8*	4806.454	0.00198§ *30*		
3656.9§ *5*	4806.454	0.00014§ *6*		
3739.8 *6*	4806.454	0.00383		
3744.0§ *2*	4806.454	0.00014§ *6*		
3800.7§ *5*	4806.454	0.00018§ *6*		
3815.9§ *5*	4806.454	0.00168§ *10*		
3817.9§ *5*	4806.454	0.00128§ *8*		
3840.8§ *4*	4806.454	0.00202§ *10*		
3844.56 *21*	4806.454	0.0068 *5*		
3873.9§ *2*	4806.454	0.00268§ *12*		
3913.1§ *20*	4806.454	≈0.00008§		
3918.2§[a] *10*	4806.454	0.00020§ *8*		
3953.4§ *3*	4806.454	0.00052§ *8*		
3982.69 *5*	4806.454	0.0259 *14*		
3991.25 *5*	4806.454	0.0241 *12*		
4005.7[a]	4806.454		(E2)	Detected in 1971Wa12. Iγ(≈4006)<3×10^{-3} (1978Bo12).
4049.7§ *5*	4806.454	0.00030§ *6*		
4060.35 *5*	4806.454	0.186 *3*		
4067.2 *2*	4806.454	0.0073 *4*		
4071.7§ *7*	4806.454	0.00014§ *4*		
4080.4§ *2*	4806.454	0.00124§ *12*		
4090.7§ *2*	4806.454	0.00148§ *14*		
4118.7§ *2*	4806.454	0.00150§ *14*		
4612.5§ *2*	4806.454	0.00313§ *28*		
4660.7§ *2*	4806.454	0.00342§ *30*		
4672.6§ *2*	4806.454	0.00118§ *12*		
4806.4§ *15*	4806.454	≤0.00014§		

† From conversion electron coefficients or sub–shell ratios. The scale of electron intensities was normalized to that of γ rays using the 133–keV E2 γ ray for Eγ<200 keV, and using the 539–, 552–, and 629–keV E1 γ rays for Eγ>480 keV. Authors estimated 20% to 30% uncertainties in Iγ (1978Bo12). Evaluator has used 25% for deducing uncertainties in experimental conversion coefficients.

‡ From 2007ChZX, unless otherwise specified. Iγ=σ_γ(Eγ) measured at 2200 m/s.

§ From 1972Bo46. Iγ are on the same scale as values given in 2007ChZX for primary γ rays.

Deduced from upper limit of conversion electron intensity (1978Bo12).

@ Only conversion electrons were detected. Given intensity is per 100 captured neutrons.

& For intensity per 100 neutron captures, multiply by 37.31 *27*.

a Placement of transition in the level scheme is uncertain.

b Multiply placed; undivided intensity given.

x γ ray not placed in level scheme.

^{238}U(n,γ) E=res: Av 1984Ch05,1972Bo46

1984Ch05: Target: 99.999% depleted ^{238}U. Neutron beams of 2 keV, FWHM=0.85 keV; and of 24 keV, FWHM=1.9 keV. Measured Eγ, Iγ for primary γ rays. Detector: three–crystal pair spectrometer.

Other measurements: 1971Ar47, 1971Wa12, 1972Bo46, 1991Ma40, 1991Oi01, 1991Sz05, 1992Ja05, 1992Po13, 1992Qu01. 1992Vo13, 1992Zh12, 1993Ro25, 1997Gu17, 1997Li11.

1972Bo46: Target: >99.999% depleted ^{238}U. Measured Eγ, Iγ (per 100 captured neutrons) of primary γ rays. Detector: Annihilation–pair Ge(Li) spectrometer.

^{239}U Levels

E(level)‡	Jπ†	Comments
0.0	5/2+	
133.9	1/2+,3/2+	
145.6	1/2+,3/2+	
193.6	5/2+	
538.6	5/2−	
687.6	1/2+,3/2+	
694.7	5/2	
715.9	1/2+,3/2+,5/2+	
726.5	1/2+,3/2+	
735.7	1/2+,3/2+,5/2+	
739.1	1/2−,3/2−	
745.8	1/2−,3/2−	
756.7	5/2+	
784.0	5/2−	
815.3	1/2−,3/2−	
823.7	1/2−,3/2−	
852.8	1/2+,3/2+	
858.8	5/2−	
887.4	5/2+	
892.3	5/2	
932.5	1/2−,3/2−	
961.9	1/2−,3/2−	
965.4	1/2,3/2	
982.9	5/2−	
988.1		
990.5		
1005.7	1/2+,3/2+,5/2+	
1018.6	5/2−	
1061.8	5/2	
1066.9	1/2−,3/2−	
1146.9	5/2	
1150.4		
1152.7		
1155.2	1/2+,3/2+	
1167.1	1/2+,3/2+	
1195.5	1/2−,3/2−	
1202.0	5/2	
1206.0	5/2	
1223.1	1/2−,3/2−	
1225.5	1/2−,3/2−	
1232.0		
1235.0		
1238.0	1/2+,3/2+	
1243.3	1/2−,3/2−	
1261.8	1/2,3/2	
1271.1	1/2,3/2	
1277.9	1/2,3/2	
1295.2	1/2,3/2,5/2	
1306.1	1/2−,3/2−	
1318.0		
1320.5		
1324.6	1/2−,3/2−	
1338.3	1/2−,3/2−,5/2+	
1360.9	1/2−,3/2−	
S(n)+x		S(n)=4806.26 *21*; x=2 keV.
S(n)+y		S(n)=4806.26 *21*; y=24 keV.

Footnotes continued on next page

^{238}U(n,γ) E=res: Av 1984Ch05,1972Bo46 (continued)

^{239}U Levels (continued)

† Spins and parities of levels populated by primary γ rays from 2–keV resonances (with Jπ=1/2+ for s–wave neutrons) are 1/2+, 1/2–, 3/2+, and 3/2– based on the assumption that γ rays carry one unit of angular momentum (E1 or M1 multipolarities). Those of levels populated from 24–keV resonances (with Jπ=1/2– and 3/2– for p–wave neutrons) are 1/2+, 3/2+, or 5/2+. Since s–wave neutron capture is dominant, and primary E1 γ rays are more intense than M1, the 1/2– and 3/2– levels are more strongly populated than 1/2+ and 3/2+. Population to 5/2 levels come from E1 primary γ rays from only 3/2– resonances (p–wave neutrons), with a weak contribution from E2 primary γ rays from 1/2+ resonances (s–wave neutrons) and 1/2– resonances (p–wave neutrons). Thus, reduced primary γ ray intensities (Iγ/Eγ^3), which are distributed into three categories defined by the spins and parities (1/2–, 3/2–), (1/2+, 3/2+), and (5/2), have provided the arguments for spin and parity assignments.

‡ ΔE≤1 keV (1984Ch05).

γ(^{239}U)

Eγ†	E(level)	Iγ/Eγ^3‡	Comments
3483.7§	S(n)+x	2.72§ *25*	
3487.8	S(n)+x		
3490.3§	S(n)+x	2.74§ *24*	Iγ/Eγ^3: 3490.3γ + 3487.8γ.
3492.0#	S(n)+y	0.34# *8*	
3502.2§	S(n)+x	1.67§ *24*	
3505.7#	S(n)+y	0.72# *9*	
3509.8	S(n)+y		
3512.3#	S(n)+y	0.68# *9*	Iγ/Eγ^3: 3512.3γ + 3509.8γ.
3524.2	S(n)+y		Weak.
3535.1#	S(n)+y	0.23# *8*	
3552.4#	S(n)+y	0.48# *7*	
3559.2#	S(n)+y	0.51# *7*	
3565.0§	S(n)+x	2.56§ *25*	
3568.5#	S(n)+y	0.49# *7*	
3570.3§	S(n)+x	0.7§ *3*	
3573.3	S(n)+x		
3576.3§	S(n)+x	0.9§ *3*	Iγ/Eγ^3: 3573.3γ + 3576.3γ.
3582.8§	S(n)+x	1.3§ *9*	
3585.2§	S(n)+x	3.4§ *9*	
3587.0#	S(n)+y	0.90# *10*	
3592.3#	S(n)+y	0.87# *11*	
3595.3	S(n)+y		
3598.3#	S(n)+y	0.48# *12*	Iγ/Eγ^3: 3598.3γ + 3595.3γ.
3604.8	S(n)+y		
3607.2#	S(n)+y	1.12# *7*	Iγ/Eγ^3: 3607.2 + 3604.8γ.
3612.8§	S(n)+x	1.93§ *20*	
3624.3#	S(n)+y	0.17# *5*	
3628.3#	S(n)+y	0.17# *5*	
3634.8#	S(n)+y	0.77# *6*	
3641.2§	S(n)+x	0.70§ *16*	
3653.1§	S(n)+x	1.07§ *23*	
3655.6	S(n)+x		
3657.9§	S(n)+x	1.14§ *23*	Iγ/Eγ^3: 3655.6γ + 3657.9γ.
3663.2#	S(n)+y	0.28# *6*	
3675.1#	S(n)+y	0.54# *25*	
3677.6	S(n)+y		
3679.9#	S(n)+y	0.76# *23*	Iγ/Eγ^3: 3679.9γ + 3677.6γ.
3683.4#	S(n)+y	0.19# *8*	
3741.4§	S(n)+x	1.05§ *15*	
3763.4#	S(n)+y	0.28# *6*	
3768.5#	S(n)+y	0.23# *6*	
3802.6§	S(n)+x	0.41§ *12*	
3811.7#	S(n)+y	0.15# *5*	
3817.8	S(n)+x		
3820.2§	S(n)+x	1.21§ *15*	Iγ/Eγ^3: 3817.8γ + 3820.2γ.
3839.8	S(n)+y		
3842.2#	S(n)+y	0.64# *5*	Iγ/Eγ^3: 3842.2γ + 3839.8γ.
3842.9§	S(n)+x	0.88§ *22*	
3846.4§	S(n)+x	1.67§ *24*	
3847.4#	S(n)+y	0.15# *5*	

Continued on next page (footnotes at end of table)

^{238}U(n,γ) E=res: Av 1984Ch05,1972Bo46 (continued)

γ(^{239}U) (continued)

Eγ†	E(level)	Iγ/Eγ³‡	Comments
3864.9#	S(n)+y	0.42# *9*	
3868.4#	S(n)+y	0.62# *9*	
3875.8§	S(n)+x	1.64§ *14*	
3897.8#	S(n)+y	0.47# *4*	
3938.0#	S(n)+y	0.16# *6*	
3942.9#	S(n)+y	0.29# *6*	
3955.5§	S(n)+x	0.83§ *11*	
3971.5#	S(n)+y	0.10# *5*	
3977.5#	S(n)+y	0.58# *11*	
3984.6§	S(n)+x	2.38§ *18*	
3993.0§	S(n)+x	1.95§ *14*	
4006.6#	S(n)+y	0.56# *4*	
4015.0#	S(n)+y	0.50# *4*	
4046.3#	S(n)+y	0.08# *3*	
4062.5§	S(n)+x	2.32§ *15*	
4069.2§	S(n)+x	1.72§ *25*	
4072.6§	S(n)+x	0.50§ *21*	
4073.6#	S(n)+y	0.29# *3*	
4081.8§	S(n)+x	0.71§ *13*	
4084.5#	S(n)+y	0.61# *4*	
4091.2	S(n)+y		
4092.4§	S(n)+x	0.54§ *11*	
4094.6#	S(n)+y	0.71# *4*	Iγ/Eγ³: 4094.6γ + 4091.2γ.
4103.8#	S(n)+y	0.55# *3*	
4114.4#	S(n)+y	0.42# *4*	
4120.7§	S(n)+x	0.62§ *10*	
4135.6#	S(n)+y	0.21# *3*	
4142.7#	S(n)+y	0.55# *4*	
4291.7#	S(n)+y	0.15# *4*	
4614.7§	S(n)+x	0.39§ *5*	
4636.7#	S(n)+y	0.49# *3*	
4662.4§	S(n)+x	1.02§ *7*	
4674.4§	S(n)+x	1.00§ *7*	
4684.7#	S(n)+y	0.96# *3*	
4696.4#	S(n)+y	1.00# *2*	
4808.3§	S(n)+x	0.64§ *6*	
4830.3#	S(n)+y	0.52# *2*	

† Nominal values deduced by evaluator from S(n)+x, S(n)+y, and level energies of 1984Ch05.
‡ Reduced average γ–ray intensity (1984Ch05).
§ From 2–keV neutrons.
# From 24–keV neutrons.

^{238}U(n,γ) E=res 2008ObZZ,1998Ob01,1995Ob01

1998Ob01,1995Ob01 – s–wave neutron resonance energies: 708.3–, 721.6–, 730.1–, 765.1 eV.
Target: 99.999% depleted ^{238}U. Measured neutrons with a time–of–flight spectrometer. Measured Eγ, Iγ for individual resonances using a coaxial high–purity Ge detector. γ rays populate and de–excite levels in the second potential well of the shape–isomeric ground state. This shape isomer may eventually undergo spontaneous fission or decay by γ rays to levels in the first potential well.
2008ObZZ – Target: depleted ^{238}U. Measured neutrons and γ–ray energies and intensities depopulating the superdeformed ground state in the first potential well.
Others: 1994Ob01, 1991Ad08.
For ^{238}U(n,γ) Fission see: 2001Vl04, 1998Mi22, 1996Eg02, 1994Mu20, 1993ObZZ, 1993Ku03, 1992LaZP.

^{238}U(n,γ) E=res 2008ObZZ,1998Ob01,1995Ob01 (continued)

^{239}U Levels

E(level)[†‡]	Jπ	$T_{1/2}$	Comments
0.0	5/2+		
98.6	9/2+		
990.5	3/2+,5/2+		
0.0+x[§]	(5/2+)	>0.25 μs	$T_{1/2}$: from delayed γγ coin (1994Ob01).
174.0+x			
477.8+x	(3/2−)		
1083.4+x	(1/2+,5/2+)		
1626.9+x	(1/2−,3/2−)		
1630.6+x	(3/2−)		
1767.5+x	(1/2−,3/2−)		
1776.5+x?			
1808.2+x?			
3107.0+x	(1/2+)		

† From 1998Ob01.
‡ x=1699 keV, from (n,γ) E=res experiment (2008ObZZ). x≈1700 keV, proposed by 1998Ob01 on the basis of neutron resonance spacings.
§ From 2008ObZZ.

γ(^{239}U)

Eγ[†]	E(level)	E(n)(eV)=708.3[†]	E(n)(eV)=721.6[†]	E(n)(eV)=730.1[†]	E(n)(eV)=765.1[†]	Comments
98.6	98.6					
[x]472.8 *11*		0.37 *3*	0.19 *2*	0.27 *3*	0.18 *2*	
477.8 *4*	477.8+x	0.20 *2*	0.42 *2*	0.20 *2*	0.17 *1*	Multipolarity: (E1).
549.8 *11*	1630.6+x	0.07 *2*	0.58 *7*	0.31 *4*	0.04 *1*	
[x]597.9 *5*		0.37 *3*	0.19 *2*	0.26 *2*	0.18 *2*	
605.6 *5*	1083.4+x	0.19 *6*	0.41 *2*	0.31 *12*	0.10 *4*	Multipolarity: (E1).
[x]632.5 *5*		0.03 *1*	0.51 *4*	0.22 *3*	0.24 *3*	
708.0[‡]	0.0+x					
990.5	990.5					
1298.8[§#] *10*	1776.5+x?	0.08[§] *2*	0.41 *6*	0.28 *4*	0.23 *4*	
	3107.0+x	0.08[§] *2*	0.41 *6*	0.28 *4*	0.23 *4*	
1339.5[#] *10*	3107.0+x	0.07 *1*	0.67 *6*	0.24 *3*	0.02 *1*	Multipolarity: (E1).
[x]1343.8 *10*		0.25 *4*	0.46 *5*	0.28 *4*		
1476.4 *11*	3107.0+x	0.08 *1*	0.56 *4*	0.26 *2*	0.10 *1*	Multipolarity: (E1).
1480.1[#] *11*	3107.0+x	0.15 *2*	0.67 *6*	0.17 *2*	0.01 *1*	Multipolarity: (E1).
1600.3[‡]	0.0+x					
2933.0 *21*	3107.0+x	0.46 *9*	0.30 *7*	0.24 *6*		
3107.0 *23*	3107.0+x		0.52 *12*	0.47 *11*	0.01 *1*	Multipolarity: (E2).

† Iγ from 1998Ob01, 1995Ob01.
‡ From 2008ObZZ.
§ Multiply placed; undivided intensity given.
# Placement of transition in the level scheme is uncertain.
x γ ray not placed in level scheme.

^{238}U(d,p) 1978Er03

E(d)=12 MeV, magnetic spectrometer, angular distribution. Other measurements: 1964Ma24, 1966Sh16, 1972Er03. Levels reported by 1966Sh16 and not observed by 1978Er03 are probably from impurities.

^{239}U Levels

E(level)	Jπ[†]	L	S[‡]
0.0	5/2+		0.0067 *12*
43 *2*	7/2+		
98.1 *15*	9/2+	4	0.075 *6*

Continued on next page (footnotes at end of table)

^{238}U(d,p) 1978Er03 (continued)

^{239}U Levels (continued)

E(level)	Jπ†	$T_{1/2}$§	L	S‡	Comments
133.5 *15*	1/2+	0.78 μs *4*	(0)	0.017 *3*	
146.1 *15*	3/2+		(2)	0.050 *9*	
165? *5*	(7/2+)				E(level): from 1966Sh16.
226.3 *15*	9/2+				
301.8 *20*	11/2+				
307.8 *15*	9/2+			0.020 *4*	
372.7 *20*	11/2−				
498.6 *15*	15/2−				
689.0 *15*	1/2+				
702.5 *15*	9/2+				
717.3 *15*	3/2+				
≈738	5/2+				
738.3 *15*	1/2−				
748.0 *20*	3/2−				
759.0 *20*	5/2+				
781.4 *20*	5/2−				
795.9 *15*	7/2−				
814.5 *15*	1/2−				
823.9 *15*	3/2−				
838.3 *15*	11/2−				
854.1 *15*	3/2+				
874.0 *15*	9/2+				
887.6 *15*	5/2+				
897.9 *15*					
919.3? *20*					
936.9 *20*	1/2−				
944.8 *20*	7/2+				
963.6 *15*	3/2−				
978.4 *15*					
996.1 *15*	9/2+				
1066.5 *15*					
1115.0 *15*					
1151.1 *20*					
1197.3 *15*					
1232.6 *15*					
1240 *3*					
1260.1 *15*					
1273 *3*					
1337.7 *20*					
1364.7 *20*					
1430 *3*					
1473 *3*					
1515 *2*					
1524 *3*					

† From 1978Er03 based on signature pattern of cross sections.
‡ From 1972Er03.
§ E(d)=12 MeV, pulsed beam (1975Ya03).

Adopted Levels, Gammas

Q(β⁻)=722.5 *10*; S(n)=6215.2 *11*; S(p)=5285.5 *15*; Q(α)=4599 *14* 2012Wa38.
Calculations.
Single–particle levels: 2004Pa40.
Half–life: 2013Zd01, 2008Do12.
β^- decay: 2009So02.
Evaluation of ^{239}U β^- decay: 2008BeZV.
Nuclear reactions.
^{238}Np(n,γ) E=thermal. Calculated σ: 2012Pr13, 2011Ch57, 2004Ha11, 2010Pr07.
^{232}Th, U(n,F), U(n,γ), U(n,2n): Deduced reaction rates: 2011Ad18.
Cluster decay.
^{239}Np(^{30}Mg): 2012Sa31.
Alpha decay.
^{239}Np (α): Calculated $T_{1/2}$, Q(α): 2011Sa40.
^{243}Am(α): Theory: 2003De17.

^{239}Np Levels

Cross Reference (XREF) Flags

A ^{239}U β^- Decay
B ^{243}Am α Decay
C ^{238}U(^{3}He,d),(α,t)

E(level)[†]	Jπ[§]	XREF	$T_{1/2}$	Comments
0.0[&]	5/2+	ABC	2.356 d *3*	%α≈1×10^{-10} from α syst (1980Sc26). %β⁻=100. Jπ: atomic beam (1969Fu11), E1 from 5/2–. $T_{1/2}$: Weighted average (Limited Relative Statistical Weight Method) of 2.346 d *4* (1956Wi25), 2.366 d *3* (1959Co93), 2.340 d *20* (1959Co63), 2.354 d *8* (1966Qa01), 2.346 d *4* (1969Bi12), and 2.3565 d *4* (1990Ab06). (χ^2/ν=4.9, data are discrepant.).
31.1309[&] *12*	7/2+	ABC		
71.13[&] *3*	9/2+	ABC		
74.6640[a] *10*	5/2–	ABC	1.39 ns *3*	Jπ: Favored α decay (HF=1.14) from 5/2–5/2[523] in ^{243}Am. $T_{1/2}$: From ^{243}Am α decay. μ=+2.0 *3*. μ: From 2011StZZ, 1967Gu08 Integral perturbed angular correlation. Compare to +1.95 *15* for 5/2[523] in ^{237}Np and +3.14 *4* for 5/2[642] in ^{237}Np. In ^{243}Am the 5/2[523] g.s. has μ=+1.503 *14* (2011StZZ,1990Iz01).
117.715[‡a] *10*	7/2–	ABC	≤40 ps	$T_{1/2}$: from ^{243}Am α decay.
122.5[&] *10*	(11/2+)	ABC		
173.086[‡a] *18*	9/2–	ABC		
180.0[&] *12*	(13/2+)	C		
220.2[b] *12*	(1/2+)[#]	C		Jπ: Tentative assignment is based on the analogy with the same rotational band in ^{237}Np.
241.312[a] *24*	(11/2–)	ABC		
257.63?[b] *25*	(3/2+)[#]	A C		
260.81[c] *3*	(3/2–)[@]	A C		Jπ: assignment is based on the analogy with the same rotational band in ^{237}Np.
267?[‡] *3*		B		
270.9[c] *14*	(1/2–)[@]	C		
315.5[c] *11*	(7/2–)[@]	C		
317.4[‡a] *15*	(13/2–)	B		
325[‡c] *3*	(5/2–)[@]	BC		
347.33 *23*	(9/2+,7/2+)	ABC		Jπ: 9/2+ from (^{3}He,d). However, from α HF and analogy to ^{237}Np, this could be 7/2+ member of 1/2[400].
359.12[b] *20*	(9/2+)[#]	AB		
411[‡] *3*		B		
420.6 *22*		C		
427[‡] *3*		B		
438.79[b] *5*	(11/2+)[#]	ABC		
448.15[d] *3*	(3/2–)	A C		Jπ: Fingerprint of (^{3}He,d) cross–section.
452.76 *4*	(5/2+,7/2–)	A		Jπ: γ's to 9/2+ and (3/2–).
474.36? *6*		A		
482.6[d] *11*	(5/2–)	C		

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued)

^{239}Np Levels (continued)

E(level)[†]	Jπ[§]	XREF	Comments
517.98[d] *3*	(7/2−)	A C	
530.21? *8*		A	
547.0? *23*	(13/2+)	C	
563.87 *5*		A	
579.34[d] *7*	(9/2−)	A C	
600? *3*		C	
616? *3*		C	
637.2? *18*		C	
657?[d] *3*	(11/2−)	C	
662.261[g] *15*	(5/2−)	AB	Jπ: Low α hindrance factor (HF=7.13) from ^{243}Am a decay. γ rays to 5/2 and 7/2 levels.
695.10[g] *4*	(7/2−)	A C	
723.7 *22*		C	
741.6[g] *21*	(9/2−)	C	
778.6 *13*		C	
784.96? *5*		A	
819.209 *18*	(7/2−)	A	Jπ: γ to (3/2−) and (11/2−).
823.4 *17*		C	
844.072 *15*	(7/2−)	A	Jπ: γ rays to 5/2+, 9/2+, (11/2−); Possible bandhead of 7/2[633].
849.45 *4*		A	
863.43? *9*		A	
864.9[e] *12*	(9/2+)	C	Jπ: from (^{3}He,d).
890.6 *12*		C	
917.1 *11*		C	
951.5 *13*		C	
959.17 *3*		A	
964.08 *17*	(7/2−)	A	Jπ: γ to (5/2−), (11/2−).
966.53 *6*		A	
992.05[f] *3*	(7/2−)	A C	Jπ: Tentatively assigned (7/2−) in (^{3}He,d).
1019.9[e] *12*	(13/2+)	C	
1040.39 *4*	(5/2−,7/2−)	A	Jπ: 780γ to (3/2−), 867γ to 9/2−.
1049.45[f] *5*	(9/2−)	A C	
1077.2 *14*		C	
1096.98 *5*	(7/2+)	A	Jπ: γ to (11/2+), (5/2−), (5/2+).
1117.8[f] *13*	(11/2−)	C	
1141.1 *17*		C	
1155.3 *19*		C	
1182.5 *14*		C	
1197.14? *10*		A	

† From ^{239}U β$^-$ Decay, unless otherwise specified.
‡ From ^{243}Am α Decay.
§ Jπ and configuration assignments are based on rotational band structure and systematics of Nilsson orbitals in nearby odd–A nuclei. Individual arguments are given mostly for rotational bandheads.
# From (^{3}He,d), based on measured L values and a comparison between experimental and calculated spectroscopic factors for various Nilsson orbitals.
@ From (^{3}He,d), rotational band parameter analogy to ^{237}Np.
& (A): 5/2[642].
a (B): 5/2[523].
b (C): 1/2[400]?
c (D): 1/2[530].
d (E): 3/2[521].
e (F): 7/2[633]?
f (G): 7/2[514].
g (H): 5/2[523]×0+.

γ(^{239}Np)

E(level)	Eγ[†]	Iγ[†]	Mult.	δ	α	Comments
31.1309	31.131 *2*	100	M1+E2	0.08 *2*	196 *20*	δ: from α decay; other: 0.17 *1* in β$^-$ decay.
71.13	(71.2)	100	[E2]		73.5	
74.6640	43.533 *1*	8.27 *15*	E1		1.16	B(E1)(W.u.)=8.7×10^{-5} *5*.

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued)

γ(^{239}Np) (continued)

E(level)	Eγ†	Iγ†	Mult.	δ	α	Comments
74.6640	74.664 *1*	100	E1		0.28	B(E1)(W.u.)=0.000208 *15*.
117.715	43.1§	11.5§	M1+E2	≈0.38	≈159	B(M1)(W.u.)>0.032; B(E2)(W.u.)>690.
	86.71§ *2*	59§ *7*	E1		0.19	B(E1)(W.u.)>0.00013.
	117.60§ *15*	100§ *14*	E1		0.086	B(E1)(W.u.)>0.00013.
173.086	50.6‡	≈2.6‡	[E1]		0.78	
	55.4‡	≈8.7‡	M1+E2	0.6 *2*	87 *25*	
	98.5‡	≈8.2‡	(E2)		15.9	
	141.89‡ *3*	100‡ *7*	E1		0.226	
241.312	169	100	[E1]		0.15	
260.81	142.93	7.1				
	186.15 *4*	100 *10*				
	260.86 *9*	11 *1*				
317.4	195‡	100‡	[E1]			
438.79	197.28 *12*	75 *13*				
	407.70 *5*	100				
448.15	187.28 *8*	23 *3*				
	330.14 *14*	2.8 *6*				
	373.51 *4*	100 *7*				
	448.19 *6*	37 *3*				
452.76	191.97 *6*	25				
	378.06 *6*	100 *9*				
	381.27 *16*	6.4 *18*				
474.36?	399.13 *13*	89 *16*				
	474.5 *1*	100 *13*				
517.98	486.87 *3*	100 *7*				
	518.01 *9*	7.3 *7*				
530.21?	455.26 *18*	40 *16*				
	499.1 *1*	100 *13*				
	530.5 *2*	53				
563.87	111.0 *2*	100				
	492.76 *7*	26 *2*				
	532.86 *10*	12 *2*				
	564.09 *20*	2 *1*				
579.34	504.76 *8*	100 *8*				
	547.99 *16*	38 *8*				
662.261	544.48 *9*	2.1 *2*				
	587.63 *5*	11.4 *5*				
	631.10 *3*	40 *2*				
	662.26 *2*	100 *6*				
695.10	220.52 *4*	100 *10*				
	522.12 *10*	8.5 *10*				
	577.15# *14*	≤4.8#				
	624.11 *7*	22 *1*				
	664.17 *9*	19 *2*				
	695.18 *8*	13 *1*				
819.209	240.00 *15*	0.67 *18*				
	255.71 *12*	0.9 *2*				
	558.46 *17*	0.46 *18*				
	577.15# *14*	≤1.1#				
	646.26 *10*	2.2 *2*				
	748.09 *3*	69 *4*				
	788.19 *7*	3.8 *3*				
	819.19 *2*	100 *5*				
844.072	326.21 *7*	3.2 *3*				
	602.79 *2*	3.5 *2*				
	769.52 *17*	0.3 *1*				
	772.95 *5*	2.1 *2*				
	812.93 *4*	50 *3*				
	844.10 *4*	100 *5*				
849.45	490.33 *13*	4.5 *9*				
	502.12 *17*	3.9 *12*				
	588.70 *8*	36 *2*				
	591.82 *19*	6 *2*				

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued)

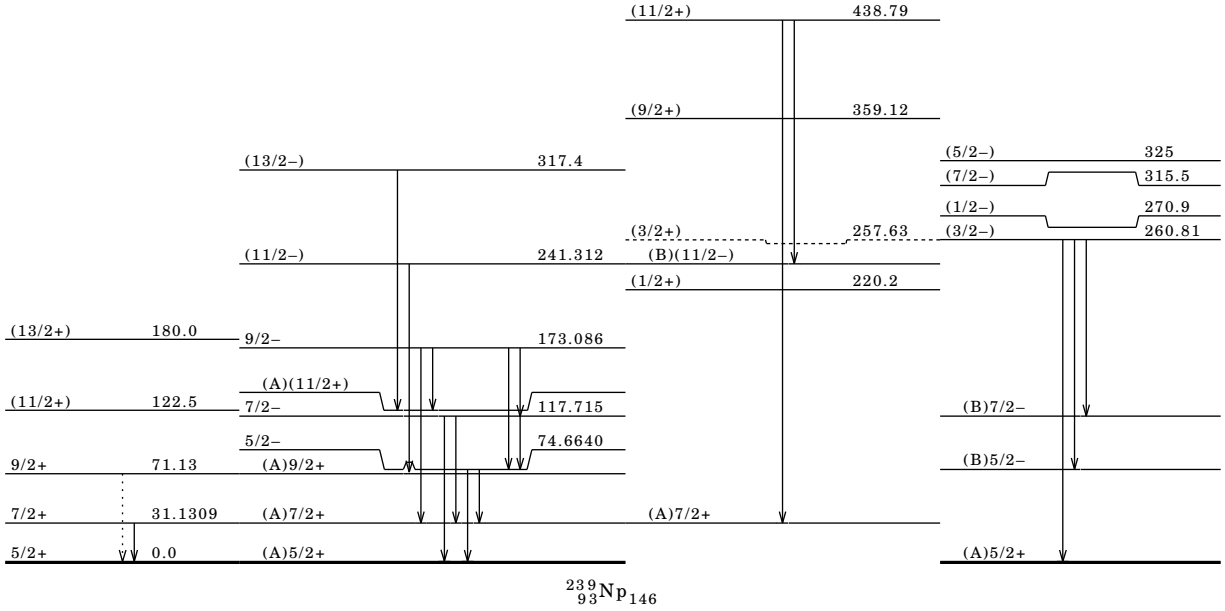
γ(^{239}Np) (continued)

E(level)	Eγ†	Iγ†
849.45	727.52 *10*	17 *2*
	774.77 *4*	100 *6*
	849.44§# *9*	13§# *1*
863.43?	201.09 *8*	12 *4*
	746.06 *11*	100 *13*
	862.56 *18*	10 *3*
959.17	174.07 *6*	100 *10*
	296.93 *8*	≤15
	395.19 *11*	21 *3*
	841.48 *12*	26 *4*
	884.45 *5*	89 *5*
	887.83 *10*	24 *3*
	928.00@ *6*	53 *3*
	959.48 *6*	80 *5*
964.08	301.64 *15*	1.2 *3*
	703.63 *10*	2.6 *3*
	722.85 *4*	30 *2*
	791.33 *6*	8.3 *5*
	846.39 *4*	35 *2*
	889.49 *4*	23 *1*
	933.09 *3*	29 *2*
	964.30 *5*	100 *5*
966.53	304.17 *10*	57
	514.1 *3*	23
	793.55 *8*	100
	849.44# *9*	72# *8*
	895.15 *15*	30 *7*
992.05	296.93 *13*	≤14
992.05	874.22 *7*	32 *2*
	917.40 *8*	25 *2*
	920.95 *8*	25 *2*
	960.99 *5*	100 *5*
	992.00 *7*	27 *2*
1040.39	258.80 *16*	3.8 *10*
	345.13 *8*	20 *2*
	567.88 *18*	2 *1*
	587.63 *5*	100 *5*
	779.57 *14*	3 *1*
	867.11 *10*	4.0 *5*
	922.83 *13*	3.1 *6*
	965.58 *10*	10
	1009.38 *18*	1.50 *5*
	1040.19 *9*	5.8 *5*
1049.45	876.14 *7*	35
	931.97 *7*	100 *7*
	974.91 *14*	7.5 *15*
	1018.14 *13*	≤19
1096.98	312.05 *3*	100
	434.44 *13*	23 *4*
	644.12 *14*	38 *8*
	658.5 *4*	11
	1065.76 *12*	12 *2*
	1096.92 *8*	33 *3*
1197.14?	535.01 *14*	100
	1122.8 *3*	52
	1196.90 *15*	70

† From ^{239}U β^- Decay, unless otherwise specified.
‡ From ^{243}Am α Decay.
§ Eγ from ^{243}Am α Decay. Iγ, weighted average from ^{239}U β^- Decay and ^{243}Am α Decay.
# Multiply placed; undivided intensity given.
@ Placement of transition in the level scheme is uncertain.

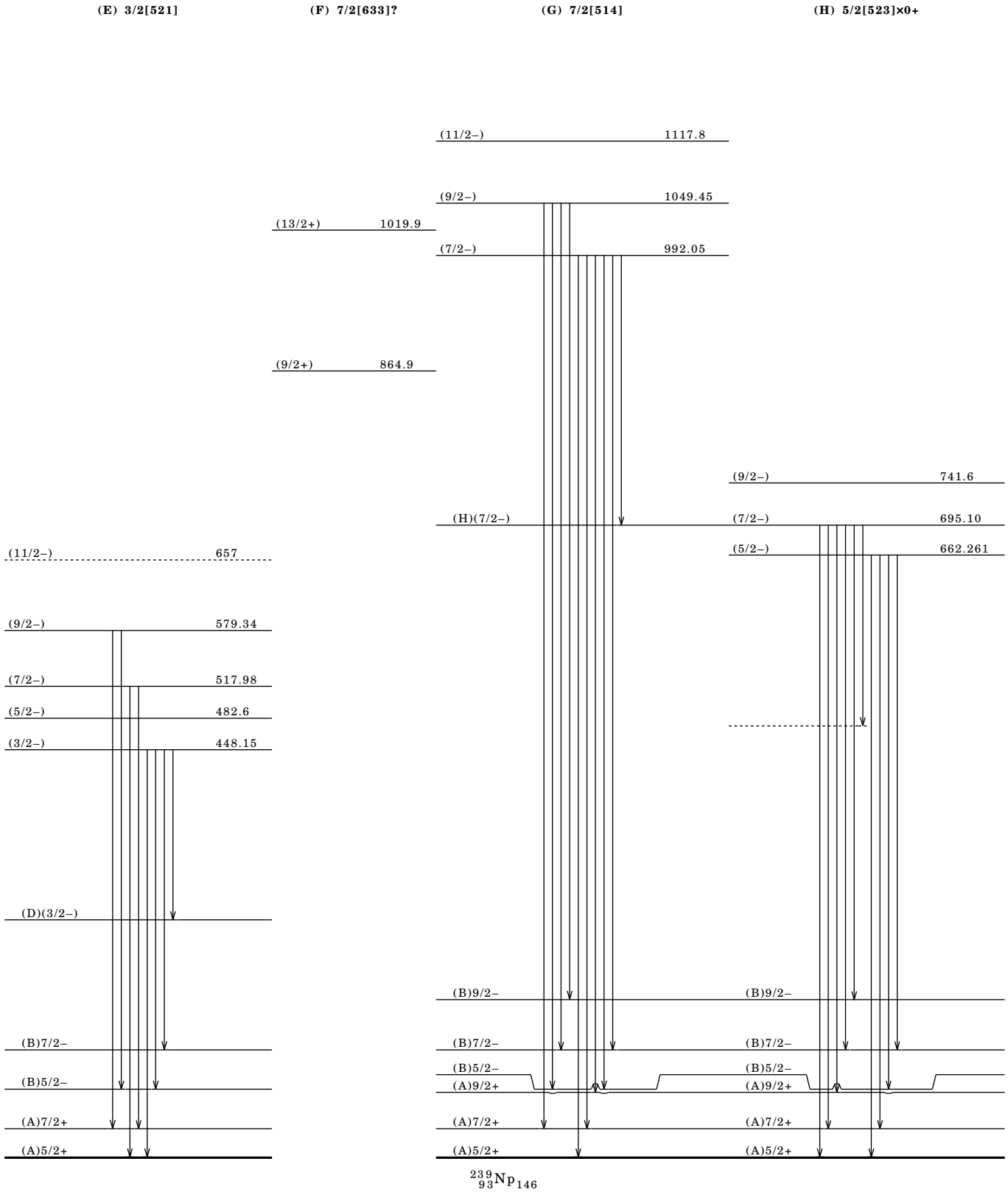
Adopted Levels, Gammas (continued)

(A) 5/2[642] **(B) 5/2[523]** **(C) 1/2[400]?** **(D) 1/2[530]**



$^{239}_{93}Np_{146}$

Adopted Levels, Gammas (continued)



$^{239}_{93}Np_{146}$

^{239}U β⁻ Decay 1969Cl12,1996Sa23,2006Wo03

Parent ^{239}U: E=0; Jπ=5/2+; $T_{1/2}$=23.45 min *2*; Q(g.s.)=1261.5 *16*; %β⁻ decay=100.
Includes 2008GrZS.
Other: 1986LoZT.

^{239}Np Levels

E(level)‡	Jπ†	E(level)‡	Jπ†	E(level)‡	Jπ†
0.0	5/2+	448.15 *3*	(3/2−)	849.45 *4*	(7/2−)
31.1309 *12*	7/2+	452.76 *4*	(5/2+,7/2−)	863.43? *9*	3/2,5/2,7/2
71.13 *3*	9/2+	474.43? *5*		959.17 *3*	
74.6640 *10*	5/2−	517.98? *3*	(7/2−)	964.208 *17*	(7/2−)
117.715 *20*	7/2−	530.21? *8*		966.53 *6*	(7/2,9/2−)
122.5? *10*	(11/2+)	563.87 *5*	(5/2+,7/2)	992.05 *3*	(7/2−)
173.086 *18*	9/2−	579.34? *7*	(9/2−)	1013.41? *6*	
241.312 *22*	(11/2−)	662.261 *15*	(5/2−)	1040.39 *4*	(5/2−,7/2−)
257.63 *25*		695.10 *4*	(7/2−)	1049.45? *5*	(9/2−)
260.81 *3*	(3/2−)	781.85? *7*		1096.98 *5*	(7/2+)
347.33 *23*		784.96? *5*		1197.14? *10*	
359.1 *2*		819.209 *18*	(7/2)		
438.79 *5*	(11/2+)	844.072? *15*	(5/2,7/2)		

† All Jπ are from adopted levels. Jπ assignments for Levels with E >200 keV are tentative and based on (^{3}He,d) in 1975Vo01.
‡ Deduced by evaluator from a least–squares fit to γ–ray energies.

β⁻ radiations

Eβ⁻†	E(level)	Iβ⁻‡#	Log *ft*	Comments
(64.4@ *16*)	1197.14?	0.0032 *1*	6.2	
(164.5 *16*)	1096.98	0.013 *1*	6.8	
(221.1 *16*)	1040.39	0.035 *2*	6.8	
(248.1@ *16*)	1013.41?	0.013 *1*	7.4	
(269.5 *16*)	992.05	0.027 *2*	7.2	
(297.3 *16*)	964.208	0.24 *1*	6.4	
(417.4 *16*)	844.072?	0.26 *1*	6.8	
(442.3 *16*)	819.209	0.27 *1*	6.9	
(566.4 *16*)	695.10	0.049 *4*	8.0	
(599.2 *16*)	662.261	0.30 *2*	7.3	
(1143.8 *16*)	117.715	1.96§ *24*	7.4	Iβ⁻: %Iβ=0.15 *3*, from γ–ray transition–intensity balance.
1211	74.6640	69.0§ *14*	5.9	Iβ⁻: %Iβ=77.0 *25*, from γ–ray transition–intensity balance. Other result: Iβ(1211)/Iβ(1285)=3.5 *7* (1964Bl11).
(1230.4 *16*)	31.1309	9.4§ *19*	6.9	Iβ⁻: %Iβ=8.5 *22*, from γ–ray transition–intensity balance.
1285	0.0	18.7§ *24*	6.6	Iβ⁻: %Iβ=13 *4*, from γ–ray transition–intensity balance.

† From 1964Bl11.
‡ From γ–ray transition intensity balances. β− branches with Iβ<0.5% are tentative because of unplaced γ rays.
§ Experimental value deduced by measuring absolute γ–ray intensities from ^{239}U β–decay and ^{239}Np β–decay in equilibrium (1996Sa23).
# Absolute intensity per 100 decays.
@ Existence of this branch is questionable.

γ(^{239}Np)

Iγ normalization: From weighted average of Iγ(74)=49.2% *12* (1996Sa02) and Iγ=53.9% *5* (2008GrZS).

Eγ†	E(level)	Iγ†@	Mult.#	δ	α	Comments
31.131‡ *2*	31.1309	13.0‡ *14*	M1+E2	0.18 *1*	263 *13*	δ: from α(exp)=274 *11*; Average of α(exp)=284 *45*, deduced by evaluator from a γ–ray transition intensity balance in ^{239}U β⁻ decay, and α(exp)=273 *11*, also deduced by evaluator from γ–ray transition intensity balance in ^{243}Am α decay. Iγ: from 0.064% *7* (1996Sa23); Other: 0.068% *10* (1986LoZT).

Continued on next page (footnotes at end of table)

^{239}U β⁻ Decay 1969Cl12,1996Sa23,2006Wo03 (continued)

γ(^{239}Np) (continued)

Eγ†	E(level)	Iγ†@	Mult.#	δ	α	Comments
(43.1)	117.715		M1+E2	0.38	154.4	δ: From α(M)exp=31 in ^{243}Am α decay. Eγ: From 2003Br12, 1971Ar47, 1969Cl12.
43.533 *1*	74.6640	827 *15*	E1		1.143	Eγ: From 1979Bo30. Iγ: from 4.07% *11* (1996Sa23); Other: 4.16% *11* (1986LoZT).
(48)	1096.98					
(50.6)	173.086					Eγ: From 2003Br12, 1971Ar47, 1969Cl12.
(55.18‡)	173.086	0.017‡	M1+E2	0.6 *2*	90 *30*	δ: from ^{243}Am α Decay.
(71.2)	71.13		[E2]		72.0	Eγ: From 2003Br12, 1971Ar47, 1969Cl12.
74.664 *1*	74.6640	10000	E1		0.276	Eγ: From 2003Br12, 1971Ar47, 1969Cl12. Iγ: from 49.2% *12* (1996Sa23); others: 48.1% *10* (1986LoZT); Iγ=48% *2* if Iγ(277.6γ)=14.1% *4* in ^{239}Np β⁻ decay (1976GlZY). Iγ=59.3% (1969Cl12).
86.72 *7*	117.715	10.8 *12*	E1		0.186	Eγ: From 2003Br12, 1971Ar47, 1969Cl12. Iγ: from 0.053% *6* (1996Sa23); Other: 0.052% *6* (1986LoZT).
111.0‡ *2*	563.87	4.1‡				
117.66 *3*	117.715	28 *4*	E1		0.0841	Eγ: From 2003Br12, 1971Ar47, 1969Cl12. Iγ: from 0.14% *3* (1996Sa23); Other: 0.13% *4* (1986LoZT).
ˣ134.71 *13*		0.41 *9*				
141.97 *2*	173.086	0.34	[E1]		0.224	
142.93	260.81	0.45	[E2]		3.03	
(169)	241.312					Eγ: From 2003Br12, 1971Ar47, 1969Cl12.
174.07 *6*	959.17	2.1 *2*				
186.15 *4*	260.81	6.3 *6*	[M1+E2]		2.6 *16*	
187.28 *8*	448.15	1.22 *14*	[M1+E2]		2.6 *16*	
191.97‡ *6*	452.76	0.56‡				
ˣ196.85‡ *10*		0.44‡				
197.28 *12*	438.79	0.53 *9*	[E1]		0.1038	
201.09 *18*	863.43?	0.11 *4*				
220.52 *4*	695.10	6.2 *6*				
231.70‡ *10*	1013.41?	0.62‡				
ˣ236.28 *14*		0.20 *4*				
240.00 *15*	819.209	0.19 *5*				
255.71 *12*	819.209	0.25 *5*				
258.80 *16*	1040.39	0.16 *4*				
260.86 *9*	260.81	0.67 *7*	[E1]		0.0549	
ˣ262.89 *19*		0.18 *7*				
ˣ265.44 *17*		0.20 *7*				
296.93& *13*	959.17	≤0.31&				
	992.05	≤0.31&	[M1+E2]		0.7 *5*	
301.64 *15*	964.208	0.24 *6*	[M1+E2]		0.6 *5*	
304.17‡ *10*	966.53	0.35‡				
312.05‡ *3*	1096.98	1.1‡				
ˣ321.71‡ *15*		0.24‡				
326.21 *7*	844.072?	0.95 *10*				
330.14 *14*	448.15	0.15 *3*	[E2]		0.1494	
332.06 *14*	784.96?	0.25 *6*				
ˣ343.74‡ *10*		0.39‡				
345.13 *8*	1040.39	0.85 *10*				
ˣ348.23 *18*		0.16 *6*				
351.33 *15*	1013.41?	0.16 *4*				
ˣ361.83 *8*		0.97 *9*				
ˣ363.1‡ *2*		0.17‡				
373.51 *4*	448.15	5.37 *40*	[M1+E2]		0.35 *25*	
378.06 *6*	452.76	2.2 *2*				
381.27 *16*	452.76	0.14 *4*				
ˣ393.01 *18*		0.14 *5*				
395.19 *11*	959.17	0.45 *6*				
399.13 *13*	474.43?	0.34 *6*				
ˣ400.55 *15*		0.20 *5*				

Continued on next page (footnotes at end of table)

^{239}U β$^-$ Decay 1969Cl12,1996Sa23,2006Wo03 (continued)

γ(^{239}Np) (continued)

Eγ†	E(level)	Iγ†@	Mult.#	α
x404.84 *18*		0.19 *7*		
407.70‡ *5*	438.79	0.71‡	[E2]	0.0830
434.44 *13*	1096.98	0.25 *4*	[E1]	0.0185
x445.81 *12*		0.24 *3*		
448.19 *6*	448.15	1.97 *15*	[E1]	0.01733
x452.17 *12*		0.34 *6*		
455.26 *18*	530.21?	0.18 *7*		
474.5 *1*	474.43?	0.38 *5*		
x478.13 *19*		0.12 *5*		
x479.55 *14*		0.22 *5*		
486.87 *3*	517.98?	13.5 *9*	[E1]	0.01469
490.33§ *13*	849.45	0.15§ *3*		
492.76 *7*	563.87	1.09 *9*		
499.1 *1*	530.21?	0.45 *6*		
502.12§ *17*	849.45	0.13§ *4*		
504.76 *8*	579.34?	1.14 *9*	[E2]	0.0488
x506.80 *14*		0.22 *5*		
514.1‡ *3*	966.53	0.14‡		
518.01 *9*	517.98?	0.98 *9*	[E1]	0.01301
522.12 *10*	695.10	0.53 *6*	[M1+E2]	0.14 *10*
530.5‡ *2*	530.21?	0.24‡		
532.86 *10*	563.87	0.50 *6*		
535.01‡ *14*	1197.14?	0.27‡		
x541.32 *10*		0.63 *7*		
544.48 *9*	662.261	0.79 *7*	[M1+E2]	0.13 *9*
547.99 *16*	579.34?	0.43 *9*	[E1]	0.01166
558.46 *17*	819.209	0.13 *5*		
560.63 *7*	1013.41?	1.27 *9*		
564.09 *20*	563.87	0.09 *4*		
567.88 *18*	1040.39	0.09 *3*		
x575.27 *5*		2.85 *15*		
577.15& *14*	695.10	≤0.3&	[M1+E2]	0.11 *8*
	819.209	≤0.3&		
x585.49 *14*		0.27 *5*		
587.63 *5*	662.261	4.2 *2*	[M1+E2]	0.11 *7*
	1040.39	4.2 *2*		
588.70§ *8*	849.45	1.19§ *8*		
591.82§ *19*	849.45	0.20§ *8*		
x599.13 *15*		0.16 *4*		
x602.68‡ *4*		0.98‡		
602.79 *2*	844.072?	1.05 *7*		
x604.85 *16*		0.21 *6*		
x607.96 *15*		0.29 *7*		
x614.53 *17*		0.14 *5*		
x618.03 *16*		0.16 *4*		
624.11 *7*	695.10	1.35 *8*	[E1]	
x629.00 *11*		0.58 *8*		
631.10 *3*	662.261	14.7 *7*	[E1]	
644.12 *14*	1096.98	0.42 *9*		
646.26 *10*	819.209	0.63 *6*		
x649.79 *19*		0.20 *8*		
658.5‡ *4*	1096.98	0.12‡	[E2]	0.0269
662.26 *2*	662.261	37 *2*	[E1]	
664.17 *9*	695.10	1.17 *10*	[E1]	
x668.76 *18*		0.12 *4*		
x670.88 *20*		0.13 *6*		
x691.01 *6*		1.61 *9*		
x692.61 *13*		0.36 *6*		
695.18 *8*	695.10	0.79 *6*	[E1]	
x700.93‡ *8*		0.42‡		
x701.21 *10*		0.52 *5*		
703.63 *10*	964.208	0.51 *6*	[E2]	0.0235
707.38 *9*	781.85?	0.48 *5*		

Continued on next page (footnotes at end of table)

^{239}U β⁻ Decay 1969Cl12,1996Sa23,2006Wo03 (continued)

γ(^{239}Np) (continued)

Eγ[†]	E(level)	Iγ[†@]	Mult.[#]	α
710.35[‡] *15*	784.96?	0.25[‡]		
[x]714.22 *9*		0.81		
722.85 *4*	964.208	5.89 *30*	[E2]	0.0222
[x]727.52 *10*		0.56 *6*		
727.52[§] *10*	849.45	0.56[§] *6*		
[x]730.92[‡] *4*		2.5[‡]		
[x]730.95 *6*		2.05 *11*		
746.06 *11*	863.43?	0.93 *12*		
748.09 *3*	819.209	19.4 *10*		
752.39 *14*	1013.41?	0.28 *6*		
[x]764.04 *11*		0.56 *7*		
[x]768.15 *11*		0.44 *5*		
769.52 *17*	844.072?	0.09 *3*		
772.94 *9*	844.072?	0.64 *6*		
774.77[§] *4*	849.45	3.3[§] *2*		
779.57 *14*	1040.39	0.14 *3*		
788.19 *7*	819.209	1.06 *7*		
[x]791.3[‡]		1.8[‡]		
791.33 *6*	964.208	1.63 *9*	[M1+E2]	0.05 *3*
793.55[‡] *8*	966.53	0.61[‡]		
[x]795.13 *15*		0.18 *4*		
812.89 *3*	844.072?	15.0 *8*		
819.19 *2*	819.209	28.1 *14*		
[x]829.59 *17*		0.10 *3*		
[x]831.86[‡] *4*		0.71[‡]		
[x]831.89 *9*		0.45 *5*		
[x]840.3[‡] *3*		0.93[‡]		
841.48 *12*	959.17	0.54 *8*		
844.05 *2*	844.072?	30.3 *15*		
846.39 *4*	964.208	6.8 *4*	[M1+E2]	0.04 *3*
849.44[§&] *9*	849.45	0.44[§&] *4*		
	966.53	0.44[&] *5*		
862.56 *18*	863.43?	0.09 *3*		
867.11 *10*	1040.39	0.165 *20*		
[x]869.57 *9*		0.35 *3*		
874.22 *7*	992.05	0.72 *5*	[M1+E2]	0.038 *23*
876.14[‡] *7*	1049.45?	0.41[‡]	[M1+E2]	0.038 *23*
884.45 *5*	959.17	1.87 *10*		
887.83 *10*	959.17	0.51 *5*		
889.49 *4*	964.208	4.56 *23*	[M1+E2]	0.036 *22*
895.15 *15*	966.53	0.18 *4*		
[x]913.68 *9*		0.41 *3*		
917.40 *8*	992.05	0.58 *4*	[M1+E2]	0.034 *20*
920.95 *8*	992.05	0.56 *4*	[E1]	
922.83 *13*	1040.39	0.132 *24*		
928.00[a] *6*	959.17	1.12 *6*		
931.97 *7*	1049.45?	1.16 *8*	[M1+E2]	0.032 *19*
933.09 *3*	964.208	5.7 *3*	[E1]	
938.59 *16*	1013.41?	0.067 *18*		
[x]948.88 *19*		0.05 *2*		
959.48 *6*	959.17	1.69 *10*		
960.99 *5*	992.05	2.28 *12*	[E1]	
964.30 *5*	964.208	19.7 *10*	[E1]	
965.58[‡] *10*	1040.39	0.44[‡]		
[x]970.07 *14*		0.20 *4*		
974.91 *14*	1049.45?	0.087 *17*	[E2]	0.01229
[x]988.51 *14*		0.097 *21*		
992.00 *7*	992.05	0.61 *4*	[E1]	
[x]1002.40 *13*		0.11 *2*		
[x]1005.27 *13*		0.14 *2*		
1009.38 *18*	1040.39	0.065 *2*		
1018.14[‡] *13*	1049.45?	≤0.22[‡]	[E1]	
1040.19 *9*	1040.39	0.245 *22*		

Continued on next page (footnotes at end of table)

^{239}U β⁻ Decay 1969Cl12,1996Sa23,2006Wo03 (continued)

γ(^{239}Np) (continued)

Eγ†	E(level)	Iγ†@	Mult.#	α
1065.76 *12*	1096.98	0.13 *2*	[M1+E2]	0.023 *13*
x1078.88‡ *15*		0.32‡		
1096.92 *8*	1096.98	0.36 *3*	[M1+E2]	0.022 *12*
x1101.99 *16*		0.067 *19*		
1122.8‡ *3*	1197.14?	0.14‡		
x1161.4‡ *2*		0.20‡		
1196.90‡ *15*	1197.14?	0.19‡		
x1204.9‡ *2*		0.32‡		

† From 2006Wo03, unless otherwise specified. Uncertainties in γ–ray intensities given in 2006Wo03 do not include the contribution from the detector efficiency. Evaluators have corrected the uncertainties given here as suggested in 2006Wo03 by combining them with fractional uncertainties as follows: 15% for Eγ<150 keV; 10% for 150 keV<Eγ<360 keV; 7% for 360 keV<Eγ<500 keV; 5% for Eγ>500 keV. Other: 1968Ma06.

‡ From 2003Br12, 1971Ar47, 1969Cl12.

§ From 2006Wo03.

From ce data of 1964Bl11, 1957Ho07, 1969En02 and from ^{243}Am α decay.

@ For absolute intensity per 100 decays, multiply by 0.00532 *17*.

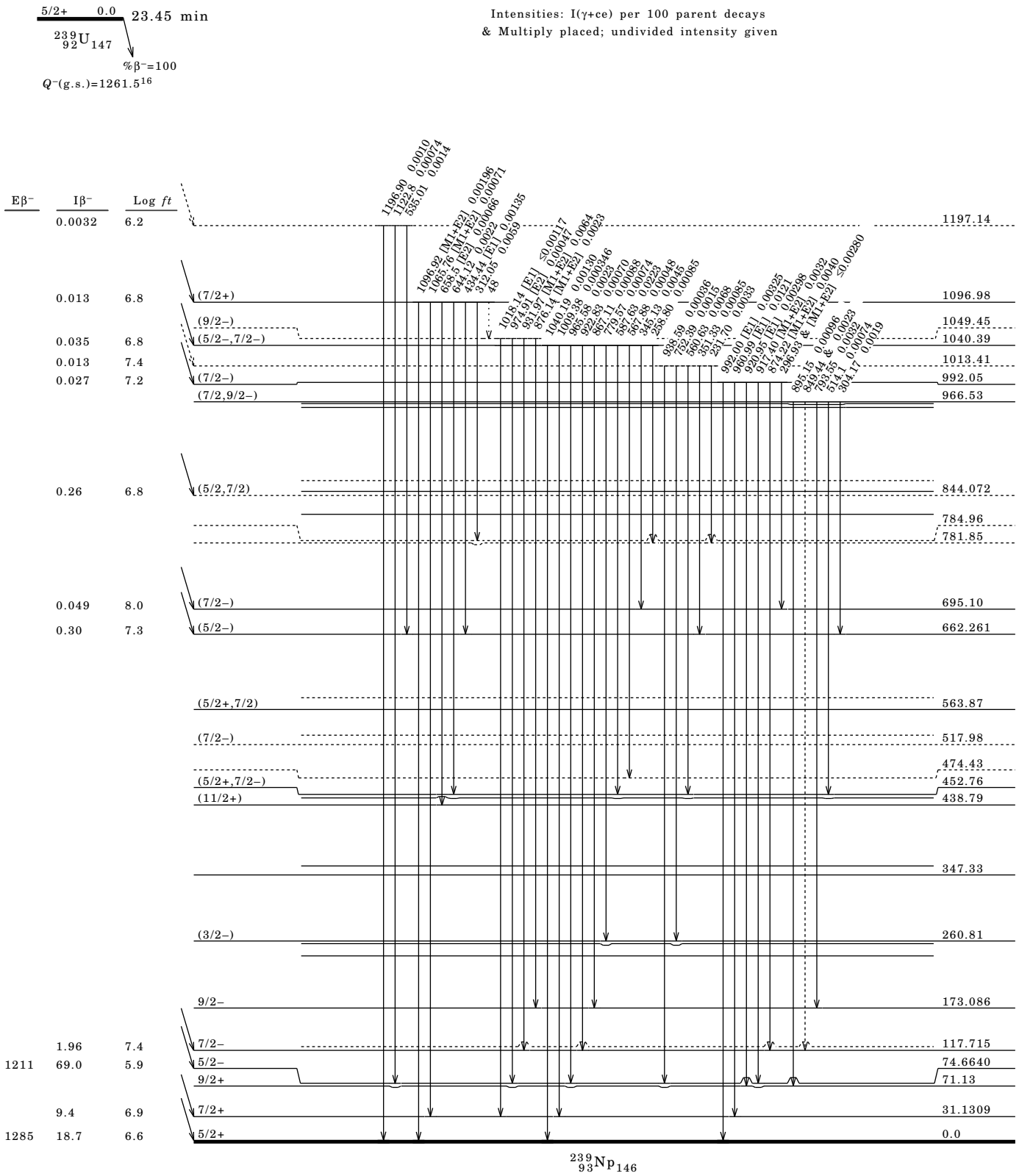
& Multiply placed; undivided intensity given.

a Placement of transition in the level scheme is uncertain.

x γ ray not placed in level scheme.

^{239}U β⁻ Decay 1969Cl12,1996Sa23,2006Wo03 (continued)

Decay Scheme



^{239}U β⁻ Decay 1969Cl12,1996Sa23,2006Wo03 (continued)

Decay Scheme (continued)

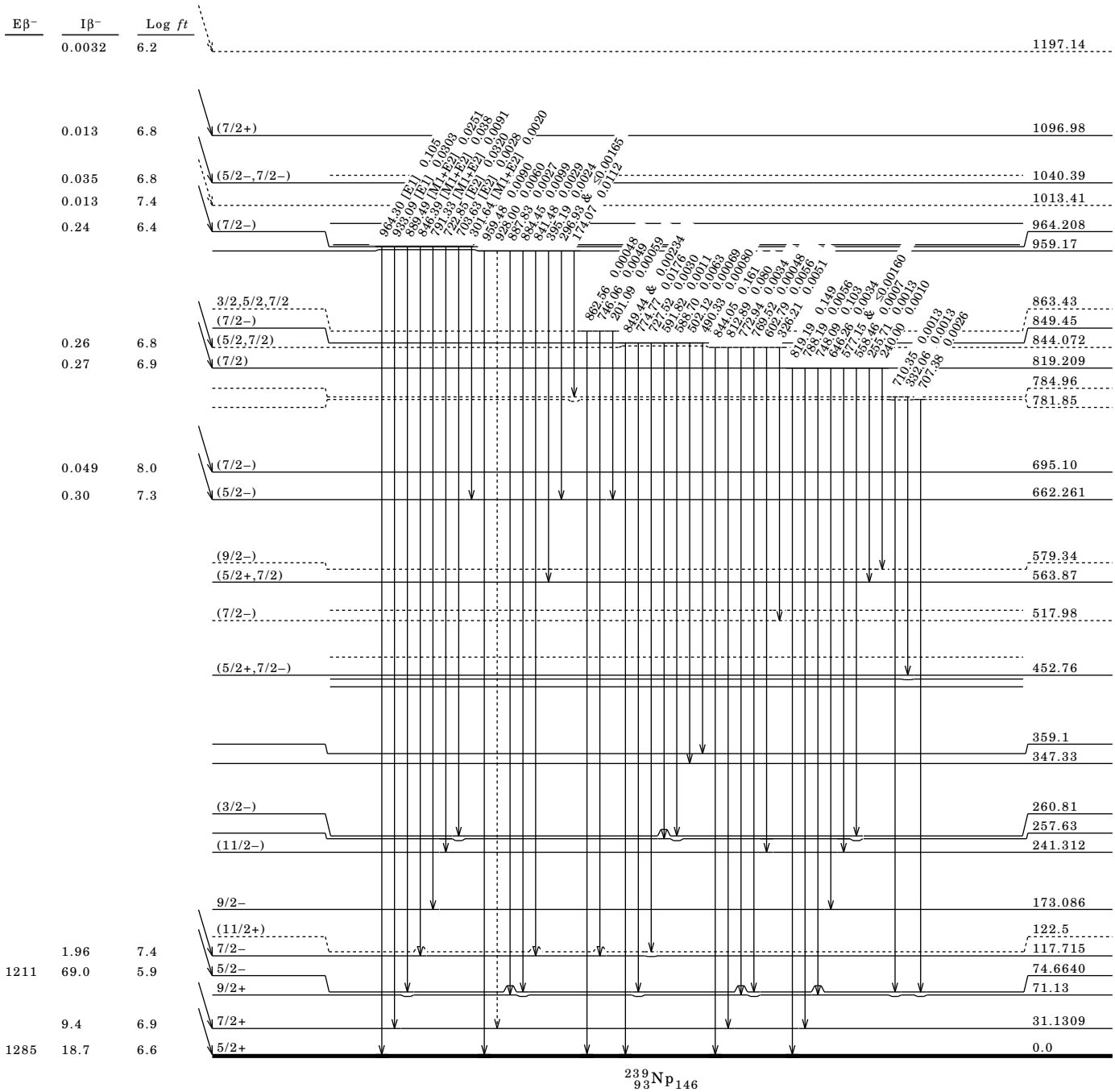
5/2+ 0.0 23.45 min

$^{239}_{92}U_{147}$

%β⁻=100

Q^-(g.s.)=1261.5[16]

Intensities: I(γ+ce) per 100 parent decays
& Multiply placed; undivided intensity given



^{239}U β⁻ Decay 1969Cl12,1996Sa23,2006Wo03 (continued)

Decay Scheme (continued)

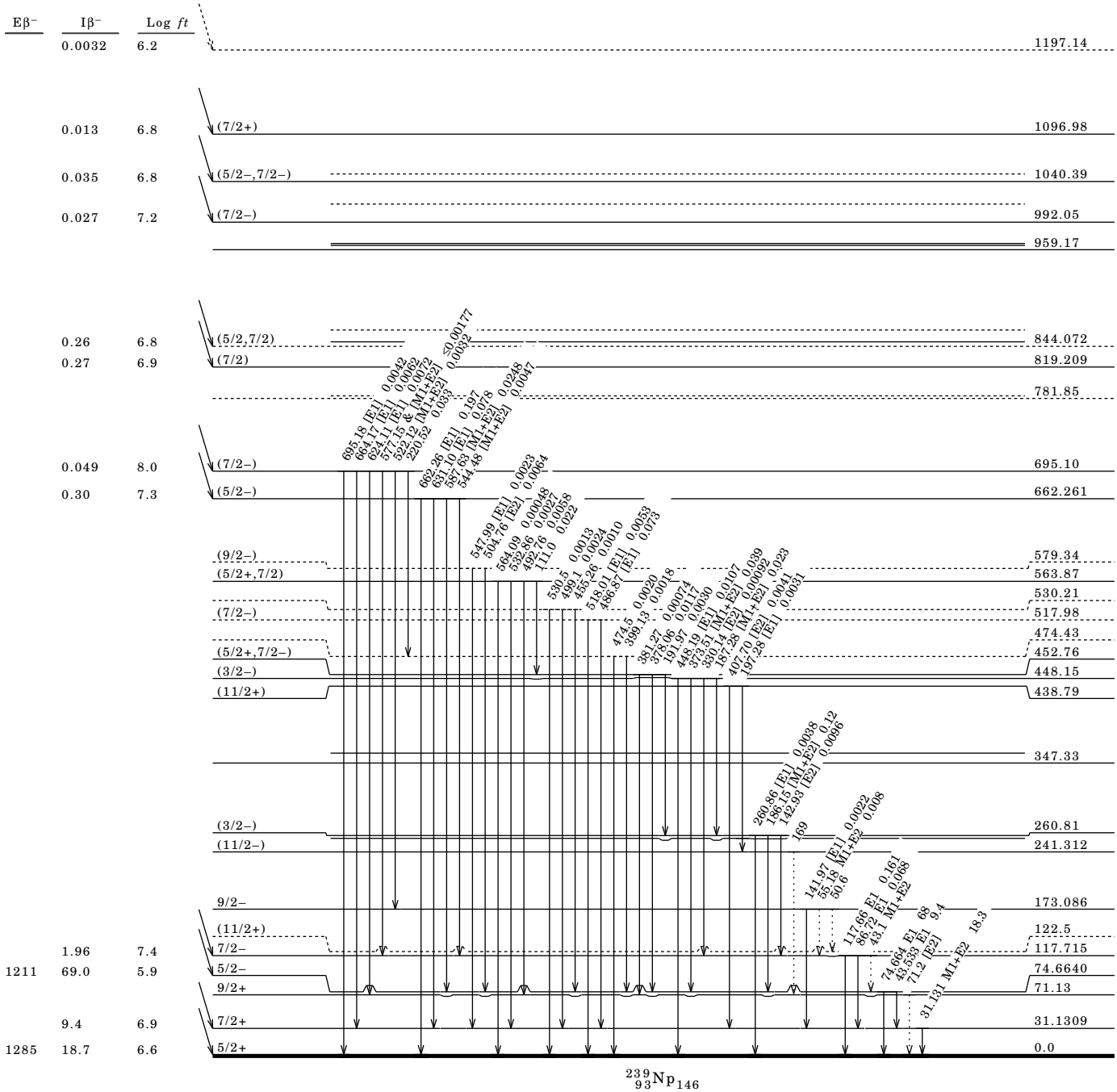
5/2+ 0.0 23.45 min

$^{239}_{92}U_{147}$

%β⁻=100

Q^-(g.s.)=1261.5[16]

Intensities: I(γ+ce) per 100 parent decays
& Multiply placed; undivided intensity given



^{243}Am α Decay 1992Ga01,1996Wo05,1996Sa23

Parent ^{243}Am: E=0.0; Jπ=5/2−; $T_{1/2}$=7364 y *22*; Q(g.s.)=5438.8 *10*; %α decay=100.
Others: 1986LoZT, 1964Ba26, 1975Pa04.
αγ, (α)(ce): 1968Va09 (semi–semi), 1969En02 (semi–semi), 1963Le17 (semi–scin).
αγ(θ): 1962Si12, 1963Fl01, 1967Fa01, 1967Hu03.
αγ(θ,H): deduced effective hyperfine field (1970An13).

^{239}Np Levels

E(level)†	Jπ§	$T_{1/2}$	Comments
0.0	5/2+		
31.130 *21*	7/2+		
71.5 *9*	9/2+		
74.660 *18*	5/2−	1.39 ns *3*	μ=+2.0 *3* (1967Gu08,2011StZZ). g=0.79 *10* from αγ(θ,H,t) (1967Gu08). $T_{1/2}$: Weighted average of 1.2 ns *1* (1960Un02), 1.40 ns *6* (1963Ch07), 1.41 ns *4* (1968Ob02), 1.38 ns *3* (1969Hu09), and 1.41 ns *4* (1970To08).
117.84 *3*	7/2−	≤0.04 ns	$T_{1/2}$: From 1969Hu09.
122.4 *10*	(11/2+)		
173.02 *4*	9/2−		
240.8 *9*	(11/2−)		
267‡ *3*	(5/2+)		
317.4 *15*	(13/2−)		
325‡ *3*	(5/2−)		
347‡ *3*	(7/2+,9/2+)		Jπ: analogy to ^{237}Np suggests 7/2+ 1/2[400] band; however, from (^{3}He,d), Jπ=9/2+.
359‡ *3*	(9/2+)		Jπ: analogy to ^{237}Np.
411‡ *3*			
427‡ *3*			
438‡ *3*	(11/2+)		
662.2	(5/2−)		

† Deduced by evaluator from a least–squares fit to γ–ray energies, unless otherwise specified.
‡ From alpha particle energy.
§ From adopted levels, unless stated otherwise.

α radiations

Eα†	E(level)	Iα§@	HF#	Comments
4695 *3*	662.2	1.7×10^{-3} *5*	7.1	Iα: measurement of 1966Le13. α intensity in coincidence with gammas is 0.0016% *5*, in coincidence with ce's is 0.00007% *3*. Iα: 0.00148% *3*, deduced by evaluator from γ–ray transition intensity balance.
4919 *3*	438	8.5×10^{-5}	5400	Iα: From Iα=0.000085% (1964Ba26), recommended in 2010BeZQ.
4930 *3*	427	1.8×10^{-4}	3000	Iα: From Iα=0.00018% (1964Ba26), recommended in 2010BeZQ.
4946 *3*	411	3.4×10^{-4}	2000	Iα: From Iα=0.00034% (1964Ba26), recommended in 2010BeZQ.
4997 *3*	359	≤0.0016	≥1000	Average of Iα(5008α + 4997α)=0.0016% *5* (1992Ga01) and Iα=0.0020% *4* (1996Sa24). Other value: Iα=0.0016 (1964Ba26).
5008 *3*	347	≤0.0016	≥1200	
5029 *3*	325	≤0.004	≥700	Iα(5035α + 5029α)=0.0039% *6*, average of Iα=0.0022% (1964Ba26), Iα=0.0033% *5* (1992Ga01), and Iα=0.0044% *5* (1996Sa24).
5035 *3*	317.4	≤0.003	≥1000	Iα: 0.00104% *2*, deduced by evaluator from γ–ray transition intensity balance.
5088 *5*	267	0.0055 *6*	1100	Iα: Average of Iα=0.004% (1964Ba26), Iα=0.0056% *7* (1992Ga01), and Iα=0.0055% *6* (1996Sa24).
5113 *1*	240.8	0.008 *3*	1100	Iα: Average of Iα=0.0054% (1964Ba26), Iα=0.010% *1* (1992Ga01), and Iα=0.010% *10* (1996Sa24). Iα: 0.0046% *1*, deduced by evaluator from γ–ray transition intensity balance.
5181 *1*	173.02	1.383 *7*	17	Iα: Weighted average (Limited Relative Statistical Weight Method) of Iα=1.1% *2* (1964Ba26,1991Ry01), Iα=1.1% *3* (1955St98, uncertainty estimated by evaluator), Iα=1.3% *2* (1956Hu96), Iα=1.36% *1* (1992Ga01), Iα=1.388% *8* (1996Sa24), and Iα=1.391% *7* (2002Da21). Iα: 1.1% *4*, deduced by evaluator from γ–ray transition intensity balance.

Continued on next page (footnotes at end of table)

^{243}Am α Decay 1992Ga01,1996Wo05,1996Sa23 (continued)

α radiations (continued)

Eα†	E(level)	Iα§@	HF#	Comments
5233.3‡ *10*	117.84	11.46 *5*	4.7	Iα: Weighted average (Limited Relative Statistical Weight Method) of Iα=10.6% *2* (1964Ba26,1991Ry01), Iα=11.5% *3* (1955St98,1991Ry01), Iα=11.5% *3* (1956Hu96), Iα=11.46% *3* (1992Ga01), Iα=11.37% *3* (1996Sa24), and Iα=11.52% *2* (2002Da21). Iα: 10.3% *4*, deduced by evaluator from γ–ray transition intensity balance.
5275.3‡ *10*	74.660	86.74 *5*	1.1	Iα: Weighted average (Limited Relative Statistical Weight Method) of Iα=87.9% *3* (1964Ba26, 1991Ry01), Iα=87.1% *4* (1955St98,1991Ry01), Iα=86.9% *4* (1956Hu96), Iα=86.74% *6* (1992Ga01), Iα=86.79% *3* (1996Sa24), and Iα=86.60% *7* (2002Da21). Iα: 88.1% *17*, deduced by evaluator from γ–ray transition intensity balance.
5321 *1*	31.130	0.192 *3*	940	Iα: Average of Iα=0.190% *7* (1992Ga01), Iα=0.194% *3* (1996Sa24), and Iα=0.190% *3* (2002Da21). Other values: Iα=0.12% (1964Ba26), Iα=0.16% (1955St98), and Iα=0.16% (1956Hu96).
5349.4‡ *23*	0.0	0.240 *3*	1200	Iα: Average of Iα=0.230% *7* (1992Ga01), Iα=0.243% *3* (1996Sa24), Iα=0.240% *3* (2002Da21). Other values: Iα=0.16% (1964Ba26), Iα=0.17% (1955St98), Iα=0.17% (1956Hu96).

† Deduced from values in 2002Da21 (s), 1996Sa24 (s), and 1964Ba26 (s), recommended in 2010BeZQ, unless otherwise specified. Other: 1968Ba25 (s).
‡ From 1991Ry01.
§ Deduced from values in 2002Da21, 1996Da24, 1992Ga01, 1964Ba26, 1956Hu96, and 1955St98, recommended in 2010BeZQ.
# Using $r_0(^{239}Np)$=1.505, average of $r_0(^{238}U)$=1.5143 *9*, $r_0(^{240}U)$=1.5062 *10*, $r_0(^{238}Pu)$=1.5013 *10*, and $r_0(^{240}Pu)$=1.4979 *7* (1998Ak04).
@ Absolute intensity per 100 decays.

γ(^{239}Np)

I(L x ray)=41% *5* (αγ pc, 1969Al14).

From decay scheme (Using program RADLST), I(L x ray)=18.8% *7*, and I(K x ray)=0.0195% *10*. The value I(K x ray)=13.5% reported by 1977St35 is clearly in error; 1972Ah02 did not observe any K x ray in spite of having a better spectrum.

Iγ normalization: from weighted average (Limited Relative Statistical Weights Method) of Iγ(74.7γ)=68.5% *15* (1984Va41), Iγ(74.7γ)=69% *3* (1960As02), Iγ(74.7γ)=61% *6* (1968Va09), Iγ(74.7γ)=66% *3* (1972Ah02), Iγ(74.7γ)=59% *4* (1977St35), Iγ(74.7γ)=60% *4* (1979Po20), Iγ(74.7γ)=68% *2* (1982Ah04), Iγ(74.7γ)=66.7% *12* (1996Wo05), Iγ(74.7γ)=68.4% *13* (1996Sa23). Other values: Iγ(74.7γ)=73% *1* (1969Al14); Iγ(74.7γ)=68.2% *14*, evaluated intensity (1986LoZT).

Eγ†	E(level)	Iγ§@	Mult.	δ	α	Comments
31.14‡ *3*	31.130	0.105 *7*	M1+E2	0.09 *2*	187 *16*	Mult.: M1+<30% E2 was deduced by 1972Sc44 from L x ray spectra in coincidence with 43.5γ (contribution from other gammas subtracted by use of (74.6γ)(L x ray) coincidence spectra). Intensity balance at 31.10–keV level requires that α=189 *15* corresponding to δ=0.09 *2*.
43.1	117.84	0.097	M1+E2	0.38	154.4	Iγ: deduced by the evaluator from α(M)exp=31, Ice(M)(43.1γ)/Iγ(117.6γ)=3.56 as measured by 1969En02, and Iγ(117.6γ)=0.84 (from intensity balance Iγ=0.11). Mult.: α(M)exp=31 from (α)(ce)/αγ (1969En02).
43.53‡ *2*	74.660	8.78 *15*	E1		1.143	Iγ: Weighted average (Limited Relative Statistical Weight Method) of Iγ=6.04% *13* (1984Va41), Iγ=4.0% *10* (1960As02), Iγ=5.3% *5* (1968Va09), Iγ=5.0% *10* (1969Al14), Iγ=5.5% *3* (1972Ah02), Iγ=5.3% *12* (1979Po20), Iγ=6.2% *3* (1982Ah04), Iγ=5.93% *10* (1996Wo05), Iγ=5.72% *17* (1996Sa23) renormalized to Iγ(74.7γ)=100. Mult.: from intensity balance. Also from ce data in ^{239}U decay.
50.6	173.02	0.0044	[E1]		0.769	
55.4	173.02	0.0154	M1+E2	0.6 *2*	80 *30*	Mult.,δ: α(L)exp=90, L12/L3=2.9 from (α)(ce)/αγ (1969En02).
(68.1)	240.8		[E2]		89.0	I(γ+ce)@: 0.0045 *CA*.
(71.2)	71.5		[E2]		72.0	

Continued on next page (footnotes at end of table)

^{243}Am α Decay 1992Ga01,1996Wo05,1996Sa23 (continued)

γ(^{239}Np) (continued)

Eγ†	E(level)	Iγ§@	Mult.	α	Comments
74.66 *2*	74.660	100.0	E1	0.276	Iγ: Iγ=67.2% *12*, weighted average (Limited Relative Statistical Weight Method) of Iγ=68.5% *15* (1984Va41), Iγ=69% *3* (1960As02), Iγ=61% *6* (1968Va09), Iγ=66% *3* (1972Ah02), Iγ=59% *4* (1977St35), Iγ=60% *4* (1979Po20), Iγ=68% *2* (1982Ah04), Iγ=66.7% *12* (1996Wo05), Iγ=68.4% *13* (1996Sa23). Mult.: α(L)exp=0.170 from (α)(ce)/αγ, L12/L3=2.2 (1969En02).
86.71‡ *2*	117.84	0.515 *13*	E1	0.186	Iγ: Weighted average (Limited Relative Statistical Weight Method) of Iγ=0.350% *10* (1984Va41), Iγ=0.37% *4* (1968Va09), Iγ=0.340% *15* (1982Ah04), Iγ=0.342% *15* (1996Wo05), Iγ=0.344% *9* (1996Sa23) renormalized to Iγ(74.7γ)=100. Mult.: α(M)exp≤0.034 from (α)(ce)/αγ (1969En02).
98.5	173.02	0.014 *CA*	(E2)	15.56	Iγ: calculated by evaluator from (Ice(L)(98.5γ)/(Ice(L)(142γ)=21.4 (1969En02), Iγ(142γ), and α(L)(98.5γ)=11.5, α(L)(142.18γ)=0.0394 (theory). Mult.: α(L)exp≥2.2, L12/L3=1.81 by (α)(ce) coincidences; photon was not observed (1969En02).
117.60 *15*	117.84	0.84 *12*	E1	0.0842	Mult.: α(L)exp=0.070 from (α)(ce)/αγ (1969En02).
141.89‡ *3*	173.02	0.171 *12*	E1	0.224	Iγ: Weighted average (Limited Relative Statistical Weight Method) of Iγ=0.130% *10* (1984Va41), Iγ=0.130% *10* (1968Va09), Iγ=0.128% *6* (1982Ah04), Iγ=0.117% *5* (1996Wo05), Iγ=0.107% *3* (1996Sa23) renormalized to Iγ(74.7γ)=100. Mult.: α(L)exp=0.055 from (α)(ce)/αγ (1969En02).
169	240.8	0.0020	[E1]	0.1489	Eγ: measured by 1968Va09 (αγ semi).
195	317.4	0.0014	[E1]	0.1067	Eγ: measured by 1968Va09 (αγ semi).
x220					Observed by 1968Va09 in coincidence with 5088α.
544.58#&	662.2				
587.77#&	662.2				Iγ(544γ+588γ)=0.0005 (1966Le13).
631.09#	662.2	0.0005			
662.24#	662.2	0.0017			

† From 1975Pa04 (semi), 1972Ah02 (semi), 1969En02 (αγ, (α)(ce) semi), unless otherwise noted. Other measurements: 1957As84, 1960As02, 1963Le17, 1966Le13, 1967Ch12, 1968Va09, 1969Al14.

‡ From 1982Ah04 equilibrium ^{243}Am source; semi.

§ From 1986LoZT, 1982Ah04, 1975Pa04, 1972Ah02, 1968Va09. Iγ normalized to 100 for 74.67γ.

From ^{239}U β^- decay. Transition was observed in 1966Le13 in αγ coincidence spectrum and placed in level scheme. The measured energy was not given in 1966Le13.

@ For absolute intensity per 100 decays, multiply by 0.672 *12*.

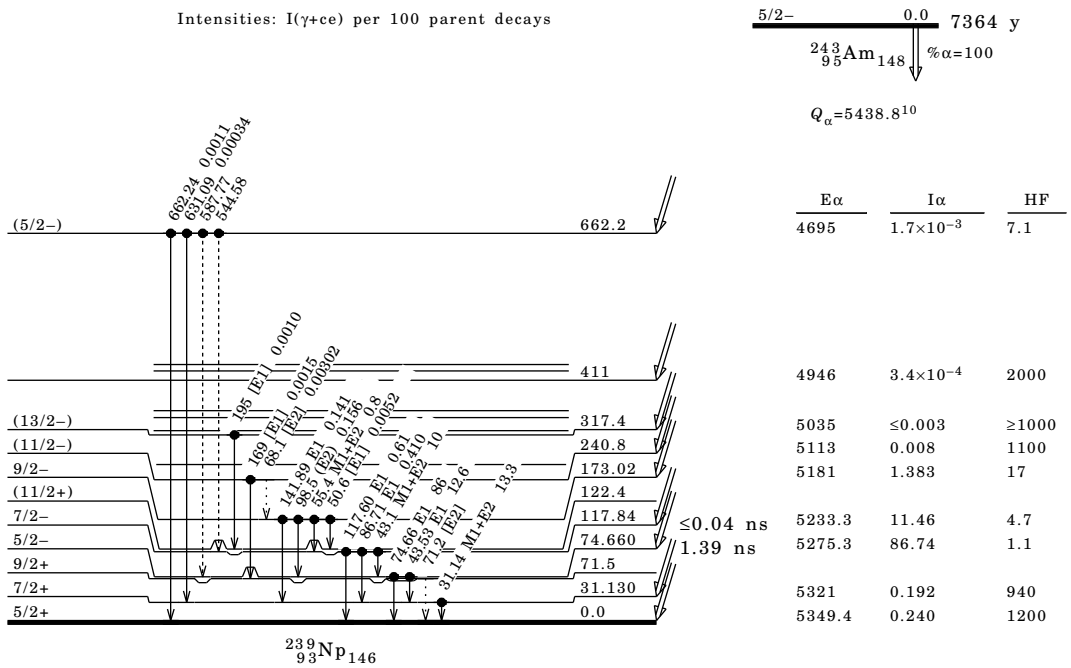
& Placement of transition in the level scheme is uncertain.

x γ ray not placed in level scheme.

^{243}Am α Decay 1992Ga01,1996Wo05,1996Sa23 (continued)

Decay Scheme

Intensities: I(γ+ce) per 100 parent decays



^{238}U(^{3}He,d),(α,t) 1975Vo01

^{239}Np Levels

(^{3}He,d) measured at 3 angles (1975Vo01).

E(level)†	Jπ§	L‡
≈0.0#	5/2+	
28# *3*	7/2+	
70.0# *12*	9/2+	2,3,4
70.0@ *12*	5/2−	2,3,4
117.8@ *16*	7/2−	0,1,2,3,4
117.8# *16*	11/2+	0,1,2,3,4
173.7@ *12*	9/2−	2,3,4,5,6
180.0# *12*	13/2+	5,6
220.2& *12*	(1/2+)	0,1,2,3,4
239.4@ *21*	11/2−	4,5,6
258.3a *13*	(3/2−)	0,1,2,3
258.3?& *13*	(3/2+)	0,1,2,3
270.9a *14*	1/2−	0,1,2
315.5a *11*	7/2−	(3),4
324?a *4*	(5/2−)	
346.8b *14*	(9/2+)	2,3,4,5,6
420.6 *22*		
437?b *3*	(11/2+)	
449.8c *11*	3/2−	0,1
482.6c *11*	5/2−	(3),4,5
521.2c *11*	7/2−	3,4
547.0?b *23*	(13/2+)	5,6
581.0c *22*	9/2−	5,6
600? *3*		
616? *3*		0,1,2,3
637.2 *18*		0,1,2
657?c *3*	(11/2−)	
695.4 *11*		3,4
723.7 *22*		
741.6 *21*		2,3,4,5,6
778.6 *13*		0,1,2,3,4
823.4 *17*		0,1,2
864.9d *12*	(9/2+)	4,5,6
890.6 *12*		4,5,6
917.1 *11*		3,4,5
951.5 *13*		4,5,6
992.9e *12*	(7/2−)	2,3,4
1019.9d *12*	(13/2+)	5,6
1049.0e *12*	(9/2−)	4,(5)
1077.2 *14*		3,4,5,6
1117.8e *13*	(11/2−)	3,4,5
1141.1 *17*		0,1,2,3
1155.3 *19*		2,3,4
1182.5 *14*		4,5,6

† Calibration is based on 10 known levels in ^{239}Np (1975Vo01).
‡ From 1975Vo01 based on angular distribution in (^{3}He,d) and on the ratio of cross sections (^{3}He,d)/(α,t).
§ From 1975Vo01 based on L values and on comparison of cross sections with DWBA calculations.
# (A): 5/2[642].
@ (B): 5/2[523].
& (C): 1/2[400]?
a (D): 1/2[530].
b (E): 3/2[651]?
c (F): 3/2[521].
d (G): 7/2[633]?
e (H): 7/2[514].

Adopted Levels, Gammas

Q(β⁻)=–802.1 *17*; S(n)=5646.2 *3*; S(p)=6155.4 *4*; Q(α)=5244.50 *21* 2012Wa38.
Other reactions:
Fission: 1997Vl02, 1997Vl01, 1997Ar09, 1996Vl01, 1993De17, 1992Ge01.
Spontaneous fission: 2012Ha06, 2011Yo12, 2008Ku21, 2006En04, 2005Re16, 2004Ro01, 2001Vl02.
^{239}Pu(n,f): 2012PrZZ, 2011Ho11, 2011Hu06, 2011Ki09, 2011Mu07.
^{239}Pu(n,n'): 1996Yu05, 1992Lo08.
^{239}Pu(n,n') E<10 MeV (2003Hi21).
^{239}Pu(n,n') E<20 MeV. Calculated σ, neutron spectrum (2011Ro24). Others: 2012Ba38, 2011Mu04.
^{239}Pu(n,n') E<300 MeV, calculated σ (2010Ha06).
^{239}Pu(γ,γ') E<5.5 MeV deduced prompt γ–ray transitions (2011Jo11).
^{239}Pu(α,α') E=55 MeV, measured Eγ,Iγ(θ), γγ coin (2011Bu11).
Cluster decay:
^{239}Pu(α): calculated $T_{1/2}$, branching ratios (2012Sa31). Others: 2013Fe03, 2010Ni02, 2009Dr05, 2007Ro08.
^{239}Pu(^{33}Si): calculated $T_{1/2}$ (2011Sh13).
^{239}Pu(^{28}Mg): calculated Q(β⁻)value, $T_{1/2}$ (2012Sa31).
^{239}Pu(^{34}Mg): calculated $T_{1/2}$ (2012Ku29).
^{239}Pu(^{30}Mg): calculated $T_{1/2}$ (2010Ni13).
Nuclear Structure.
^{239}Pu: calculated single–quasiparticle energies (2005Pa73).
^{239}Pu: calculated Coriolis decoupling factors (2009Mi02).
^{239}Pu: rotational bands (2009Ra27).
^{239}Pu: K–forbidden log *ft* values (2009So02).
^{239}Pu: evaluated data, Decay Data Evaluation Project (DDEP) (2008BeZV).
^{239}Pu: compiled data on superdeformed bands and fission isomers (2002Si26).
^{239}Pu: x–ray transition energies (2003De44).
Others: 2005Si30, 2004Sa55, 2003Ad31, 2003Ad34, 2003Ka23, 2003Ok01.

^{239}Pu Levels

Cross Reference (XREF) Flags

A ^{239}Np β⁻ Decay	E ^{243}Cm α Decay	I ^{239}Pu(d,d')
B Muonic Atom	F ^{238}Pu(n,γ) E=th	J Coulomb Excitation
C ^{238}U(α,3nγ)	G ^{238}Pu(d,p)	K ^{239}Pu(γ,γ')
D ^{239}Am ε Decay	H ^{239}Pu(n,n')	

E(level)	Jπ†	XREF	$T_{1/2}$	Comments
0.0&	1/2+	ABCDEFGHIJK	24110 y *30*	μ=+0.203 *4* (2011StZZ). Quadrupole deformation parameter deduced from splitting of giant–dipole resonance in photoabsorption β(2)=0.29 *3* (1976Gu15), β(2)=0.245 (1986Be38). From muonic x–rays 1986Zu01 deduce β(2)=0.2607 *7*, β(4)=0.0896 *18* and Q=11.56 *6*. 1978Cl03 deduce Q=11.66 *11*. From optical isotope shifts 1985Ge08 deduce Q=11.3 *10*. Jπ: Atomic beam (1969Fu11). 285γ E2 from 5/2+ at 285.4 keV. $T_{1/2}$: from 1986LoZT. 1990GlZZ recommend 24113 y *40* with a confidence level of >99% (the standard deviation is 11 y). Others: 24060 y *19*, specific α activity (1975Al15); 24048 y *25*, calorimetry, value corrected by 1977Ja08 (1970OeZZ); 24124 y *14*, specific α activity, and 24139 y *14*, mass spectrometry (1977Ja08); 24164 y *14* mass spectrometry (1978Ma45); 24101 y *8* calorimetry (1978Se12); 24019 y *21* specific α activity, and 24089 y *23* mass spectrometry (1978Pr07). %α=100; %SF=3.1×10^{-10} *6*. $T_{1/2}$: $T_{1/2}$(SF)=8×10^{15} y *2*, value recommended in 2000Ho27. Other values: $T_{1/2}$(SF)=7.8×10^{15} y *16* (1985Dr09); $T_{1/2}$(SF)=5.5×10^{15} y *16* (1952Se67) ($\Delta T_{1/2}$ is due to statistics only).
7.861#a *2*	3/2+	ABCDEFGH JK	36 ps *3*	Q=–2.319 *7* (2011StZZ). $T_{1/2}$: from B(E2)=5.313 22 in muonic atom.
57.275#& *2*	5/2+	ABCDEF HIJ	101 ps *5*	Q=–3.345 *13* (2011StZZ). $T_{1/2}$: from Moss (1972Ga28). Others: ≈0.2 ns from Coul. ex., 102 ps *8* from B(E2)(1/2+ to 5/2+)=7.95 *4* in muonic atom and adopted γ branching.

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued)

^{239}Pu Levels (continued)

E(level)	Jπ†	XREF	$T_{1/2}$	Comments
75.705[#a] *3*	7/2+	ABCDEFGHIJ		Q=−3.83 *3* (2011StZZ). $T_{1/2}$: 111 ps from B(E2) (3/2+ to 7/2+)=7.00 *4* in muonic atom and assuming Iγ(67γ)=100%.
163.76[#&] *3*	9/2+	ABCDEFGHIJ	73 ps *4*	$T_{1/2}$: from B(E2)=6.43 *3* in muonic atom and adopted Iγ branching.
192.8[#a] *10*	11/2+	C E GHIJ		
285.460[#d] *2*	5/2+	A DE GH	1.12 ns *5*	μ=−1.3 *3* (2011StZZ). μ: from β^- decay. Jπ: favored α decay (HF=1.33) from ^{243}Cm (Jπ=5/2+). $T_{1/2}$: from 1974Pa03. Other: 1951Gr34.
318.5[&] *7*	13/2+[@]	C IJ		
330.124[#d] *4*	7/2+	A DE G		
358.1[a] *1*	15/2+[@]	C IJ		
387.42[#d] *2*	9/2+	A DE G		
391.584[#e] *3*	7/2−	A DE	193 ns *4*	Jπ: 61.5γ E1 to 7/2+, 106.1γ E1(+M2) to 5/2+. α decay HF=130 is comparable to HF=90 for the analogous transition in ^{241}Pu α decay; γ(θ) in ^{239}Np β^- decay. $T_{1/2}$: from 1955En07. Other: 1974Pa03.
434[#e] *3*	(9/2−)	E		
462[#d] *3*	(11/2+)	E G		
469.8[#b] *4*	(1/2−)[§]	A EFG IJ		Jπ: from (d,d').
487[#e] *3*	(11/2−)	E G		
492.1[#c] *3*	3/2−	A EFG IJ		
505.6[#b] *2*	(5/2−)	A DEFG IJ		
511.838[f] *13*	7/2+	A D		Jπ: 124γ M1(+E2) to 9/2+, 226γ M1+E2 to 5/2+.
519.3[&] *6*	17/2+[@]	C J		
538[#] *3*		E G		
556.2[#c] *5*	(7/2−)	A EF IJ		
565[f]	(9/2+)	G		
570.6[a] *7*	19/2+[@]	C J		
583[b] *3*	(9/2−)	IJ		
620[e]	(15/2−)	G		
634[f]	11/2+	G		
661.1[c] *11*	(11/2−)[@]	G IJ		
698.7[b] *10*	(13/2−)	J		
716		G		
752.5 *5*	1/2+,3/2[§]	EFG I		
756[#] *3*		E		
763[#] *3*		E		
764.6[&] *6*	(21/2+)[@]	C J		
779 *3*		G I		
798.2 *5*	1/2,3/2[§]	F I		
805.1 *5*	1/2,3/2[§]	F		
806.7[c] *15*	(15/2−)[@]	J		
813[#] *3*		E		
825.5 *10*	1/2,3/2[§]	F I		
828.0[a] *7*	(23/2+)[@]	C J		
854 *2*		E I		
857.5[b] *10*	(17/2−)	J		
888.0 *5*	1/2,3/2[§]	FG		
900 *2*		G I		
915 *3*		I		
933.3 *10*	1/2,3/2[§]	F		
948 *3*		I		
990[g]	(3/2−)	G I		
992.4[c] *18*	(19/2−)[@]	J		
1017[g]	(1/2−)	G		
1027 *2*		I		
1038[g]	(7/2−)	G		
1052.9[&] *3*	(25/2+)	C J		
1058.1[b] *11*	(21/2−)	J		
1062 *2*		I		
1099.9 *5*	1/2,3/2[§]	F		
1100[g]	(5/2−)	G		
1127.6[a] *7*	(27/2+)[@]	C J		
1137[g]	(11/2−)	G		
1174		G		
1214[h]	(1/2+)	G		
1219.7[c] *21*	(23/2−)[@]	J		
1233[h]	(3/2+)	G		
1233[i]	(9/2−)	G		
1261[h]	(5/2+)	G		
1261[j]	(3/2+)	G		
1289[j]	(5/2+)	G		
1300.9[b] *12*	(25/2−)	J		
1311[h]	(7/2+)	G		
1342[j]	(7/2+)	G		
1359[h]	(9/2+)	G		
1381.1[&] *7*	(29/2+)[@]	C J		
1390		G		
1409[j]	(9/2+)	G		
1437		G		
1465		G		
1467.3[a] *8*	(31/2+)[@]	C J		
1487.7[c] *23*	(27/2−)[@]	J		
1488		G		
1584.9[b] *14*	(29/2−)	J		
1748.2[&] *7*	(33/2+)[@]	C J		
1795.5[c] *25*	(31/2−)	J		
1846.3[a] *8*	35/2+[@]	J		
1908.9[b] *15*	(33/2−)	J		
2040.25 *21*	(1/2,3/2)[‡]	K		
2046.9 *3*	(1/2,3/2)[‡]	K		
2135.0 *4*	(1/2,3/2)[‡]	K		
2143.56 *13*	(1/2,3/2)[‡]	K		
2144[c] *3*	(35/2−)[@]	J		
2151.0 *3*	(1/2,3/2)[‡]	K		
2151.8[&] *7*	(37/2+)[@]	J		

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued)

^{239}Pu Levels (continued)

E(level)	Jπ†	XREF	$T_{1/2}$	Comments
2262.0[a] *8*	(39/2+)@	J		
2272.0[b] *16*	(37/2−)	J		
2289.0 *3*	(1/2,3/2)‡	K		
2431.7 *3*	(1/2,3/2)‡	K		
2454.4 *3*	(1/2,3/2)‡	K		
2460.5 *4*	(1/2,3/2)‡	K		
2464.6 *3*	(1/2,3/2)‡	K		
2471.1 *3*	(1/2,3/2)‡	K		
2529.4[c] *23*	(39/2−)	J		
2589.4& *8*	(41/2+)@	J		
2672.0[b] *17*	(41/2−)	J		
2712.8[a] *8*	(43/2+)@	J		
2951.4[c] *25*	(43/2−)	J		
3059.7& *8*	(45/2+)@	J		
3100[k] *200*	(5/2+)	K	7.5 μs *10*	$T_{1/2}$: from 1977GoZH. Others: 8 μs *1* (1970Po01), 9 μs *1* (1973Na35), 8.1 μs *8* (1972Wo07), 11 μs *2* (1979Ba02), 6.5 μs *4* (1980Gu20). See also: 1971Ta17. E(level): from ^{239}Pu(γ,n) (1972Ga04). E=2.7 MeV from ^{238}U(α,3n) (1971Br38,1972Wo07,1980Bj02). Others: 1970Bu02, 1974Ga41, 1973PoZA. Ratio of isomeric to prompt fission 7.9×10^{-5} in ^{240}Pu(γ,n) E(γ)≤45 MeV (1980Gu20). Mass distribution in fission of the isomer studied by 1977GoYZ. %SF≤100. Q of rotational band built on g.s. of second potential minimum studied by 1977Ha01. Q=36.5 *25* assuming moment of inertia for the band 5% lower than the ^{240}Pu case. K≥5/2 from decay time of high−charge states. Other: 1977GoZH.
3108.0[b] *20*	(45/2−)	J		
3124.3[k]	(7/2+)	K		
3156.2[k]	(9/2+)			
3196.1[a] *9*	(47/2+)@	J		
3303	(9/2−)	K	2.6 ns *+40−12*	Assignment: ^{238}U(α,3n), ce−fission coin (1979Ba02). Jπ: γ−ray deexcitation, Alaga ratios. Calculations suggest 9/2[734]. $T_{1/2}$: from 1979Ba02. Others: 1977Ha01, 1980Gu20, 1977GoZH. %SF≤100.
3407[c] *3*	(47/2−)	J		
3558.2& *9*	(49/2+)@	J		
3578.0[b] *22*	(49/2−)	J		
3713.0[a] *24*	(51/2+)	J		
3895[c] *3*	51/2−	J		
4080.0[b] *24*	(53/2−)	J		
4087.1& *24*	(53/2+)	J		
4256[a] *3*	(55/2+)	J		
4413[c] *3*	55/2−	J		

† From γ−ray multipolarities, rotational band structure, and systematics of Nilsson orbitals in nearby odd−A nuclei. Individual arguments are given mostly for rotational bandheads. Jπ assignments from ^{238}Pu(d,p) are based on angular distributions and cross section fingerprints.
‡ From expected dominance of dipole excitation in ^{239}Pu(γ,γ').
§ Fed in ^{238}Pu(n,γ), E=thermal from 1/2+, γ−ray deexcitation to 1/2+ and 3/2+.
# From ^{243}Cm α decay.
@ From Coulomb Excitation.
& (A): 1/2[631], α=+1/2.
a (B): 1/2[631], α=−1/2.
b (C): 1/2[631]×0−, α=+1/2 (octupole vibration on g.s.).
c (D): 1/2[631]×0−, α=−1/2 (octupole vibration on g.s.).
d (E): 5/2[622].
e (F): 7/2[743].
f (G): 7/2[624].
g (H): 1/2[761].

Footnotes continued on next page

Adopted Levels, Gammas (continued)

^{239}Pu Levels (continued)

[h] (I): 1/2[620].
[i] (J): 7/2[613]?
[j] (K): 3/2[622]?
[k] (L): 5/2[633] in second potential minimum. Rotational parameters A=3.36 *10* keV, B=4 *3* eV (1979Ba02). Q and δ suggest that spin and angular momentum for the band are antiparallel, consistent with 5/2[633].

γ(^{239}Pu)

E(level)	Eγ	Iγ	Mult.[§]	δ	α	Comments
7.861	7.860[#] *3*	100[#]	M1+E2	0.055 *3*	5.7×10^{3} *4*	B(M1)(W.u.)=0.220 *24*; B(E2)(W.u.)=3.1×10^{3} *5*. B(E2)(W.u.)>>RUL.
57.275	49.412[#] *4*	100[#]	M1+E2	0.50 *3*	126 *8*	Iγ: from ^{239}Np β$^-$. From B(E2) ratios in muonic atom and δ=0.50 Iγ(49.4γ)=66, if Iγ were exactly 85 then δ=0.59 rather than 0.50 *3*. B(M1)(W.u.)=0.0075 *16*; B(E2)(W.u.)=220 *50*.
	57.273[#] *4*	≈30[#]	E2		222	B(E2)(W.u.)=291 *47*.
75.705	(18.4 *CA*)		[M1+E2]			
	67.841 *7*		E2		98.5	
163.76	88.06[#] *3*	12[#]	M1+E2	0.50	12.26	B(M1)(W.u.)=0.00295 *18*; B(E2)(W.u.)=27.7 *17*.
	106.47[#] *4*	100[#]	E2		11.80	B(E2)(W.u.)=450 *30*.
192.8	117.3[a] *3*	100	E2		7.55 *14*	
285.460	209.753[#] *2*	23.6[#] *7*	M1+E2[c]	0.37[c] *8*	2.93 *13*	B(M1)(W.u.)=7.4×10^{-5} *7*; B(E2)(W.u.)=0.07 *3*.
	228.183[#] *2*	75.7[#] *21*	M1+E2[c]	0.28[c] *7*	2.41 *9*	B(M1)(W.u.)=0.000194 *15*; B(E2)(W.u.)=0.09 *4*.
	277.599[#] *2*	100[#] *3*	M1+E2[c]	0.23[c] *10*	1.42 *7*	B(M1)(W.u.)=0.000145 *13*; B(E2)(W.u.)=0.029 *25*.
	285.460[#] *2*	5.2[#] *1*	E2		0.247	B(E2)(W.u.)=0.0262 *15*.
318.5	125[a]					
	154.3 *4*	100	E2		2.38 *5*	Eγ: From (α,3nγ).
330.124	44.663[#] *5*	100[#] *15*	M1+E2	0.20 *3*	86 *8*	
	166.319[#] *6*	9[#] *2*	M1		6.23	
	254.40[#] *3*	85[#] *8*	M1+E2	−0.159 *6*	1.85	
	272.87[#] *9*	62[#] *8*	M1+E2	+0.165 *9*	1.518	
	322.3[#] *2*	5.4[#] *8*	[E2]		0.1699	
358.1	165.3[a] *3*		E2		1.80	
387.42	57.30[#] *CA*	≈100[#]	M1(+E2)		28.6 *4*	α: For M1.
	101.96[#] *2*	≈8.9[#]	E2		14.42	
	311.7[#] *2*	19[#] *2*	(M1+E2)	≤0.2	1.06 *2*	
391.584	(4.2[#])	[#]	[E1]			
	61.460[#] *2*	4.8[#] *6*	E1		0.473	B(E1)(W.u.)=1.42×10^{-7} *22*.
	106.125[#] *2*	100[#] *10*	E1(+M2)	−0.007 *7*	0.117 *11*	α(L)exp=0.19 *3*; α(M)exp=0.050 *8*; α(N+...)exp=0.017 *3*. Mult.: conversion is anomalous. B(E1)(W.u.)=5.7×10^{-7} *8*; B(M2)(W.u.)=0.011 *+23−11*.
	315.880[#] *3*	5.8[#] *6*	E1(+M2)	+0.008 *8*	0.0372 *9*	B(E1)(W.u.)=1.26×10^{-9} *17*; B(M2)(W.u.)=$4.\times10^{-6}$ *+8−4*.
	334.310[#] *3*	7.7[#] *6*	E1(+M2)	+0.006 *4*	0.0329	B(E1)(W.u.)=1.41×10^{-9} *17*; B(M2)(W.u.)=2.1×10^{-6} *+28−21*.
469.8	461.9[@] *5*	100[@]	[E1]		0.01684	
	469.8[@] *5*	69[@]	[E1]		0.01628	
492.1	434.7[@] *5*	100[@]	E1(+M2)	−0.002 *2*	0.0190	
	484.3[@] *5*	8[@]	[E1]		0.01533	
	492.3[@] *5*	46[@]	[E1]		0.01485	
505.6	430.0[&] *3*	100[&] *18*				
	448.3[&] *5*	≈7[&]				
	497.8[&] *3*	88[&] *18*				
511.838	124.416[&] *15*	3.0[&] *3*	M1(+E2)	<0.26	13.8 *4*	
	181.715[&] *10*	33[&] *2*	M1+E2	−0.150 *7*	4.77	
	226.383[&] *12*	100[&] *6*	M1+E2	+0.133 *6*	2.58	
	436.0[&] *3*	0.24[&] *3*	[M1]		0.428	
	454.6[&] *3*	0.36[&] *4*	[M1]		0.382	
	504.0[&] *3*	0.42[&] *4*	[E2]		0.0516	

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued)

γ(^{239}Pu) (continued)

E(level)	Eγ	Iγ	Mult.§	α
519.3	160[a]			
	201.0[a] *2*	100	E2	0.839
556.2	392.4[@] *5*	100[@]	[E1]	0.0234
	≈498.7[@]	≈62[@]	[E1]	0.01448
570.6	212.0[a] *2*	100	E2	0.688
661.1	343[a]			
	497[a]			
698.7	340			
	505			
752.5	695.6[b]	40[b]		
	744.6[b]	80[b]		
	752.5[b]	100[b]		
764.6	194[a]			
	245.3[a] *2*		(E2)	0.409
798.2	790.4[b]	100[b]		
	798.2[b]	71[b]		
805.1	797.3[b]	100[b]		
	805.1[b]	30[b]		
806.7	145.6[a]		(E2)	3.03
	287[a]			
	488[ad]			
825.5	817.5[b]	45.5[b]		
	825.5[b]	100.0[b]		
828.0	256.9[a] *2*		(E2)	0.350
857.5	159[a]			
	287[a]			
	498[a]			
888.0	888.4[b]	100[b]		
933.3	925.7[b]	25[b]		
	933.6[b]	100[b]		
992.4	185.8[a]		(E2)	1.132
	228[a]			
1052.9	288.2 *1*	100	(E2)	0.240
1058.1	201			
	230			
	487			
1127.6	299.5[a] *2*	100	(E2)	0.213
1219.7	166[a]			
	227.3[a]		(E2)	0.534
	455[a]			
1300.9	173			
	243[a]		(E2)	0.423
	473			
1381.1	254[a]			
	328.5[a] *2*	100	[E2]	0.1605
1467.3	340.0[a] *2*	100	(E2)	0.1451
1487.7	268.0[a]	100	(E2)	0.304
1584.9	283.5[a]	100	(E2)	0.253
	457			
1748.2	281[a]			
	367.1[a] *2*	100	(E2)	0.1166
1795.5	308[a]		(E2)	0.195
1846.3	379.0[a] *2*	100	(E2)	0.1067
1908.9	323.9[a]		(E2)	0.1674
	441			
2040.25	2040.25 *21*	100		
2046.9	2046.9 *3*	100		
2135.0	2135.0 *4*	100		
2143.56	2135.0[d] *4*	31		
	2143.56[e] *13*	100		
2144	348[a]		(E2)	0.1356

Continued on next page (footnotes at end of table)

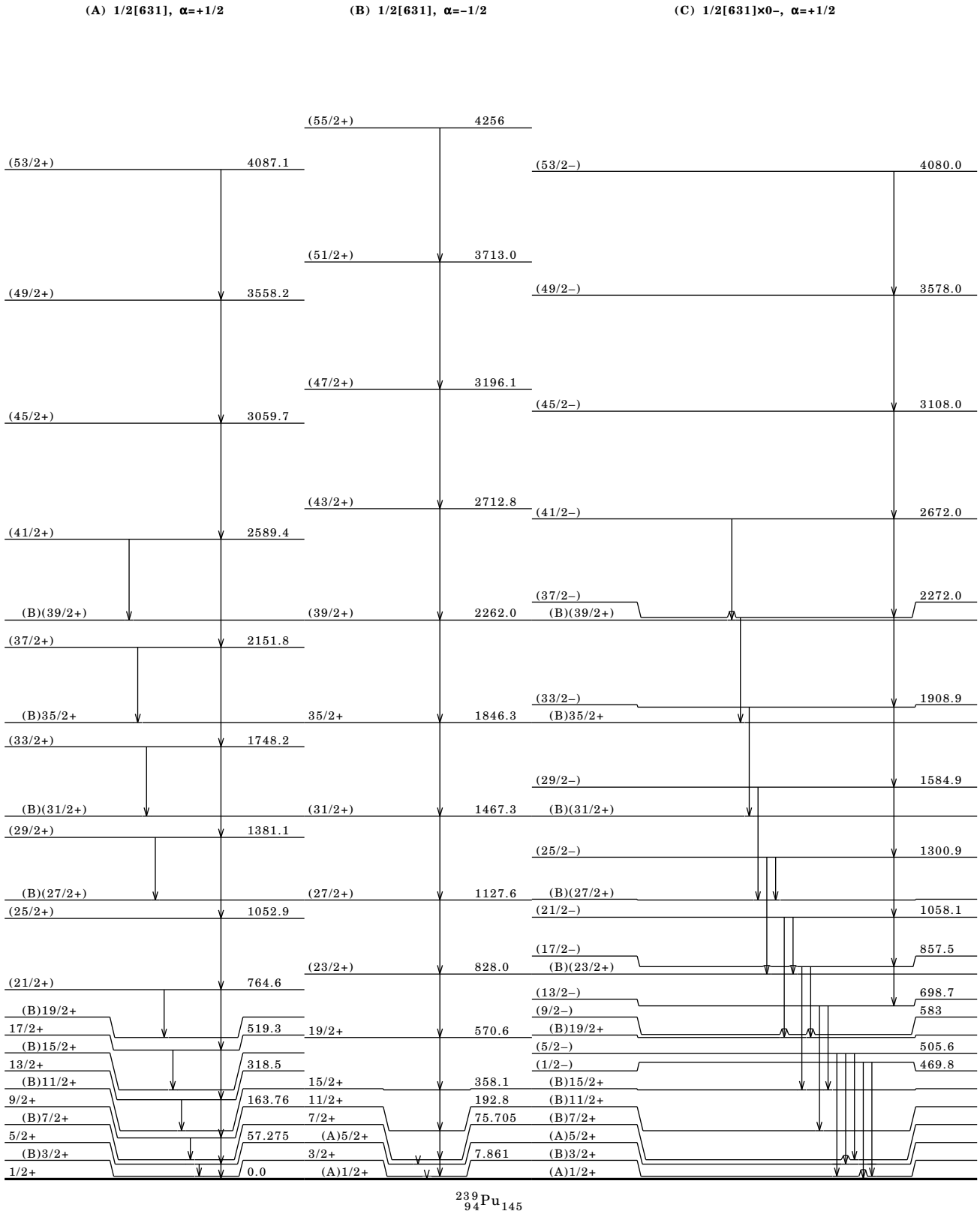
Adopted Levels, Gammas (continued)

γ(^{239}Pu) (continued)

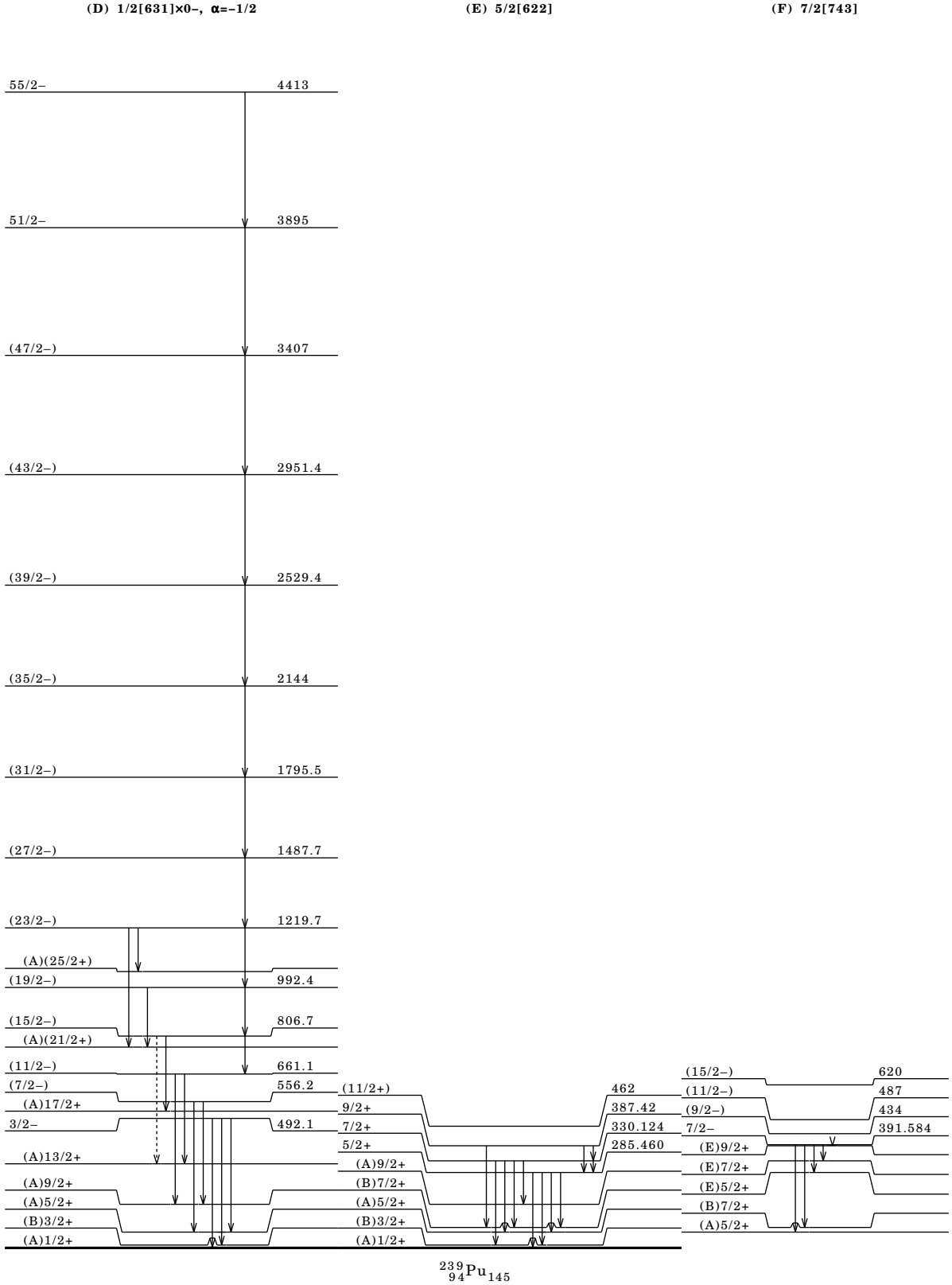
E(level)	Eγ	Iγ	Mult.§	δ	α	I(γ+ce)	Comments
2151.0	2143.56[e] *13*	100					
	2151.0 *3*	39					
2151.8	305[a]						
	403.5[a] *2*	100	(E2)		0.0901		
2262.0	415.4[a] *2*	100	(E2)		0.0835		
2272.0	362.8[a]		(E2)		0.1205		
	425						
2289.0	2289.02 *25*	100					
2431.7	2423.48 *22*	100					
	2431.66 *25*	90					
2454.4	2454.4 *3*	100					
2460.5	2460.5 *4*	100					
2464.6	2464.6 *3*	100					
2471.1	2471.1 *3*	100					
2529.4	386						
2589.4	327[a]						
	437.7[a] *2*	100	(E2)		0.0730		
2672.0	400						
	409						
2712.8	450.8[a] *2*	100	(E2)		0.0677		
2951.4	422						
3059.7	470.3[a] *2*	100	(E2)		0.0610		
3108.0	436						
3124.3	24.3		‡			73[†] *15*	
3156.2	31.9		M1+E2[‡]	>0.85	2.7×10^{3} *11*	55[†] *10*	
	56.2		E2[‡]		243	25[†] *5*	
3196.1	483.3[a] *4*	100	(E2)		0.0571		
3303	146.6		(E1)[‡]		0.211	91[†] *20*	B(E1)(W.u.)≈1.2×10^{-5}.
	178.5		(E1)[‡]		0.1335	41[†] *10*	B(E1)(W.u.)≈3.2×10^{-6}.
	202.8[d]		[M2][‡]		14.58	4[†] *2*	B(M2)(W.u.)≈1.7.
3407	456						
3558.2	498.5[a] *4*	100	(E2)		0.0530		
3578.0	470	100					
3713.0	515	100					
3895	488	100					
4080.0	502	100					
4087.1	528	100					
4256	543	100					
4413	518	100					

† Intensity in second potential minimum (1979Ba02). Other: 1976BeZM.
‡ From ce data of 1979Ba02, L12/L3 ratios.
§ Based on ^{239}Np β^- decay and ^{243}Cm α decay (1991Sh06).
# From ^{243}Cm α decay.
@ From ^{239}Np β^- Decay.
& From ^{239}Am ε Decay.
a From Coulomb Excitation.
b From ^{238}Pu(n,γ) E=th.
c From conversion electron data in ^{243}Cm α decay.
d Placement of transition in the level scheme is uncertain.
e Multiply placed.

Adopted Levels, Gammas (continued)

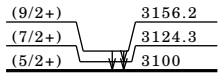


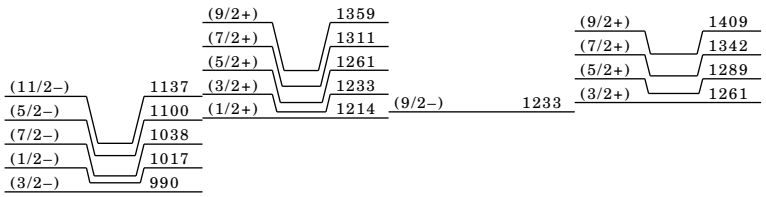
Adopted Levels, Gammas (continued)

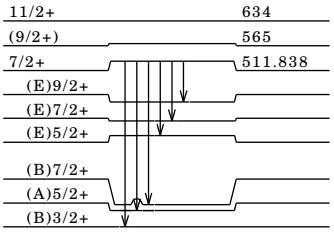


Adopted Levels, Gammas (continued)

(G) 7/2[624] **(H) 1/2[761]** **(I) 1/2[620]** **(J) 7/2[613]?** **(K) 3/2[622]?** **(L) 5/2[633]**







$^{239}_{94}Pu_{145}$

^{239}Np β⁻ Decay 1959Ew90,1965Da04,1996Wo05

Parent ^{239}Np: E=0; Jπ=5/2+; $T_{1/2}$=2.356 d *3*; Q(g.s.)=722.5 *10*; %β⁻ decay=100.

^{239}Pu Levels

E(level)	Jπ	$T_{1/2}$	Comments
0.0	1/2+	24110 y *30*	
7.861	3/2+		
57.276 *2*	5/2+		
75.706?	7/2+		
163.76	9/2+		
285.460	5/2+	1.12 ns† *5*	g=−0.49 *11* (1974Pa03). g−factor: assuming paramagnetic correction β=2.16.
330.125	7/2+		
387.41	9/2+		
391.586	7/2−	193 ns† *4*	
469.8	(1/2−)		
492.2	3/2−		
505.2	5/2−		
511.81 *6*	7/2+		
556.2	(7/2−)		

† Average of values from 1974Pa03, 1955En07, 1951Gr34.

β⁻ radiations

Eβ⁻†	E(level)	Iβ⁻‡§#	Log *ft*	Comments
(166.3 *10*)	556.2	≈0.003	≈9.7	
(210.7 *10*)	511.81	1.70 *6*	7.3	
(217.3 *10*)	505.2	0.0074 *2*	9.7	
(230.3 *10*)	492.2	0.020 *1*	9.3	
(252.7@ *10*)	469.8	≥0.0027	≤9.9 1u	
341 *3*	391.586	44 *2*	6.5	
393 *3*	330.125	7 *2*	7.5	
438 *3*	285.460	45 *3*	6.8	
(646.8@ *10*)	75.706?			
(665.2@ *10*)	57.276			
713 *3*	7.861	2 *1*	8.9	Iβ⁻: 1952Fr25, 1956Ba95, 1959Co63.

† From 1959Co63.
‡ I(β⁻) to 7.85, 57 and 75 levels deduced from I(β⁻ to 7.85)/ I(β⁻ to 57+75)=1.6 (1959Co63) and from Σ(Iβ) to higher levels)=100.
§ I(β⁻ to 57+75 level)<2.
# Absolute intensity per 100 decays.
@ Existence of this branch is questionable.

γ(^{239}Pu)

x−rays(Pu):

Eγ (1982Ah04)	Iγ(%α) (1982Ah04)		Iγ(%α) (1972Ah02)	Calculated (RADLST)
99.53	12.8 *4*	$K\alpha_2$ x ray	14.5 *6*	13.1 *5*
103.74	20.4 *6*	$K\alpha_1$ x ray	22.2 *8*	20.8 *7*
117.6	7.3 *3*	$K\beta_1'$ x ray		10.3 *4* (Kβ x ray)
120.6	2.6 *1*	$K\beta_2'$ x ray	2.8 *1*	

The agreement between measured and calculated K x ray supports the experimental γ−ray intensities and assigned multipolarities.

Others: 1975Pa04, 2008Gr11.

Iγ normalization: all γ−ray intensities were measured on an absolute scale (per 100 disintegrations of ^{239}Np).

Continued on next page (footnotes at end of table)

^{239}Np β⁻ Decay 1959Ew90,1965Da04,1996Wo05 (continued)

γ(^{239}Pu) (continued)

Eγ	E(level)	Iγ[†c]	Mult.	δ[a]	α	I(γ+ce)[c]	Comments
(4.2 *CA*)	391.586		[E1]			2.6 *CA*	I(γ+ce): from transition intensity balance at 387-keV level, where no significant β⁻ feeding is expected (5/2+ to 9/2+).
7.85[§]	7.861		M1+E2	0.055 *3*	5.7×10^3 *4*		δ: from ^{239}Am ε decay.
(18.4)	75.706?		[M1+E2]				
44.66[&] *2*	330.125	0.13 *1*	M1+E2	0.20 *3*	86 *8*		Iγ: from 1982Ah04. δ: from ^{239}Am ε decay.
49.41[&] *2*	57.276	0.12 *2*	M1+E2	0.50 *3*	126 *8*		δ: from ^{239}Am ε. Iγ: weighted average of 0.11% *1* (1982Ah04) and 0.18% *3* (1974HeYW). Iγ; =0.11 from ce(L) of 1959Ew90 and α(L)=95.
57.28[&d]	57.276	≈0.036[d]	E2		222		Iγ: from Iγ(57γ, 57 level)/Iγ(49γ)≈0.3 in ^{243}Cm α decay and Iγ(49γ)=0.12% *2* in ^{239}Np β⁻ Decay.
(57.3[d])	387.41	≈0.09[d]	[M1]		28.6 *4*		I(γ+ce): from Iγ(doublet)=0.135% *7* (1982Ah04) and Iγ(57γ, 57-keV level)≈0.036%.
61.460[‡] *2*	391.586	1.30 *2*	E1		0.473		Iγ: weighted average (Limited Relative Statistical Weight Method) of 1.40% *7* (1996Wo05), 1.29% *2* (1984Va41), and 1.29% *6* (1982Ah04).
67.86[§] *2*	75.706?	0.10 *3*	E2		98.4		Iγ: from 1974HeYW.
88.06[§] *3*	163.76	0.006[#] *2*	M1+E2	0.50	12.26		
101.965 *13*	387.41	0.008 *CA*	E2		14.42		Iγ,Eγ: from ^{239}Am ε decay.
106.123[‡] *2*	391.586	25.34 *17*	E1(+M2)	−0.007 *7*	0.26 *3*		α(L)exp=0.19 3; α(M)exp=0.050 *8*; α(N+...)exp=0.017 *3*. α: L1/L2=0.87 *9*/0.93 *9* 1959Ew90, conversion is anomalous. Other: 1957Ew30, 2008Go10. Iγ: Other value: 26.3% 10, weighted average (Limited Relative Statistical Weight Method) of 25.23% *28* (1996Wo05), 27.4% *4* (1984Va41), 26.4% *8* (1982Ah04), 26.6% *10* (1977St35), and 27.8% *9* (1972Ah02).
106.47[§] *4*	163.76	0.049[#] *8*	E2		11.80		
124.4	511.81	≈0.01	M1(+E2)	<0.26	13.8 *4*		Mult.,Iγ: from ^{239}Am ε decay.
166.39[§] *6*	330.125	0.016[#] *7*	M1		6.22		
181.70 *3*	511.81	0.082 *3*	M1+E2	−0.150 *7*	4.77		α(K)exp=3.0 *4*; α(L)exp=0.62 *8*. Iγ: Other value: 0.0831% 24, weighted average (Limited Relative Statistical Weight Method) of 0.085% *5* (1996Wo05), 0.07% *1* (1984Va41), 0.083% *4* (1982Ah04), and 0.075% *8* (1972Ah02).
209.753[‡] *2*	285.460	3.363 *20*	M1(+E2)	0.37[b] *8*	2.93 *13*		Iγ: Other value: 3.42% 3, weighted average (Limited Relative Statistical Weight Method) of 3.43% *7* (1996Wo05), 3.46% *5* (1984Va41), 3.30% *10* (1982Ah04), 3.36% *14* (1977St35,1991Po17), and 3.42% *10* (1972Ah02).

Continued on next page (footnotes at end of table)

^{239}Np β$^-$ Decay 1959Ew90,1965Da04,1996Wo05 (continued)

γ(^{239}Pu) (continued)

Eγ	E(level)	Iγ[†c]	Mult.	δ[a]	α	Comments
226.38 *2*	511.81	0.259 *16*	M1+E2	+0.133 *6*	2.58	Iγ: weighted average (Limited Relative Statistical Weight Method) of 0.230% *14* (1996Wo05), 0.28% *2* (1984Va41), and 0.24% *3* (1977St35,1991Po17). Eγ: from 1982Ah04.
227.83[d] *CA*	391.586	0.51[d] *CA*	[E1]		0.080	
228.183[‡] *1*	285.460	10.730 *87*	M1(+E2)	0.28[b] *7*	2.41 *9*	Iγ: After subtracting Iγ=0.51% for the 227.83–keV γ–ray component that deexcites the 391.5–keV level, and Iγ=0.259% *16* for the 226.38–keV γ–ray component from the 511–keV level. Iγ: Other value: 11.14% *11*, weighted average (Limited Relative Statistical Weight Method) of 10.91% *16* (1996Wo05), 11.21% *18* (1984Va41), 11.20% *30* (1982Ah04), 11.78% *44* (1977St35,1991Po17), 11.40% *3* (1972Ah02), after subtracting Iγ=0.51% for the 227.83–keV γ–ray component that deexcites the 391.5–keV level.
254.40[&] *3*	330.125	0.1092 *22*	M1+E2	−0.159 *6*	1.85	Iγ: Other value: 0.109% 2, weighted average (Limited Relative Statistical Weight Method) of 0.1078% *27* (1996Wo05), 0.12% *1* (1984Va41), 0.110% *6* (1982Ah04), and 0.11% *1* (1972Ah02).
272.84[&] *3*	330.125	0.0766 *19*	M1+E2	+0.165 *9*	1.519	Iγ: Other value: 0.077% 2, weighted average (Limited Relative Statistical Weight Method) of 0.0762% *24* (1996Wo05), 0.08% *1* (1984Va41), 0.077% *4* (1982Ah04), and 0.08% *1* (1972Ah02).
277.599[‡] *1*	285.460	14.505 *79*	M1+E2	0.23[b] *10*	1.42 *7*	Iγ: Other value: 14.44% 10, weighted average (Limited Relative Statistical Weight Method) of 14.53% *17* (1996Wo05), 14.38% *21* (1984Va41), 14.5% *4* (1982Ah04), 14.30% *24* (1979Mo25), 15.0% *5* (1977St35,1991Po17),14.1% *4* (1974Yu04), and 14.5% *4* (1972Ah02).
285.460[‡] *2*	285.460	0.7939 *64*	E2		0.247	Iγ: Other value: 0.79% 1, weighted average (Limited Relative Statistical Weight Method) of 0.797% *10* (1996Wo05), 0.77% *2* (1984Va41), 0.790% *25* (1982Ah04), 0.93% *6* (1977St35,1991Po17), and 0.76% *2* (1972Ah02).
315.880[‡] *3*	391.586	1.600 *12*	E1(+M2)	+0.008 *8*	0.0372 *9*	Iγ: Other value: 1.60% 2, weighted average (Limited Relative Statistical Weight Method) of 1.604% *20* (1996Wo05), 1.60% *3* (1984Va41), 1.60% *5* (1982Ah04), 1.63% *7* (1977St35,1991Po17), and 1.52% *5* (1972Ah02).
(322.26 *CA*)	330.125	0.0052 *CA*	[E2]		0.174	Iγ: from Iγ branchings in ^{239}Am ε decay and ^{243}Cm α decay.
334.310 *2*	391.586	2.056 *13*	E1(+M2)	+0.006 *6*	0.0329 *6*	Iγ: Other value: 2.06% 2, weighted average (Limited Relative Statistical Weight Method) of 2.050% *25* (1996Wo05), 2.08% *3* (1984Va41), 2.06% *6* (1982Ah04), 2.10% *10* (1977St35,1991Po17), and 1.95% *7* (1972Ah02). Eγ: from 1974HeYW, 1959Ew90.
392.4[@] *5*	556.2	0.0016[@]				
429.5[@] *5*	505.2	0.0039[@]				
434.7[@] *5*	492.2	0.013[@]	E1(+M2)	−0.002 *2*	0.0190	
447.6[@] *5*	505.2	0.00026[@]				
454.2[@] *5*	511.81	0.00082[@]	[M1]		0.383	
461.9[@] *5*	469.8	0.0016[@]				
469.8[@] *5*	469.8	0.0011[@]				

Continued on next page (footnotes at end of table)

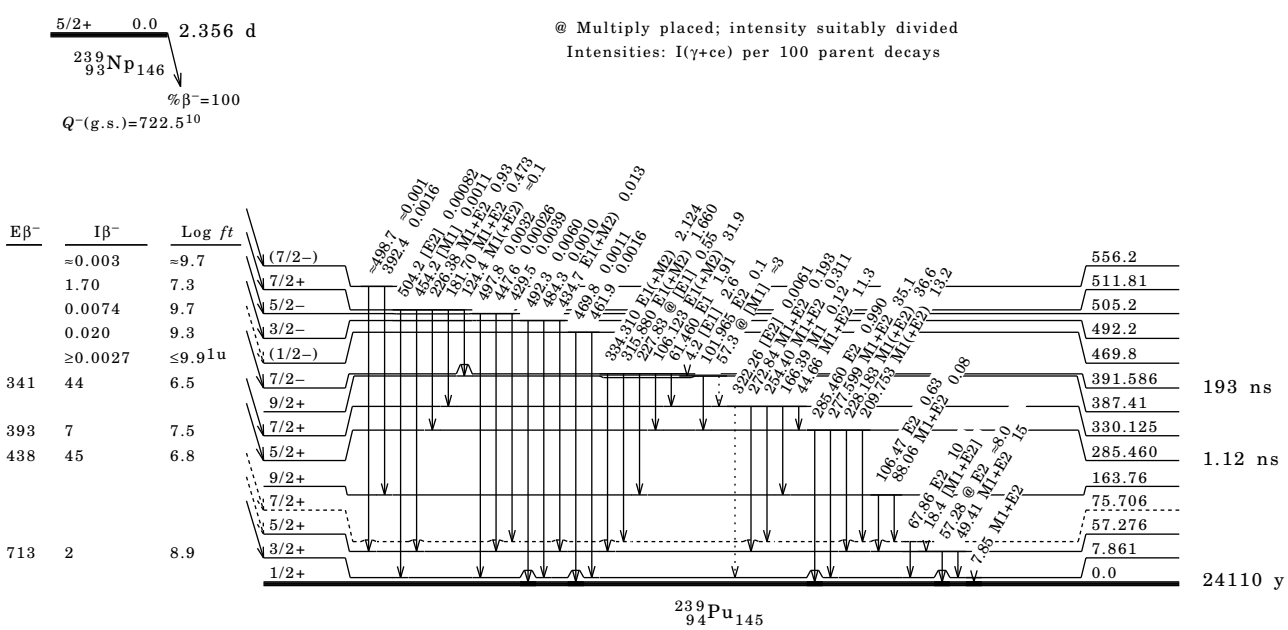
^{239}Np β⁻ Decay 1959Ew90,1965Da04,1996Wo05 (continued)

γ(^{239}Pu) (continued)

Eγ	E(level)	Iγ†c	Mult.	α
484.3@ 5	492.2	0.0010@		
492.3@ 5	492.2	0.0060@		
497.8@ 5	505.2	0.0032@		
≈498.7@	556.2	≈0.001@		
504.2@ 5	511.81	0.00078@	[E2]	0.0516

† Unless otherwise specified, absolute γ–ray intensities are values deduced from thermal neutron activations analysis [^{238}U(n,γ)] combined with absolute intensities measured by several authors, and included as fitted parameters in a least–squares fit (2005Tr08).
‡ From 1976BoYH corrected for change in calibration line of $K\alpha_1$ x ray of U from 98.440 to 98.4346 eV (cryst). See also 1979Bo30.
§ From 1959Ew90, magnetic spectrometer ce.
# From ce data of 1959Ew90 and theoretical conversion coefficient α.
@ From 1965Da04; Ge(Li), ΔIγ estimated by evaluator at 15–30%.
& From 1982Ah04.
a From 1972Kr07, 1959Ew90, 1990Si12, unless otherwise specified. Other: 1974Pa03.
b Deduced by evaluator from conversion electron data of 1991Sh06 in ^{243}Cm α decay.
c Absolute intensity per 100 decays.
d Multiply placed; intensity suitably divided.

Decay Scheme



Muonic Atom

Muonic atom ($T_{1/2}$=50.8 ns *20*) muon decay electrons measured (1977Jo09). Muonic atom ($T_{1/2}$=48.6 ns *5*) fission fragments measured (1980Wi06); the longer $T_{1/2}$ obtained by measuring electrons may be due to interference of long–lived background caused by muon capture by prompt fission fragments.

Muonic x–rays measured with Ge(Li). Muons stopped in 99.1% ^{239}Pu target. From analysis of K, L, and M x–rays 1986Zu01 derived B(E2) and Q values for the g.s. band up to 9/2+ as well as parameters for the deformed–Fermi charge distribution (1986Zu01).

Muonic Atom (continued)

^{239}Pu Levels

B(E2) and Q (spectroscopic moment) values from 1986Zu01.

E(level)	Jπ	Comments
0.0	1/2+	β(2)=0.2607 *7*, β(4)=0.0896 *18*, Q=11.56 *6*, moment (E4)=0.0896 *18* (1986Zu01). Other: Q=11.66 *11*, moment (E4)=0.85 *16* (1978Cl03). The analysis is model dependent, see 1986Zu01 for details.
7.861	3/2+	B(E2)(1/2+ to 3/2+)=5.313 *22*, Q=−2.319 *7*.
57.276	5/2+	B(E2)(1/2+ to 5/2+)=7.95 *4*, B(E2)(3/2+ to 5/2+)=1.10 *3* Q=−3.345 *13*.
75.706	7/2+	B(E2)(3/2+ to 7/2+)=7.00 *4*, B(E2)(5/2+ to 7/2+)=0.476 *13* Q=−3.826 *26*.
163.76	9/2+	B(E2)(5/2+ to 9/2+)=6.43 *3*.

^{239}Am ε Decay 1972Po04

Parent ^{239}Am: E=0; Jπ=(5/2)−; $T_{1/2}$=11.9 h *1*; Q(g.s.)=802.1 *17*; %ε decay=99.990 *1*.
Other measurements: 1957Sm77, 1960Gl01, 1972Po12.

^{239}Pu Levels

E(level)‡	Jπ†	Comments
0.0	1/2+	
7.860 *3*	3/2+	
57.273 *4*	5/2+	
75.701 *8*	7/2+	
163.76 *2*	9/2+	
285.46 *1*	5/2+	$T_{1/2}$: 1.09 ns *6*, from γγ(θ,H,t) (1973PaYM).
330.12 *1*	7/2+	
387.42 *1*	9/2+	
391.60 *1*	7/2−	
505.7 *2*	(5/2−)	
511.84 *1*	7/2+	

† From adopted levels.
‡ Deduced by evaluator from a least-squares fit to γ-ray energies.

β^+,ε Data

Eε	E(level)	Iε†‡	Log *ft*
(290.3 *17*)	511.84	18.1 *21*	5.9 *1*
(296.4 *18*)	505.7	0.0033 *6*	9.7 *1*
(410.5 *17*)	391.60	0.065 *10*	8.8 *1*
(472.0 *17*)	330.12	≈3.5	≈7.2
(516.6 *17*)	285.46	71 *8*	6.0 *1*
(726.4§ *17*)	75.701	≈3.4	≈7.7
(744.8§ *17*)	57.273	≈2.4	≈7.8

† Deduced by evaluator from γ-ray transition intensity balance.
‡ For intensity per 100 decays, multiply by 0.99990 *1*.
§ Existence of this branch is questionable.

^{239}Am ε Decay 1972Po04 (continued)

γ(^{239}Pu)

$K\alpha_2$ x ray=35.5% , $K\alpha_1$ x ray=56.2% , and Kβ x ray=27.8% calculated by evaluator (RADLST) agree well with experimental $K\alpha_2$ x ray=35.0% *15*, $K\alpha_1$ x ray=53.9% *23*, and Kβ x ray=27.0% *12* (1972Po04), respectively. This agreement suggests negligible ε feeding to g.s. and 7.86–keV levels.

Iγ normalization: assuming negligible ε feeding to g.s. and first excited state; this assumption is consistent with the measured x–ray intensities (Iε<1% to g.s. from log $f^{1u}t$>8.5).

Eγ	E(level)	Iγ§	Mult.†	δ†	α	I(γ+ce)§	Comments
(4.2 *CA*)	391.60		[E1]				
7.860 *3*	7.860		M1+E2	0.055 *3*	5.7×10^3 *4*	≈88	
(18.4)	75.701		[M1+E2]			<3	
44.663 *5*	330.12	0.09 *1*	M1+E2	0.20 *3*	86 *8*		
49.412 *4*	57.273	0.11 *1*	M1+E2	0.50 *3*	126 *8*		
57.273 *4*	57.273	≈0.09	E2		222		Iγ: from Iγ=0.170 *17* after subtracting ≈0.08 for 57.3γ deexciting the 387 level. Iγ(57γ)≈0.09 disagrees with Iγ(57γ, 57 level) in ^{243}Cm α decay and ^{239}Np β$^-$ Decay.
57.3 *CA*	387.42	≈0.08	M1(+E2)		27.9		α: for M1. Iγ: from Iγ(57γ, 387 level)/Iγ(311γ)≈4.7 in ^{243}Cm α decay, and Iγ(311γ)0.017 *2*.
(61.480 *4*)	391.60	0.0020 *4*	E1		0.472		
67.841 *7*	75.701	0.130 *13*	E2		98.5		
88.06 *3*	163.76	≈0.0008	(M1+E2)	0.50	12.26		Iγ: from ^{239}Np β$^-$ decay Iγ(88.06γ)/Iγ(106.50γ)=0.12 *5*, and Iγ(106.50γ)=0.007 *1*.
101.965 *13*	387.42	≈0.008	E2		14.42		
106.1 *2*	391.60	0.043 *5*	E1(+M2)		0.26 *3*		α(L)exp=0.19 *3*; α(M)exp=0.050 *8*; α(N+...)exp=0.017 *3*. Iγ: from Iγ(106γ doublet)=0.05 *1* after subtracting Iγ(106γ, 163–keV level)=0.007 *1*. α: anomalous E1 conversion (from ^{239}Np β$^-$ of 1959Ew90).
106.50 *3*	163.76	0.007 *1*	E2		11.78		Iγ: from intensity balance at 163–keV level.
124.416 *15*	511.84	0.10 *1*	M1(+E2)	<0.26	13.8 *4*		
(166.39 *6*)	330.12	≈0.009	M1		6.22		Iγ: deduced from Iγ(166.39γ)/Iγ(254.4γ) =0.111 *23*, using I(ce(L1))(166.39γ)/I(ce(K))(254.4γ)= 7 *1*/105 *15* from ^{239}Am ε decay (1959Ew90), the following theoretical conversion coefficients: α(L1)(166.39γ; M1)=0.932, and α(K)(254.4γ; M1+E2)=1.556, and Iγ(254.4γ)=0.084 *6*.
181.715 *10*	511.84	1.08 *6*	M1+E2	−0.12 *6*	4.80 *10*		δ: from 1972Kr07, 1972Po04, 1959Ew90.
209.8 *1*	285.46	3.5 *2*	M1+E2	0.37‡ *8*	2.93 *13*		
226.383 *12*	511.84	3.3 *2*	M1+E2	0.55 *10*	2.13 *14*		
228.184 *12*	285.46	11.3 *6*	M1+E2	0.28‡ *7*	2.41 *9*		
254.4 *1*	330.12	0.084 *6*	M1+E2	−0.12 *6*	1.86 *4*		
272.8 *1*	330.12	0.064 *5*	M1		1.553		
277.604 *16*	285.46	15.0 *7*	M1+E2	0.23‡ *10*	1.42 *7*		
285.5 *1*	285.46	0.80 *5*	E2		0.247		
311.7 *2*	387.42	0.017 *2*	(M1+E2)		0.6 *5*		
315.9 *2*	391.60	0.0032 *5*	E1(+M2)	−0.10 *12*	0.07 *12*		Iγ: from ^{239}Np β$^-$ decay, the value Iγ=0.0170 *15* in 1972Po04 is probably a typographical error.
322.3 *2*	330.12	0.0026 *3*	[E2]		0.1699		
334.3 *2*	391.60	0.0042 *5*	E1(+M2)	+0.02 *3*	0.034 *6*		
430.0 *3*	505.7	0.0017 *3*					
436.0 *3*	511.84	0.008 *1*	[M1]		0.428		

Continued on next page (footnotes at end of table)

^{239}Am ε Decay 1972Po04 (continued)

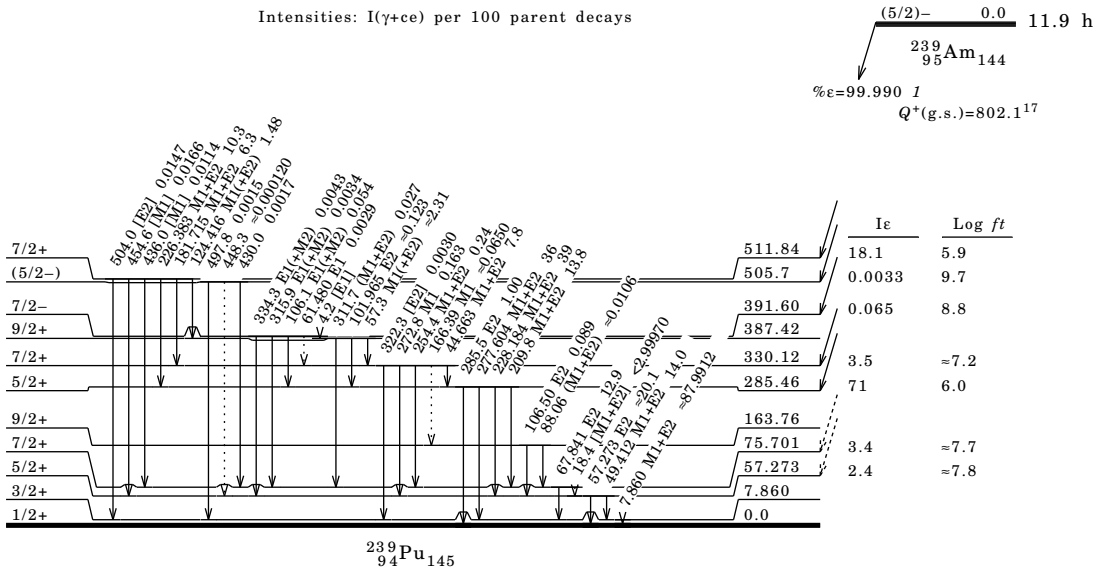
γ(^{239}Pu) (continued)

Eγ	E(level)	Iγ§	Mult.†	α	Comments
(448.3 *5*)	505.7	≈0.00012			From ^{239}Np β⁻ decay.
454.6 *3*	511.84	0.0120 *12*	[M1]	0.382	
497.8 *3*	505.7	0.0015 *3*			
504.0 *3*	511.84	0.0140 *14*	[E2]	0.0516	

† Based on ce data of 1957Sm77,1972Po04 and γ(θ) of 1972Kr07, unless otherwise specified.
‡ Deduced by evaluator from conversion electron data of 1991Sh06 in ^{243}Cm α decay.
§ For absolute intensity per 100 decays, multiply by 1.00 *10*.

Decay Scheme

Intensities: I(γ+ce) per 100 parent decays



^{243}Cm α Decay

Parent ^{243}Cm: E=0.0; Jπ=5/2+; $T_{1/2}$=28.9 y *4*; Q(g.s.)=6168.8 *10*; %α decay=99.71 *3*.
^{243}Cm–Q(α): From 2012Wa38.
^{243}Cm–$T_{1/2}$: Recommended in 2012Ch30, weighted average (using the Limited Statistical Weight method) of 29.0 y *8* (1958Ch38) and 29.20 y *12* (1986Ti03). Other value: 29.1 y *1* (1989Ho24).
See also the evaluation from the Decay Data Evaluation Project (ddep) (2012Ch30).
αγ: 1953As14, 1963Le17, 1966Ba07, 1977VaZW.
αγ(θ): 1963Fl01.
(L x ray)(γ)(θ): 1975Za11.
(K x ray)(L x ray)(θ): 1974Ma27.

^{239}Pu Levels

E(level)‡	Jπ†	$T_{1/2}$	Comments
0.0	1/2+		
7.8607 *20*	3/2+		
57.2750 *20*	5/2+		
75.7055 *23*	7/2+		
163.755 *23*	9/2+		
192.8 *10*	11/2+		
285.4594 *17*	5/2+	≈1.2 ns	$T_{1/2}$: from 1956St23.
330.124 *3*	7/2+		

Continued on next page (footnotes at end of table)

^{243}Cm α Decay (continued)

^{239}Pu Levels (continued)

E(level)‡	Jπ†	Comments
387.419 *20*	9/2+	
391.5847 *22*	7/2−	
427? *3*		
434 *3*	(9/2−)	
451? *5*		
462 *3*	(11/2+)	
469.8 *4*	(1/2−)	E(level): from adopted levels.
481? *3*		
487 *3*	(11/2−)	
492.1 *3*	3/2−	
499? *3*		
505.56 *20*	(5/2−)	
538 *3*		
543? *3*		
556.2 *5*	(7/2−)	E(level): from adopted levels; from Eα E(level)=552 *3*.
746 *3*		
756 *3*		
763 *3*		
813 *3*		
850 *15*		

† From adopted levels.
‡ Deduced by evaluator from a least–squares fit to γ–ray energies.

α radiations

Eα†	E(level)	Iα‡@	HF§	Comments
5226 *15*	850	0.00039	138	Eα: from 1963Le17 (αγ semi).
5267 *3*	813	0.0015	61.0	
5316 *3*	763	0.001	185	
5323 *3*	756	0.003	68.1	
5332 *3*	746	0.003	78.4	
5523 *3*	556.2	0.002	1550	
5532& *3*	543?	0.006	614	
5537 *3*	538	0.002	1970	
5568 *3*	505.56	0.007	861	
5575& *3*	499?	0.007	937	
5582 *3*	492.1	≈0.009	≈797	
5587 *3*	487	≈0.02	≈383	
5593& *3*	481?	0.01	828	
5607&				
5609 *3*	469.8	≤0.01	≥957	Iα: I(5609α + 5607α)=0.01 was measured by 1966Ba07.
5612 *3*	462	≈0.03	≈353	
5622&	451?	0.06	203	
5639 *3*	434	0.14	108	
5646&	427?	0.03	553	
5682 *3*	391.5847	0.2	130	Iα=0.41% *4*, deduced by evaluator from γ–ray transition intensity balance.
5686	387.419	1.6	17.1	Iα≈2.5% *1*, deduced by evaluator from γ–ray transition intensity balance.
5713& *5*		≤0.04		From 1963Dz07 (s).
5742.1# *9*	330.124	11.5# *5*	4.89	Iα=9.5% *21*, deduced by evaluator from γ–ray transition intensity balance.
5785.2# *9*	285.4594	73.2# *23*	1.33	Iα=72% *3*, deduced by evaluator from γ–ray transition intensity balance.
5876 *3*	192.8	0.7	430	
5907 *3*	163.755	0.1	4260	Iα=0.11% *2*, deduced by evaluator from γ–ray transition intensity balance.
5991.8# *15*	75.7055	5.7# *2*	211	Iα≈7%, deduced by evaluator from γ–ray transition intensity balance.
6010	57.2750	1.1	1350	
6058# *1*	7.8607	4.7# *3*	559	Iα≈6%, deduced by evaluator from γ–ray transition intensity balance.
6066.2# *17*	0.0	1.5# *2*	1920	

† From 1966Ba07 (s), unless otherwise specified. 1966Ba07 reported uncertainties of 1 keV near their alpha calibration lines of 5167.7 (^{240}Pu), 5498.8 (^{238}Pu), 5806.1 (^{244}Cm), and 2–3 keV elsewhere. Others: 1953As14, 1957As70, 1957As83, 1962Iv01, 1963Le17, 1963Dz07, 1970By01, 1971Bb10, 1976BaZZ, 1977VaZW.

Footnotes continued on next page

^{243}Cm α Decay (continued)

α radiations (continued)

‡ From 1966Ba07, unless otherwise specified. Others: 1976BaZZ, 1963Dz07, 1963Le17.
§ Using $r_0(^{239}Pu)$=1.4996, average of $r_0(^{238}Pu)$=1.5013 *10* and $r_0(^{240}Pu)$=1.4979 *7* (1998Ak04).
# From 1979Ry03 and 1991Ry01.
@ For α intensity per 100 decays, multiply by 0.9971 *3*.
& Existence of this branch is questionable.

γ(^{239}Pu)

x-rays(Pu):

Eγ (1972Ah02)	Iγ(%α) (1972Ah02)		Calculated (RADLST)
99.536	13.5 *5*	$K\alpha_2$ x ray	12.5 *5*
103.750	20.8 *8*	$K\alpha_1$ x ray	19.8 *8*
117.1	7.6 *3*	$K\beta_1'$ x ray	9.8 *4* (Kβ x ray)
120.6	2.6 *1*	$K\beta_2'$ x ray	

The agreement between measured and calculated K x ray supports the experimental γ-ray intensities and assigned multipolarities.
Iγ normalization: from 1972Ah02.

Eγ†	E(level)	Iγ‡&	Mult.@	δ@	α	I(γ+ce)&	Comments
(4.2 *CA*)	391.5847		[E1]				
(7.860§ *3*)	7.8607	≈0.015	M1+E2	0.055 *3*	5.7×10^3 *4*	≈85	I(γ+ce): deduced by evaluator from γ-ray and α-particle transition intensity balance at 7.86-keV level. I(γ+ce)(7.86γ)=I(γ+ce)(49γ) + I(γ+ce)(67γ) + I(γ+ce)(277γ) + Iα(6058α)≈85%. Iγ: deduced by evaluator from I(γ+ce)(7.86γ)≈85% and α=5700 *400*.
(18.43 *CA*)	75.7055		(M1+E2)				ce lines were obscured by Auger lines in ^{239}Am decay; an upper limit of 3% for its transition intensity was given by 1972Po04.
44.663 *5*	330.124	0.13 *2*	M1+E2	0.20 *3*	86 *8*		Iγ: deduced from Iγ(44.66γ)/Iγ(254.4γ)=0.13 *1*/0.11 *6*, as observed in ^{239}Np β^- decay (1982Ah04), and Iγ(254.4γ)=0.11 *1*.
(49.412§ *4*)	57.2750	≈0.2	M1+E2	0.50 *3*	126 *8*		Iγ: From decay scheme and transition intensity balance.
57.273b *4*	57.2750	≈0.05b	E2		222		Iγ: γ ray placed twice in level scheme. Iγ=0.14 *1* was measured for the doublet. Iγ from transition intensity balance at 57-keV level. I(γ+ce)(228γ) + I(γ+ce)(272γ) + I(γ+ce)(334γ) + Iα(6010) − I(γ+ce)(49γ)≈0.06%.
57.30b	387.419	≈0.09b	[M1+(E2)]		28.6 *5*		Iγ: from Iγ(doublet)=0.14% *1* and Iγ(57γ, 57-keV level)≈0.05%. Eγ: from E(level) difference. E=57.273 *4* measured for the doublet. α: for M1. Transition intensity balance at 387-keV level and theoretical α(E2)=221 suggest a negligibly small E2 admixture.

Continued on next page (footnotes at end of table)

^{243}Cm α Decay (continued)

γ(^{239}Pu) (continued)

Eγ†	E(level)	Iγ‡&	Mult.@	δ@	α	Comments
(61.460§ *2*)	391.5847	0.015 *2*	E1		0.473	Iγ: deduced from Iγ(61.46γ)/Iγ(334.31γ)=129 *2*/207 *3*, which was recommended by 1986LoZT, and from ^{239}Np β⁻ decay.
(67.841§ *7*)	75.7055	0.20 *5*	E2		98.5	Iγ: From decay scheme and transition intensity balance.
(88.06§ *3*)	163.755	0.0016	M1+E2	0.50	12.26	Iγ: from Iγ(88.06)/Iγ(106.47)=0.12 *5*, from ^{239}Np β⁻ decay.
(101.96§ *2*)	387.419	0.008 *CA*	E2		14.42	Iγ: from Iγ(101.96γ)/Iγ(311.7γ)≈8/17, as deduced by 1972Po04 in ^{239}Am ε decay.
(106.125§ *2*)	391.5847	0.31 *3*	E1(+M2)	−0.007 *7*	0.26 *3*	α: experimental anomalous conversion coefficient (1959Ew90). Other: 1957Ew30. Iγ: deduced from Iγ(106.12γ)/Iγ(334.31γ)=27.2 *4*/2.07 *3*, as measured in ^{239}Np β⁻ decay.
(106.47§ *4*)	163.755	0.0136	E2		11.80	Iγ: from intensity balance at 163.76 level.
(117.1 *CA*)	192.8					
(166.39§ *6*)	330.124	0.012 *3*	M1		6.22	Iγ: deduced from Iγ(166.39γ)/Iγ(254.4γ)=0.111 *23*, using I(ce(L1))(166.39γ)/I(ce(K))(254.4γ)=7 *1*/105 *15* from ^{239}Am ε decay (1959Ew90), and the following theoretical conversion coefficients: α(L1)(166.39γ; M1)=0.932, and α(K)(254.4γ; M1+E2)=1.457.
209.753 *2*	285.4594	3.30 *10*	M1+E2	0.37 *8*	2.93 *13*	δ: from α(K)exp=2.42 *14*; α(L12)exp=0.488 *15* (1991Sh06). Other value: δ=−0.004 *+1−24* from γ(θ) (1972Kr07,1990Si12).
228.183 *2*	285.4594	10.6 *3*	M1+E2	0.28 *7*	2.41 *9*	δ: from α(K)exp=2.01 *7*; α(M)exp=0.0968 *59* (1991Sh06). Other value: δ=+0.001 *+9−1* from γ(θ) (1972Kr07,1990Si12).
254.40 *3*	330.124	0.11 *1*	M1+E2	−0.159 *6*	1.85	
272.87 *9*	330.124	0.08 *1*	M1+E2	+0.165 *9*	1.518	
277.599 *2*	285.4594	14.0 *4*	M1+E2	0.23 *10*	1.42 *7*	δ: from α(K)exp=1.19 *5*; α(L12)exp=0.238 *10*, α(M)exp=0.0579 *29* (1991Sh06). Other value: δ=+0.165 *2*, from γ(θ) (1972Kr07,1990Si12).
285.460 *2*	285.4594	0.73 *2*	E2		0.247	
311.7 *2*	387.419	0.017 *2*	[M1+E2]	≤0.2	1.057 *23*	δ: assumed by evaluator.
315.880 *3*	391.5847	0.018 *2*	E1(+M2)	+0.008 *8*	0.0372 *9*	
322.3 *2*	330.124	0.007 *1*	[E2]		0.1699	
334.310 *3*	391.5847	0.024 *2*	E1(+M2)	+0.006 *6*	0.0329 *6*	
(392.4§ *5*)	556.2					
(430.0§ *3*)	505.56					
(434.7§ *5*)	492.1					
(447.6§ *5*)	505.56					
(461.9§ *5*)	469.8					
(469.8§ *5*)	469.8					
(484.3§ *5*)	492.1					
(492.3§ *5*)	492.1					
(497.8§ *3*)	505.56					
(499§)	556.2					
x≈640#a						Uncertain transition.
x≈680#						
x≈720#						
x≈740#						
x≈760#						

† Measurements of 1959Ew90 (s ce), 1965Ma17 (cryst), 1972Po04 (s ce, semi), and 1979Bo30 (cryst), and 1982Ah04 (semi) observed in ^{239}Np and ^{239}Am decays, except as noted. Other measurements: 1953As14 (scin), 1955Sc08 (s ce), 1956Ne17 (pc, scin), 1964Ba31 (αγ, semi).

‡ From 1972Ah02. Photon intensity per 100 α decays. Other measurements: 1956Ne17, 1964Ba31.

§ Transition was not observed in ^{243}Cm α decay. Eγ is from the decay of ^{239}Np and ^{239}Am.

From 1963Le17 (αγ and (α)(ce) coin).

@ From ce data in ^{239}Am, ^{239}Np, and ^{243}Cm decays; and γ(θ) measurements by 1972Kr07, 1990Si12 from polarized ^{239}Np, unless otherwise specified.

Footnotes continued on next page

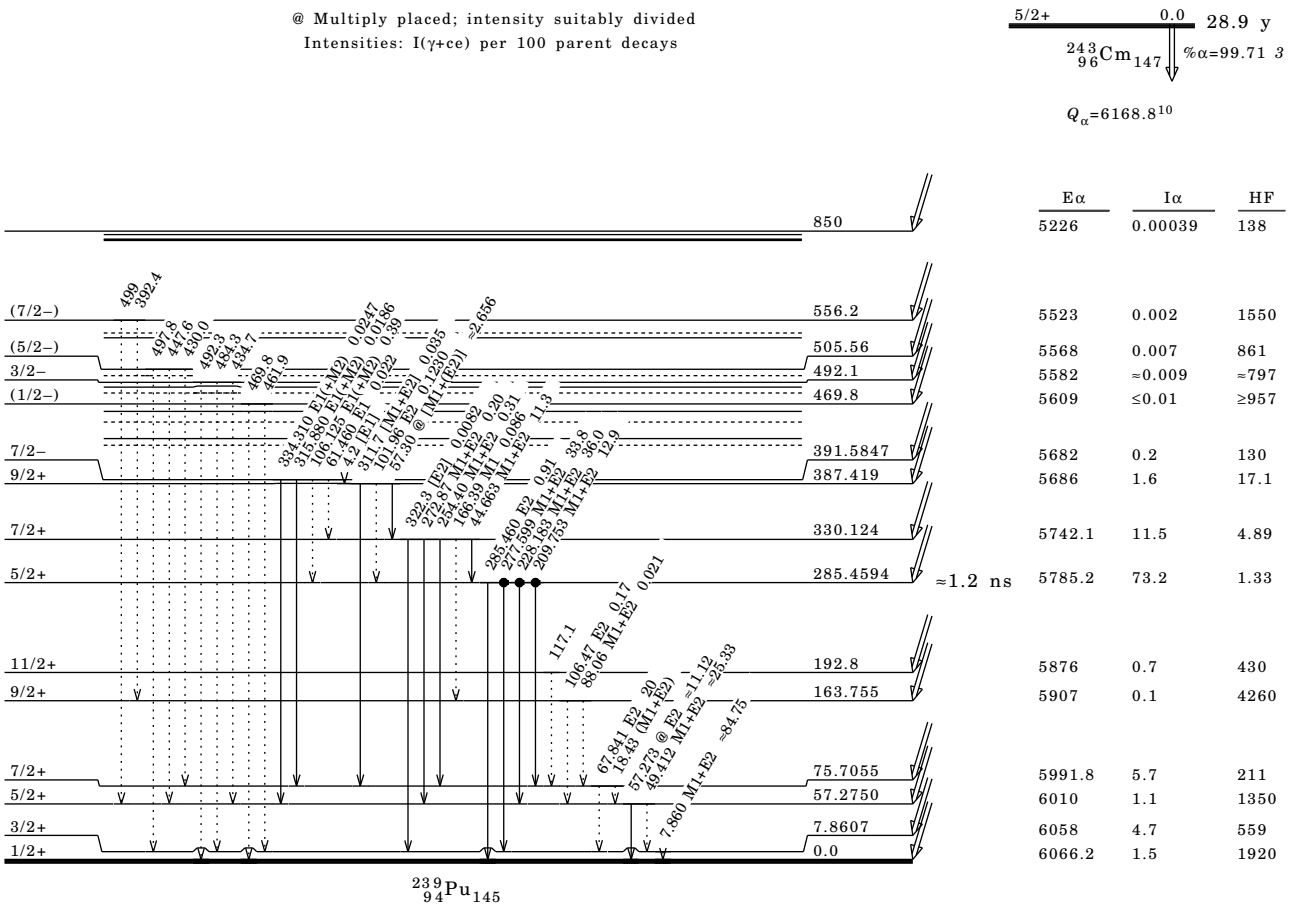
^{243}Cm α Decay (continued)

γ(^{239}Pu) (continued)

& For absolute intensity per 100 decays, multiply by 0.9971 *3*.
a Placement of transition in the level scheme is uncertain.
b Multiply placed; intensity suitably divided.
x γ ray not placed in level scheme.

Decay Scheme

@ Multiply placed; intensity suitably divided
Intensities: I(γ+ce) per 100 parent decays



^{238}U(α,3nγ) 1983Ha44

E(α)=35 MeV; ce mag spect, γ Ge(Li), ceγ coin.
Moment of inertia parameters for the g.s. 1/2[631] band deduced.

^{239}Pu Levels

E(level)	Jπ	E(level)	Jπ	E(level)	Jπ
0.0	1/2+	318.21	13/2+	1053.2	25/2+
7.861	3/2+	358.22	15/2+	1126.9	27/2+
57.276	5/2+	519.27	17/2+	1382.8	29/2+
75.706	7/2+	570.31	19/2+	1466.9	31/2+
163.76	9/2+	764.8	21/2+		
192.81	11/2+	827.2	23/2+		

^{238}U(α,3nγ) 1983Ha44 (continued)

γ(^{239}Pu)

Eγ	E(level)	Mult.†	Comments
(7.861 *2*)	7.861		
(57.276 *2*)	57.276		
(67.846 *2*)	75.706		
106.47 *4*	163.76	E2	Eγ: from Adopted Gammas.
117.1 *1*	192.81	E2	
154.45 *8*	318.21	E2	
165.41 *8*	358.22	E2	
201.06 *8*	519.27	E2	
212.09 *8*	570.31	E2	
245.6 *1*	764.8	[E2]	
256.9 *1*	827.2	[E2]	
288.3 *2*	1053.2	[E2]	
299.7 *2*	1126.9	[E2]	
329.6 *4*	1382.8	[E2]	
340.0 *4*	1466.9	[E2]	

† From L conversion electron subshell ratios.

^{238}Pu(n,γ) E=th 1975WeZA,1975MaXY

^{239}Pu Levels

E(level)	Jπ†	E(level)	Jπ†	E(level)	Jπ†
0.0	1/2+	492.1	3/2−	825.5	1/2,3/2
7.9	3/2+	505.4	(5/2−)	888.0	1/2,3/2
57.3	5/2+	556.6	(7/2−)	933.3	1/2,3/2
75.7	7/2+	752.5	1/2+,3/2	1099.5	1/2,3/2
163.8	9/2+	798.2	1/2,3/2	(5646.6 *3*)	1/2+
470.1	1/2−	805.1	1/2,3/2		

† From adopted levels.

γ(^{239}Pu)

Eγ	E(level)	Iγ‡	Eγ	E(level)	Iγ‡	Eγ	E(level)	Iγ‡
392.7	556.6	0.3†	744.6	752.5	0.8†	4547.1 *3*	(5646.6)	7.3 *15*
429.7	505.4	1.4†	752.5	752.5	1.0†	4714.7 *3*	(5646.6)	1.8 *7*
434.9	492.1	3.1†	790.4	798.2	1.7†	4759.0 *8*	(5646.6)	1.0 *5*
448.5	505.4	0.2†	797.3	805.1	1.0†	4821.8 *3*	(5646.6)	24 *5*
462.2	470.1	4.3†	798.2	798.2	1.2†	4842.0 *5*	(5646.6)	3.6 *12*
470.1	470.1	2.4†	805.1	805.1	0.3†	4848.8 *6*	(5646.6)	2.0 *5*
484.3	492.1	0.4†	817.5	825.5	1.0†	4894.9 *7*	(5646.6)	2.0 *5*
492.2	492.1	2.3†	825.5	825.5	2.2†	5154.6 *5*	(5646.6)	3.5 *8*
497.6	505.4	1.4†	888.4	888.0	0.5†	5176.9 *2*	(5646.6)	23 *5*
499.4	556.6	0.5†	925.7	933.3	0.1†	5638.0	(5646.6)	
695.6	752.5	0.4†	933.6	933.3	0.4†	5646.6 *5*	(5646.6)	2.0 *5*

† Relative intensities.
‡ Absolute intensity per 100 neutron captures.

^{238}Pu(d,p) 1973Gr26

E(d)=12.1, 13.1 MeV; measured scattered protons, σ(90°,125°,150°). Detector: magnetic spectrograph, FWHM=13 keV.

^{239}Pu Levels

E(level)[‡]	Jπ[†]	E(level)[‡]	Jπ[†]	E(level)[‡]	Jπ[†]
0.0[§]	1/2+	565[a]	9/2+	1214[c]	(1/2+)
8[§]	3/2+	620[&]	(15/2−)	1233[c]	(3/2+)
75[§]	7/2+	634[a]	11/2+	1233[d]	(9/2−)
163[§]	9/2+	658		1261[c]	(5/2+)
191[§]	11/2+	716		1261[e]	(3/2+)
284[@]	5/2+	749		1289[e]	(5/2+)
326[@]	(7/2+)	780		1311[c]	(7/2+)
386[@]	9/2+	885		1342[e]	(7/2+)
464[#]	(1/2−)	901		1359[c]	(9/2+)
464[@]	(11/2+)	990[b]	(3/2−)	1390	
488[#]	(3/2−)	1017[b]	(1/2−)	1409[e]	(9/2+)
488[&]	(11/2−)	1038[b]	(7/2−)	1437	
507[#]	(5/2−)	1100[b]	(5/2−)	1465	
507[a]	(7/2+)	1137[b]	(11/2−)	1488	
538		1174			

[†] Based on angular distributions and cross–section fingerprints.
[‡] FWHM=13 keV (1973Gr26).
[§] (A): 1/2[631].
[#] (B): 1/2[631]×0−.
[@] (C): 5/2[622].
[&] (D): 7/2[743]?
[a] (E): 7/2[624].
[b] (F): 1/2[761].
[c] (G): 1/2[620].
[d] (H): 7/2[613]?
[e] (I): 3/2[622]?

^{239}Pu(γ,γ') 2008Be31

Jπ(^{239}Pu g.s.)=1/2+.
E=2.8 MeV bremsstrahlung radiation provided by 4 MeV Van de Graaff electron accelerator at High Voltage Research Laboratory (HVRL), Massachusetts Institute of Technology (MIT) facility. Measured Eγ, Iγ using two HPGe detectors. Other: 2011Jo11.

^{239}Pu Levels

E(level)	Jπ	Integrated cross section (eV*b)[†]	Comments
0.0	1/2+[‡]		
7.861 *3*	3/2+[‡]		
2040.25 *21*	(1/2,3/2)[§]	8 *2*	
2046.9 *3*	(1/2,3/2)[§]	5 *2*	
2135.0? *4*	(1/2,3/2)[§]	4 *2*	
2143.56 *13*	(1/2,3/2)[§]	<17	Integrated cross section (eV*b): Total cross section estimated by evaluators.
2151.0 *3*	(1/2,3/2)[§]	12 *7*	Total cross section estimated by evaluators.
2289.0 *3*	(1/2,3/2)[§]	8 *2*	
2431.7 *3*	(1/2,3/2)[§]	19 *4*	
2454.4 *3*	(1/2,3/2)[§]	9 *3*	
2460.5 *4*	(1/2,3/2)[§]	6 *4*	
2464.6 *3*	(1/2,3/2)[§]	8 *4*	
2471.1 *3*	(1/2,3/2)[§]	6 *2*	

[†] The cross section data were normalized by 2008Be31 to that of the 2211–keV transition in ^{27}Al and its known strength.
[‡] From Adopted Levels.
[§] From expected dominance of dipole excitation in (γ,γ').

^{239}Pu(γ,γ') 2008Be31 (continued)

γ(^{239}Pu)

Eγ	E(level)	Comments
7.860† *3*	7.861	
2040.25 *21*	2040.25	
2046.9 *3*	2046.9	
2135.0‡§ *4*	2135.0?	Cross section=4 eVb *2*.
	2143.56	Cross section=4 eVb *2*. Eγ: placement is tentative since the energy difference is 8.6 keV *3* as compared to an expected 7.86 keV.
2143.56‡ *13*	2143.56	Cross section=13 eVb *2*.
	2151.0	Cross section=13 eVb *2*.
2151.0§ *3*	2151.0	Cross section=5 eVb *2*.
2289.02 *25*	2289.0	
2423.48 *22*	2431.7	Cross section=10 eVb *2*.
2431.66 *25*	2431.7	Cross section=9 eVb *3*.
2454.4 *3*	2454.4	
2460.5 *4*	2460.5	
2464.6 *3*	2464.6	
2471.1 *3*	2471.1	

† From Adopted Gammas.
‡ Multiply placed.
§ Placement of transition in the level scheme is uncertain.

^{239}Pu(n,n') 1982Ha34

E(n)=700, 3400 keV. Optical–model fit to data. Deduced deformations β(2)=0.220 *11*, β(4)=0.070 *7* (1982Ha34).

^{239}Pu Levels

E(level)	Jπ†
0.0	1/2+
8	3/2+
57	5/2+
76	7/2+
164	9/2+
193	11/2+
286	5/2+

† From Adopted Levels.

^{239}Pu(d,d') 1976Th01

E(d)=16–MeV, FWHM≈12 keV. σ(90°,125°) measured (1976Th01). Other measurement: 1973Gr26.

^{239}Pu Levels

E(level)	Jπ†	E(level)	Jπ†	E(level)
0.0‡	1/2+	491§ *4*	3/2−	824 *2*
57‡ *2*	5/2+	505§ *2*	5/2−	854 *2*
76‡ *2*	7/2+	555§ *2*	7/2−	900 *2*
164‡ *2*	9/2+	583§ *3*	9/2−	915 *3*
194‡ *2*	11/2+	659§ *3*	11/2−	948 *3*
317‡ *2*	13/2+	750 *3*		993 *3*
360‡ *2*	15/2+	779 *3*		1027 *2*
470§ *2*	1/2−	800 *3*		1062 *2*

Footnotes continued on next page

^{239}Pu(d,d') 1976Th01 (continued)

^{239}Pu Levels (continued)

† From 1976Th01 based upon cross section signature pattern for rotational bands.
‡ (A): 1/2[631].
§ (B): 1/2[631]×0− octupole vibration on g.s.

Coulomb Excitation 2005Zh20,1957Ne07

2005Zh20: ^{207}Pb beam, E=1300 MeV. Measured Eγ, Iγ, γγ, γγ(θ)(DCO) with the Gammasphere array of 101 Compton–suppressed HPGe detectors.
1993De12: 99.967% enriched ^{239}Pu target. Projectile: ^{117}Sn, E=42.9 MeV. Measured Eγ, γγ coin. Detector: Spin Spectrometer, an array of 45 NaI detectors and 18 BGO or NaI shielded, Compton–suppressed Ge detectors. Other: 1995Cr01.
1990StZZ: ^{239}Pu target. Projectile: ^{90}Zr, E=500 MeV. Measured Eγ, γγ coin. Detector: Ge(Li) array.
1957Ne07: ^{239}Pu target. Projectile: Alpha particles, E=2.85 MeV. Measured Eγ, Iγ. Detector: proportional counter.

^{239}Pu Levels

E(level)†	Jπ	Comments
0.0§	1/2+	
7.861‡# *2*	3/2+	
57.275‡§ *2*	5/2+	B(E2)=5.3 *3* (1957Ne07) using α=214.
75.705‡# *3*	7/2+	
163.76‡§ *3*	9/2+	
193.5# *8*	11/2+	
318.5§ *7*	13/2+	
359.2# *9*	15/2+	
469.8@	(1/2−)	
492.1&	(3/2−)	
505.6@	(5/2−)	
519.5§ *9*	17/2+	
556.0& *7*	(7/2−)	
570.9# *10*	19/2+	
583@	(9/2−)	
661.2& *8*	11/2−	
698.7@ *10*	13/2−	
764.7§ *10*	21/2+	
806.4& *9*	15/2−	
828.0# *11*	23/2+	
857.5@ *10*	17/2−	
992.5& *10*	19/2−	
1053.1§ *11*	25/2+	
1058.1@ *11*	21/2−	
1127.8# *13*	27/2+	
1219.4& *11*	23/2−	
1300.9@ *12*	25/2−	
1381.5§ *13*	29/2+	
1467.8# *14*	31/2+	
1487.4& *15*	27/2−	
1584.9@ *14*	29/2−	
1748.5§ *14*	33/2+	
1795.4& *18*	31/2−	
1847.0# *15*	35/2+	
1908.9@ *15*	33/2−	
2143.4& *21*	35/2−	
2152.2§ *16*	37/2+	
2263.0# *16*	39/2+	
2272.0@ *16*	37/2−	
2529.4& *23*	39/2−	
2590.1§ *17*	41/2+	
2672.0@ *17*	41/2−	
2714.0# *19*	43/2+	
2951.4& *25*	43/2−	

Continued on next page (footnotes at end of table)

Coulomb Excitation 2005Zh20,1957Ne07 (continued)

^{239}Pu Levels (continued)

E(level)†	Jπ	E(level)†	Jπ	E(level)†	Jπ
3060.1§ *20*	45/2+	3559.1§ *22*	(49/2+)	4080.0@ *24*	(53/2−)
3108.0@ *20*	45/2−	3578.0@ *22*	(49/2−)	4087.1§ *24*	(53/2+)
3198.0# *22*	47/2+	3713.0# *24*	(51/2+)	4256# *3*	(55/2+)
3407& *3*	47/2−	3895& *3*	51/2−	4413& *3*	55/2−

† Deduced by evaluators from least−squares fit to Eγ's; ΔEγ=1 keV assumed for each transition, unless otherwise noted.
‡ From ^{239}Pu in Adopted Gammas.
§ (A): 1/2[631], α=+1/2.
# (B): 1/2[631], α=−1/2.
@ (C): Octupole band, α=+1/2. Band associated with octupole vibration at low spin.
& (D): Octupole band, α=−1/2. Band associated with octupole vibration at low spin.

γ(^{239}Pu)

Eγ	E(level)	Mult.	Eγ	E(level)	Mult.	Eγ	E(level)	Mult.
7.860† *3*	7.861		257	828.0	E2§	425	2272.0	#
49.412† *4*	57.275	M1+E2‡	268	1487.4	(E2)@	436	3108.0	
57.273† *4*	57.275	E2	281	1748.5		438	2590.1	E2§
67.841† *7*	75.705	E2	284	1584.9	(E2)@	441	1908.9	#
88.06† *3*	163.76	M1+E2‡	287&	806.4	#	451	2714.0	E2§
106.47† *4*	163.76	E2		857.5	#	455	1219.4	#
118	193.5	E2§	288	1053.1	§	456	3407	
125	318.5		300	1127.8	§	457	1584.9	#
145	806.4	(E2)@	305	2152.2		470&	3060.1	E2§
155	318.5	E2§	308	1795.4	(E2)@		3578.0	
159	857.5		324	1908.9	(E2)@	473&	992.5	#
160	519.5		327	2590.1			1300.9	#
166&	359.2	E2§	328	1381.5	E2§	484	3198.0	E2§
	1219.4	#	340&	698.7	#	487	1058.1	#
173	1300.9	#		1467.8	E2§	488&	806.4	#
186	992.5	(E2)@	343	661.2	#		3895	
194	764.7		348	2143.4	(E2)@	497	661.2	#
201&	519.5	E2§	363	2272.0	(E2)@	498	857.5	#
	1058.1		367	1748.5	§	499&	556.0	#
212	570.9	E2§	379	1847.0	E2§		3559.1	E2
225	1053.1		386	2529.4		502	4080.0	
227	1219.4	(E2)@	392	556.0	#	505	698.7	#
228	992.5	#	400	2672.0		515	3713.0	
230	1058.1	#	404	2152.2	E2§	518	4413	
243	1300.9	(E2)@	409	2672.0	#	528	4087.1	
245	764.7	E2§	416	2263.0	E2§	543	4256	
254	1381.5		422	2951.4				

† From ^{239}Pu in Adopted Gammas.
‡ From Adopted Gammas.
§ γγ(θ) analysis supports stretched E2 transition (2005Zh02).
# Linking transition suggested by 2005Zh20 as E1.
@ From γ−ray angular distributions (1993De12).
& Multiply placed.

Adopted Levels, Gammas

Q(β⁻)=–1756 *54*; S(n)=7102 *51*; S(p)=4061.7 *17*; Q(α)=5922.4 *14* 2012Wa38.

^{239}Am Levels

Cross Reference (XREF) Flags

A ^{239}Cm ε Decay
B ^{243}Bk α Decay

E(level)	Jπ†	XREF	$T_{1/2}$	Comments
0.0‡	(5/2)–	AB	11.9 h *1*	Jπ: favored (HF=1.4) α–particle transition to ^{235}Np(49 keV, (5/2)–,5/2[523]). $T_{1/2}$: from 1972Po04. Others: 12.1 h *4* (1960Gl01), 11.9 h *5* (1972PoZS). %ε=99.990 *1*; %α=0.010 *1*. %ε, %α (1972Po04). Other measurements: 1960Gl01, 1952Hi63. Calculated $T_{1/2}$(^{32}Si)=1.3×10^{23} s (2012Ba35), 1.12×10^{23} s,8.1×10^{24} s (using two–different proximity potentials 2012Ku29). Calculated $T_{1/2}$(^{34}Si)=7.8×10^{26} s (2012Sa31). Other similar calculations: 2011Sa40, 2011Sh13, 2010Ni13.
40.7‡ *7*	(7/2–)	AB		
94‡ *6*	(9/2–)	B		
156‡ *7*	(11/2–)	B		
187.1§ *5*	(5/2+)	AB		Jπ: 146.4γ (E1) to (7/2–), 187.1γ (E1) to (5/2)–. Low HF(≈111) from ^{243}Bk α Decay is consistent with no spin flip (1972El21).
220§ *6*	(7/2+)	B		
260§ *6*	(9/2+)	B		
317§ *7*	(11/2+)	B		
≈370§	(13/2+)	B		
557# *6*	(3/2–)	B		Jπ: favored α Decay (HF≈4.1) from ^{243}Bk ((3/2–), 3/2[521]).
586# *6*	(5/2–)	B		Jπ: HF≈10 from ^{243}Bk α Decay suggests Jπ=(5/2–).
2500 *200*	(7/2+)		163 ns *12*	%SF≤100. SF isomer. $T_{1/2}$ from 1971Br38, 1972Br35. Others: 1969La14, 1973Fl03, 1970Vi05, 1985Ra28. $T_{1/2}$(SF) calc=161 ns (2005Re16). E(level): from ^{240}Pu(p,2n) (1972Br35,1969La14), ^{237}Np(α,2n) and ^{239}Pu(d,2n) (1971Br38). E=2.4 MeV (1980Bj02). μ=(+)2.6 *2* (2011StZZ). μ: g=0.74 *5* (1985Ra28). g–factor measured by perturbed angular correlation of fission fragments in a magnetic field (1985Ra28). Jπ: 7/2[404] orbital was assigned from g–factor by 1985Ra28 (g–factor was assumed to be positive).

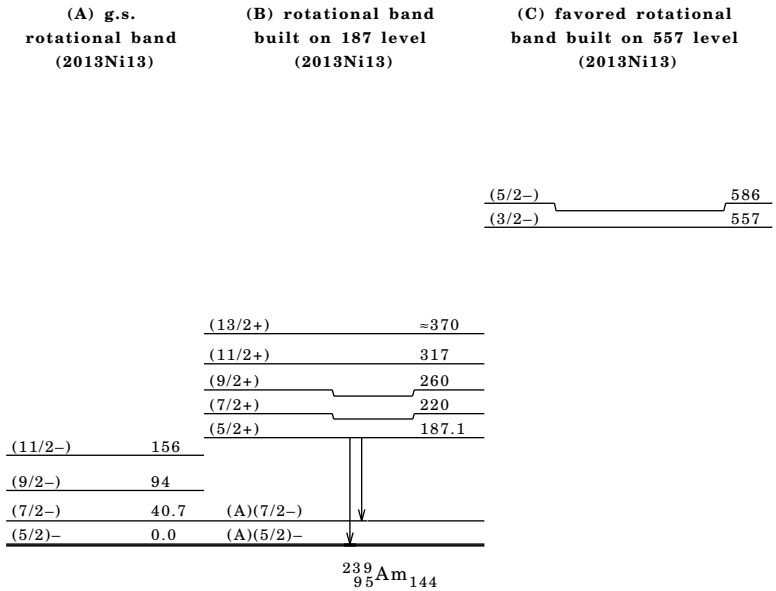
† From rotational band structure and systematics of Nilsson orbitals. Additional arguments for spin and parity assignments are given mostly for bandheads.
‡ (A): g.s. rotational band (2013Ni13).
§ (B): Rotational band built on 187 level (2013Ni13).
# (C): Favored rotational band built on 557 level (2013Ni13).

γ(^{239}Am)

E(level)	Eγ†	Iγ†	Mult.†	α
187.1	146.4 *5*	20 *8*	(E1)	0.215 *4*
	187.1 *5*	100 *25*	(E1)	0.1220 *19*

† From ^{243}Bk α decay.

Adopted Levels, Gammas (continued)



^{239}Cm ε Decay 1952Ca42,1958Va37

Parent ^{239}Cm: E=0; Jπ=(7/2−); $T_{1/2}$=2.7 h *8*; Q(g.s.)=1756 *54*; %ε+%β$^+$ decay=100.
^{239}Cm: $T_{1/2}$,Q(g.s.) From ^{239}Cm Adopted Levels.
2008Qi03: ^{239}Cm was produced via the fusion reaction ^{232}Th(^{12}C,5n), E=70–74 MeV. Curium was chemically separated. Measured Eγ, Iγ. Determined upper limit on α emission from ^{239}Cm: %α/%ε<0.00001.
The decay scheme is based on 2008Qi03, on unpublished results in 1952Ca42, 1958Va37, and ^{243}Bk α decay.

^{239}Am Levels

E(level)	Jπ†
0.0	(5/2)−
42	(7/2−)
188	(5/2+)

† From Adopted Levels.

β$^+$,ε Data

Eε	E(level)	Comments
(1570 *60*)	188	Iε: ε feeding to g.s. ((5/2)−) and 42–keV ((7/2−)) level is expected. Log *ft*: Iε<100% yields log *ft*>6.3. This value is consistent with a 5/2+,5/2[642] configuration assignment for this level. Similar transitions in neighboring nuclei have: log *ft*=6.59 in ^{239}Np (5/2+,5/2[642]) β$^-$ decay to the 391–keV level (7/2−,7/2[743]), log *ft*≤6.8 in ^{237}Pu (7/2−,7/2[743]) ε Decay to ^{237}Np (g.s., 5/2+,5/2[642]) Analogy to ^{237}Pu ε Decay suggests that ^{239}Cm ε Decay to ^{239}Am(g.s., 5/2−,5/2[523]) should be ≈12% (log *ft*=7.3), and to ^{239}Am(220 keV, 7/2+,5/2[642]), ≈9% (log *ft*=7.4).
(1710 *60*)	42	
(1760 *60*)	0.0	

^{239}Cm ε Decay 1952Ca42,1958Va37 (continued)

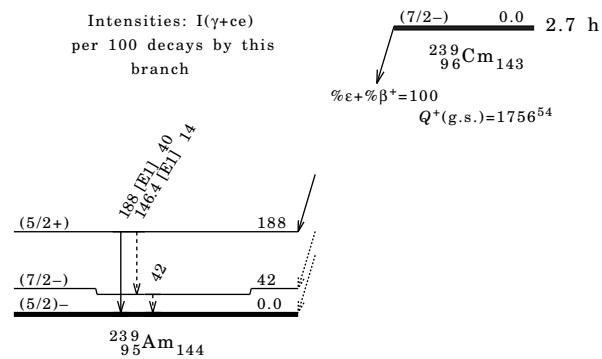
γ(^{239}Am)

Iγ normalization: Measured in 2008Qi03.

Eγ	E(level)	Iγ†‡	Mult.	α
42#	42			
146.4#	188	33	[E1]	0.215
188	188	100	[E1]	0.122

† From 2008Qi03.
‡ For absolute intensity per 100 decays, multiply by 0.36.
# Placement of transition in the level scheme is uncertain.

Decay Scheme



^{243}Bk α Decay 1966Ah02,1991Ry01

Parent ^{243}Bk: E=0.0; Jπ=(3/2−); $T_{1/2}$=4.5 h *2*; Q(g.s.)=6874 *4*; %α decay≈0.150.
αγ: 1956Ch77, 1966Ah02.
K x ray: Iγ=8 *3*.
2013Ni13: calculated branching ratios to three rotational bands. Others: 2011Zh36, 2010Ni02.

^{239}Am Levels

E(level)	Jπ†	$T_{1/2}$	E(level)	Jπ†	E(level)	Jπ†
0.0‡	(5/2)−	11.9 h *1*	187.1§ *5*	(5/2+)	≈370§	(13/2+)
40.7‡ *7*	(7/2−)		220§ *6*	(7/2+)	557# *6*	(3/2−)
94‡ *6*	(9/2−)		260§ *6*	(9/2+)	586# *6*	(5/2−)
156‡ *7*	(11/2−)		317§ *7*	(11/2+)		

† From adopted levels.
‡ (A): g.s. rotational band. Calculated α branching=29.8% (2013Ni13).
§ (B): Rotational band built on 187 level. Calculated α branching=52.8% (2013Ni13).
# (C): Favored rotational band built on 557 level calculated α branching=17.5% (2013Ni13).

α radiations

Eα†	E(level)	Iα‡#	HF§	Eα†	E(level)	Iα‡#	HF§
6185 *4*	586	3.9 *5*	≈10	6577 *4*	187.1	25.6 *16*	≈111
6213 *4*	557	13.6 *9*	≈4.1	6608 *5*	156	≈0.7	≈5560
≈6397	≈370	≈0.2	≈2120	6669 *4*	94	≈1.2	≈6060
6449 *5*	317	0.7 *2*	≈1060	6721 *4*	40.7	12.5 *9*	≈982
6505 *4*	260	6.9 *7*	≈195	6761 *4*	0.0	15.4 *10*	≈1190
6545 *4*	220	19.4 *13*	≈104				

Footnotes continued on next page

^{243}Bk α Decay 1966Ah02,1991Ry01 (continued)

α radiations (continued)

† From 1966Ah02 (semi) recalibrated by 1991Ry01.
‡ From 1966Ah02. Intensity per 100 α decays.
§ Using $r_0(^{239}Am)$=1.496, average of $r_0(^{238}Pu)$=1.5013 *10*, $r_0(^{240}Pu)$=1.4979 *7*, $r_0(^{238}Cm)$=1.490 *20*, and $r_0(^{240}Cm)$=1.495 *12* (1998Ak04). HF values are approximate because of the imprecise value of ≈0.15% for the alpha–particle branching.
# For α intensity per 100 decays, multiply by ≈0.0015.

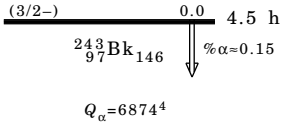
γ(^{239}Am)

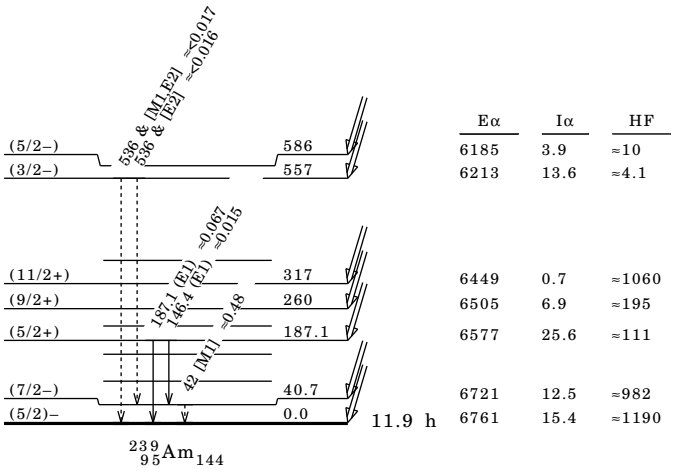
Eγ†	E(level)	Iγ‡#	Mult.	α	Comments
42@ *3*	40.7	4	[M1]	79 *20*	Iγ: is inconsistent with decay scheme; Iγ≤0.3 from transition intensity balance.
146.4 *5*	187.1	8 *3*	(E1)§	0.215 *4*	
187.1 *5*	187.1	40 *10*	(E1)§	0.1220 *19*	
536@& *10*	557	<10&	[E2]	0.0473 *22*	Eγ: probable unresolved doublet to g.s. and 40.7 levels. Iγ has not been divided.
	557	<10&	[M1,E2]	0.16 *11*	Eγ: probable unresolved doublet to g.s. and 40.7 levels. Iγ has not been divided.

† From 1966Ah02 (αγ–semi), 1956Ch77 (αγ–scin).
‡ Photon intensity per 100 α decays (1966Ah02,1956Ch77).
§ Multipolarity is E1 or E2 from relative photon and K x ray intensities. However, the ratio of reduced transition probabilities suggests E1 multipolarity.
# For absolute intensity per 100 decays, multiply by ≈0.0015.
@ Placement of transition in the level scheme is uncertain.
& Multiply placed; undivided intensity given.

Decay Scheme

Intensities: I(γ+ce) per 100 parent decays
& Multiply placed; undivided intensity given





Adopted Levels

Q(β⁻)=−3103 *SY*; S(n)=6368 *55*; S(p)=4564 *74*; Q(α)=6540 *50* 2012Wa38.
ΔQ(β⁻)=214 syst (2012Wa38).

^{239}Cm Levels

Cross Reference (XREF) Flags

A ^{243}Cf α Decay

E(level)	Jπ	XREF	$T_{1/2}$	Comments
0.0	(7/2−)		2.7 h *8*	$T_{1/2}$: Estimated by 2008Qi03 from 188.2γ(t). $T_{1/2}$=2.5 h *4* from 188γ(t), Am K x ray(t) (2002ShZS). Others: 3 h (1952Ca42) unpublished results, 2.9 h (1958Va37) unpublished results. Jπ: Nilsson orbital syst (1972El21) suggest 7/2[743]; The close lying 1/2[631] orbital is an unlikely assignment given the intense 188γ (deexciting the 5/2+ level in ^{239}Am), which suggests that ^{239}Cm populates the 188−keV (5/2+,5/2[642]) level. %ε=100; %α<0.001 (2008Qi03). No α observed; %α<0.001 (2008Qi03). In a private communication to 2008Qi03, 2002ShZS report three alpha events with an energy of 6.43 MeV *14* assigned to ^{239}Cm decay. Other %α<0.1 (1958Va37) $T_{1/2}$(α)≈11 d (theory, 1997Mo25) gives %α≈1. Assignment: ^{239}Pu(α,4n) (1952Ca42), parent of ^{239}Am (1958Va37).
≈242	(1/2+)	A		E(level): from Eα and syst value for Q(α)(^{243}Cf)=7420 (2012Wa38) (in ^{237}Pu the analogous level lies at 145 keV above the 7/2−,7/2[743] state). Jπ: favored α from 1/2[631] ^{243}Cf.

^{243}Cf α Decay

Parent ^{243}Cf: E=0.0; Jπ=(1/2+); $T_{1/2}$=10.7 min *5*; Q(g.s.)=7420 syst; %α decay≈14.0.
Q(α)=7420 keV, systematic value for ^{243}Cf g.s. decay (2012Wa38) suggests that the observed 7170− and 7060−keV α's feed levels in ^{239}Cm at about 130 and 242 keV, respectively.

^{239}Cm Levels

E(level)	Jπ†	Comments
0.0	(7/2−)	Alpha decay to this level was not detected (1967Fi04).
≈130?		
≈242	(1/2+)	

† From adopted levels.

α radiations

Eα‡	E(level)	Iα§#	HF†	Comments
7060 *10*	≈242	≈71	≈0.70	Iα: 7060α/7171α≈2.5 is given in 1967Fi04. HF: the α HF is low for J=1/2 (compare HF=2.7 and 2.5 for the favored transitions in the α decay of ^{239}Pu and ^{241}Cm, respectively) suggesting that the α branch for ^{243}Cf is <14%, as estimated in 1967Si08. Eα: 7050 *20* is reported in 1967Si08.
7170@ *10*	≈130?	≈29	≈4.5	Not seen by 1967Si08. It may have been obscured in their spectrum by the presence of the 7.22−MeV α from ^{244}Cf.

† Using r_0(^{239}Cm)=1.493, average of r_0(^{238}Cm)=1.490 *20* and r_0(^{240}Cm)=1.495 *12* (1998Ak04).
‡ Measurements of 1967Fi04 (semi). Other measurement: 1967Si08.
§ From 1967Fi04.
# For α intensity per 100 decays, multiply by ≈0.14.
@ Existence of this branch is questionable.

Adopted Levels

Q(β⁻)=–3995 *SY*; S(n)=8036 *SY*; S(p)=2483 *SY*; Q(α)=7200 *SY* 2012Wa38.
ΔQ(β⁻)=294 syst; ΔS(n)=328 syst; ΔS(p)=207 syst; ΔQ(α)=200 syst (2012Wa38).
Others:
Discovery of ^{239}Bk: 2013Fr02.
Calculated $T_{1/2}$ for α decay of ^{243}Es: 2013Zd01, 2011Sa40.
Calculated single–particle energies: 2004Pa40.

^{239}Bk Levels

Cross Reference (XREF) Flags

A ^{243}Es α Decay

E(level)	Jπ	XREF	Comments
0.0	(3/2−,7/2+)	A	%ε>99; %SF<1; %α<1. $T_{1/2}$: decay of ^{239}Bk was not detected. $T_{1/2}$≈100 s from systematics and theory (2010An08). No a nor SF observed (2010An08). Partial half–life estimates are: $T_{1/2}$(α)≈115 h (1997Mo25), $T_{1/2}$(ε)≈12 min (1973Ta30). Jπ: Jπ=3/2− or 7/2+ depending upon whether ^{243}Es g.s. Jπ is 7/2+ or 3/2− respectively. From syst 3/2[521] or 7/2[633] are the expected low–lying states. α HF suggests that 7/2+ is the g.s. (the HF for 7/2[633] to 3/2[521] should be a factor 4 bigger than the HF for 3/2[521]. to 7/2[633] transition because of phase space considerations).
47 *10*	(7/2+,3/2−)	A	Jπ: Jπ=7/2+ or 3/2− depending upon whether ^{243}Es g.s. Jπ is 7/2+ or 3/2−, respectively. Jπ: Configuration=7/2+[633] or 3/2−[521].
197? *14*		A	

^{243}Es α Decay 1973Es02,1989Ha27,2010An08

Parent ^{243}Es: E=0; Jπ=(7/2+,3/2−); $T_{1/2}$=23 s *3*; Q(g.s.)=8072 *10*; %α decay=61 *6*.
^{243}Es–$T_{1/2}$: Measured in 2010An08 from timing of 7893α.
^{243}Es–Q(α): From 2012Wa38.
^{243}Es: Configuration=7/2+[633] or 3/2−[521].
^{243}Es–%α decay: from ^{243}Es α decay (2010An08).
Decay scheme based on α–particle measurements and using Q(α) (^{243}Es)=8072 *10* (2012Wa38).
2010An08, 2006An13:
^{243}Es source obtained from ^{247}Md α decay.
^{247}Md was produced via ^{209}Bi(^{40}Ar,2n). ^{40}Ar beam with E=187 and 198 MeV from the UNILAC bombarded a 0.450 μg/cm^2 metallic ^{209}Bi target evaporated on a 40 μg/cm^2 Carbon backing. The target was covered with a 10 μg/cm^2 Carbon foil. The experiments were performed at the velocity filter SHIP at GSI.
Measured: α, γ, (recoil)α, half–lives, α decay branching ratios.
Detection system: at the focal plane of SHIP two time–of–flight detectors, an array of position–sensitive Si detectors and a Ge clover detector consisting of four Ge crystals were placed.
HIVAP code was used to predict the cross sections reported in 1989Ha27. Theoretical calculations: Woods–Saxon potential.

^{239}Bk Levels

E(level)	Jπ	Comments
0.0	(3/2−,7/2+)	
47 *10*	(7/2+,3/2−)	E(level): level not in 2010An08. Suggested from adopted Q(α).
197 *14*		

^{243}Es α Decay 1973Es02,1989Ha27,2010An08 (continued)

α radiations

Eα†	E(level)	Iα†‡#	HF§	Comments
7745@ *10*	197	3.8 *11*	15	Iα: Tentative α from α(ER) correlated events.
7850 *20*		14.6 *20*	18	
7893 *10*	47	71 *5*	2.6	Eα,Iα: Eα=7899 *3*, Iα=87 *12* in 1989Ha27. 1973Es02 reported one α group at Eα=7890 *20*.
7939@ *10*	0.0	11 *5*	24	Eα,Iα: From 1989Ha27. Eα: 2010An08 has not reported this α–particle. Iα: From Iα(7939)/Iα(7899)=(13 *7*)/(87 *12*)=0.149 *83* (1989Ha27) and Iα(7893)=79.4 *25* (2010An08).

† From 2010An08, unless otherwise specified.
‡ Renormalized by evaluators to intensities per 100 alpha–particle decays.
§ Using $r_0(^{239}Bk)$=1.49, average of $r_0(^{238}Cm)$=1.490 *20*, and $r_0(^{238}Cf)$=1.495 *12* (1998Ak04).
# For α intensity per 100 decays, multiply by 0.61 *6*.
@ Existence of this branch is questionable.

Adopted Levels

Q(β^-)=−5310 *SY*; S(n)=7103 *SY*; S(p)=3260 *SY*; Q(α)=7810 *SY* 2012Wa38.
ΔQ(β^-)=364 syst, ΔS(n)=364 syst, ΔS(p)=330 syst, ΔQ(α)=56 syst (2012Wa38).
Assignment: daughter of ^{243}Fm (1981Mu12,2013Fr02).

^{239}Cf Levels

Cross Reference (XREF) Flags

A ^{243}Fm α Decay

E(level)	XREF	$T_{1/2}$	Comments
(0.0)	A	39 s *+37−12*	%ε=?; %α=? $T_{1/2}$: from 1981Mu12. Calculated values of $T_{1/2}(\varepsilon)$: ≈100 s (1973Ta30); ≈5.6 s (1997Mo25). From α syst, %α>50. Calculated $T_{1/2}$(SF)=5.7×10^3 y (1994EfZW). Jπ: expected low−lying configurations are 5/2[633] and 3/2[631].

^{243}Fm α Decay 1981Mu12

Parent ^{243}Fm: E=0; Jπ=?; $T_{1/2}$=0.231 s *9*; Q(g.s.)=8693 *50*; %α decay=91 *3*.
^{243}Fm−$T_{1/2}$: from 2008Kh10 for 2700 *8*.55 MeV α's. Earlier value of 0.18 s *+8−4* based only on 10 α's.
^{243}Fm−%α decay: from 2008Kh10. Other value: %BR=40 *20* from α−α parent−daughter correlations (1981Mu12).
^{206}Pb(^{40}Ar,3n), E(Ar)=194 MeV; velocity filter; position−sensitive surface barrier detectors, α−α parent−daughter correlations; excitation curve (1981Mu12).

^{239}Cf Levels

E(level)
(0.0)

α radiations

Eα
8546 *25*

REFERENCES FOR A=239

1943Mi10 A.C.G.Mitchell, L.Slotin, J.Marshall, V.A.Nedzel, L.J.Brown, J.R.Pruett – CP–597 (1943)
1947Fe05 N.Feather, R.S.Krishnan – Proc.Cambridge Phil.Soc. 43, 267 (1947)
1951Gr34 R.L.Graham, R.E.Bell – Phys.Rev. 83, 222A (1951)
1952Ca42 R.J.Carr, G.H.Higgins – Priv.Comm., quoted by 1967LE24 (1967)
1952Fr25 M.S.Freedman, F.Wagner,Jr., D.W.Engelkemeir – Phys.Rev. 88, 1155 (1952)
1952Hi63 G.H.Higgins – Thesis, Univ.California (1952); UCRL–1796 (1952)
1952Se67 E.Segre – Phys.Rev. 86, 21 (1952)
1953As14 F.Asaro, S.G.Thompson, I.Perlman – Phys.Rev. 92, 694 (1953)
1955En07 D.Engelkemeir, L.B.Magnusson – Phys.Rev. 99, 135 (1955)
1955Sc08 J.F.Schooley, J.Rasmussen – UCRL–2932, p.63 (1955)
1955St98 F.Stephens, J.Hummel, F.Asaro, I.Perlman – Phys.Rev. 98, 261 (1955)
1956Ba95 S.A.Baranov, K.N.Shlyagin – At.Energ.USSR 1, 52 (1956); J.Nuclear Energy 3, 132 (1956)
1956Ch77 A.Chetham–Strode, Jr. – Thesis, Univ.California (1956); UCRL–3322 (1956)
1956Hu96 J.P.Hummel – Thesis, Univ.California (1956); UCRL–3456 (1956)
1956Ne17 J.O.Newton, B.Rose, J.Milsted – Phil.Mag. 1, 981 (1956)
1956St23 D.Strominger – Thesis, Univ.California (1956); UCRL–3374 (1956)
1956Wi25 L.Wish – Nucleonics 14, No.5, 102 (1956)
1957As70 F.Asaro, S.G.Thompson, F.S.Stephens,Jr., I.Perlman – Bull.Am.Phys.Soc. 2, No.8, 393 R1 (1957)
1957As83 F.Asaro, S.G.Thompson, F.S.Stephens, Jr., I.Perlman – Priv.Comm., quoted by 1964HY02 (1964)
1957As84 F.Asaro, F.S.Stephens, I.Perlman – Priv.Comm., quoted by 1960AS02 (1960)
1957Ew30 G.T.Ewan, J.W.Knowles, D.R.MacKenzie – Phys.Rev. 108, 1308 (1957)
1957Ho07 J.M.Hollander – Priv.Comm., quoted by 1960AS02 (1960)
1957Ne07 J.O.Newton – Nuclear Phys. 3, 345 (1957)
1957Sm77 W.G.Smith, W.M.Gibson, J.M.Hollander – Phys.Rev. 105, 1514 (1957)
1958Ch38 G.R.Choppin, S.G.Thompson – J.Inorg.Nucl.Chem. 7, 197 (1958)
1958Va37 R.Vandenbosch – Priv.Comm., quoted by 1967LE24 (1967)
1959Co63 R.D.Connor, I.L.Fairweather – Proc.Phys.Soc.(London) 74, 161 (1959)
1959Co93 D.Cohen, J.C.Sullivan, A.J.Zielen – J.Inorg.Nucl.Chem. 11, 159 (1959)
1959Ew90 G.T.Ewan, J.S.Geiger, R.L.Graham, D.R.MacKenzie – Phys.Rev. 116, 950 (1959)
1960As02 F.Asaro, F.S.Stephens, J.M.Hollander, I.Perlman – Phys.Rev. 117, 492 (1960)
1960Gl01 R.A.Glass, R.J.Carr, W.M.Gibson – J.Inorg.Nuclear Chem. 13, 181 (1960)
1960Un02 J.P.Unik – UCRL–9093, p.41 (1960)
1962Iv01 R.B.Ivanov, A.S.Krivokhatskii, V.G.Nedovesov – Izvest.Akad.Nauk SSSR, Ser.Fiz. 26, 976 (1962); Columbia Tech.Transl. 26, 984 (1963)
1962Si12 K.Siegbahn, F.Asaro – Phys.Letters 2, 323 (1962)
1963Ch07 P.R.Christensen – Nucl.Phys. 41, 17 (1963)
1963Dz07 B.S.Dzhelepov, R.B.Ivanov, V.G.Nedovesov, V.P.Chechev – Zh.Eksperim.i Teor.Fiz. 45, 1360 (1963); Soviet Phys.JETP 18, 937 (1964)
1963Fl01 E.Flamm, F.Asaro – Phys.Rev. 129, 290 (1963)
1963Le17 C.M.Lederer – Thesis, Univ.California (1963); UCRL–11028 (1963)
1964Ba26 S.A.Baranov, V.M.Kulakov, V.M.Shatinsky – Nucl. Phys. 56, 252 (1964)
1964Ba31 I.A.Baranov, A.S.Krivokhatskii, A.N.Silantev – Izv. Akad. Nauk SSSR, Ser. Fiz. 28, 1255 (1964); Bull. Acad. Sci. USSR, Phys. Ser. 28, 1154 (1965)
1964Bl11 K.J.Blinowska, P.G.Hansen, H.L.Nielsen, O.Schult, K.Wien – Nucl. Phys. 55, 331 (1964)
1964Hy02 E.K.Hyde, I.Perlman, G.T.Seaborg – The Nuclear Properties of the Heavy Elements, Vol.II, Prentice–Hall, Inc., Englewood Cliffs, N.J. (1964)
1964Ma24 B.E.F.Macefield, R.Middleton – Nucl.Phys. 59, 561 (1964)
1965Da04 D.W.Davies, J.M.Hollander – Nucl.Phys. 68, 161 (1965)
1965Ma17 B.P.K.Maier – Z.Physik 184, 143 (1965)
1966Ah02 I.Ahmad – Thesis, Univ.California (1966); UCRL–16888 (1966)
1966Ba07 S.A.Baranov, Y.F.Rodionov, V.M.Kulakov, V.M.Shatinskii – Yadern.Fiz. 4, 1108 (1966); Soviet J.Nucl.Phys. 4, 798 (1967)
1966Le13 C.M.Lederer, J.K.Poggenburg, F.Asaro, J.O.Rasmussen, I.Perlman – Nucl.Phys. 84, 481 (1966)
1966Qa01 S.M.Qaim – Nucl.Phys. 84, 411 (1966)
1966Sh16 R.K.Sheline, W.N.Shelton, T.Udagawa, E.T.Jurney, H.T.Motz – Phys.Rev. 151, 1011 (1966)
1967Ch12 R.N.Chanda, R.A.Deal, R.P.Schuman – IN–1048, p.31 (1967)
1967Fa01 F.Falk, S.Tornkvist, J.E.Thun, H.Snellman, K.Siegbahn, F.Asaro – Z.Physik 198, 106 (1967)
1967Fi04 P.R.Fields, R.F.Barnes, R.K.Sjoblom, J.Milsted – Phys.Lett. 24B, 340 (1967)
1967Gu08 C.Gunther, D.R.Parsignault – Nucl.Phys. A104, 588 (1967)
1967Hu03 J.M.R.Hutchinson – Phys.Rev. 157, 1093 (1967)
1967Le24 C.M.Lederer, J.M.Hollander, I.Perlman – Table of Isotopes, Sixth Edition, John Wiley and Sons, Inc., New York (1967)
1967Si08 T.Sikkeland, A.Ghiorso, J.Maly, M.J.Nurmia – Phys.Lett. 24B, 333 (1967)
1968Ba25 S.A.Baranov, V.M.Kulakov, V.M.Shatinskii – Yadern.Fiz. 7, 727 (1968); Soviet J.Nucl.Phys. 7, 442 (1968)
1968Ma06 D.R.Mackenzie, R.D.Connor – Nucl.Phys. A108, 81(1968)
1968Ob02 E.S.Oberhofer – Thesis, North Carolina State University (1968)
1968Va09 J.R.Van Hise, D.Engelkemeir – Phys.Rev. 171, 1325 (1968)
1969Al14 B.M.Aleksandrov, O.I.Grigorev, N.S.Shimanskaya – Yadern.Fiz. 10, 14 (1969); Soviet J.Nucl.Phys. 10, 8 (1970)
1969Bi12 C.B.Bigham, R.W.Durham, J.Ungrin – Can.J.Phys. 47, 1317 (1969)

REFERENCES FOR A=239 (CONTINUED)

1969Cl12 J.E.Cline, D.A.Tripp – Priv.Comm. (November 1969)
1969En02 D.Engelkemeir – Phys.Rev. 181, 1675 (1969)
1969Fu11 G.H.Fuller, V.W.Cohen – Nucl.Data Tables A5, 433 (1969)
1969Hu09 J.M.R.Hutchinson, W.B.Mann, C.N.Smith, J.K.Whittaker – Intern.J.Appl.Radiation Isotopes 20, 493 (1969)
1969Hu21 J.B.Hunt, J.C.Robertson, T.B.Ryves – J.Nucl.Energy 23, 705 (1969)
1969La14 N.L.Lark, G.Sletten, J.Pedersen, S.Bjornholm – Nucl.Phys. A139, 481 (1969)
1970An13 E.J.Ansaldo, L.Grodzins – Phys.Lett. 32B, 479 (1970)
1970Bu02 S.C.Burnett, H.C.Britt, B.H.Erkkila, W.E.Stein – Phys.Lett. 31B, 523 (1970)
1970By01 J.Byrne, R.J.D.Beattie, S.Benda, I.Collingwood – J.Phys.B 3, 1166 (1970)
1970OeZZ F.L.Oetting – Proc.Int.Conf.on Plutonium and Other Actinides, 4th, Santa Fe, New Mexico, M.A.Musil, Ed., The Metallurgical Soc., New York, Pt.1, p.154 (1970)
1970Po01 S.M.Polikanov, G.Sletten – Nucl.Phys. A151, 656 (1970)
1970To08 H.Ton, W.Beens, S.Roodbergen, J.Blok – Nucl.Phys. A155, 235 (1970)
1970Vi05 N.Vilcov – Stud.Cercet.Fiz. 22, 795 (1970)
1971Ar47 A.Artna–Cohen – Nucl.Data Sheets B6, 577 (1971)
1971Bb10 S.A.Baranov, V.M.Shatinskii, V.M.Kulakov – Yad.Fiz. 14, 1101 (1971); Sov.J.Nucl.Phys. 14, 614 (1972)
1971Br38 H.C.Britt, B.H.Erkkila – Phys.Rev. C4, 1441 (1971)
1971Ta17 B.Tamain, B.Pfeiffer, H.Wollnik, E.Konecny – Nucl.Phys. A173, 465 (1971)
1971Wa12 O.A.Wasson, R.E.Chrien, G.G.Slaughter, J.A.Harvey – Phys.Rev. C4, 900 (1971)
1972Ah02 I.Ahmad, M.Wahlgren – Nucl.Instrum.Methods 99, 333 (1972)
1972Bo16 H.Bolterauer – Z.Naturforsch. 27a, 1 (1972)
1972Bo46 L.M.Bollinger, G.E.Thomas – Phys.Rev. C6, 1322 (1972)
1972Br35 H.C.Britt, B.H.Erkkila, B.B.Back – Phys.Rev. C6, 1090 (1972)
1972El21 Y.A.Ellis, M.R.Schmorak – Nucl.Data Sheets B8, 345 (1972)
1972Er03 J.R.Erskine – Phys.Rev. C5, 959 (1972)
1972Ga04 Y.P.Gangrskii, V.N.Maykov, I.F.Kharisov, Y.M.Tsipenyuk – Yad.Fiz. 16, 271 (1972); Sov.J.Nucl.Phys. 16, 151 (1973)
1972Ga28 J.Gal, Z.Hadari, E.R.Bauminger, S.Ofer – Phys.Lett. 41B, 53 (1972)
1972Kr07 K.S.Krane, C.E.Olsen, W.A.Steyert – Phys.Rev. C5, 1671 (1972)
1972Po04 F.T.Porter, I.Ahmad, M.S.Freedman, R.F.Barnes, R.K.Sjoblom, F.Wagner,Jr., P.R.Fields – Phys.Rev. C5, 1738 (1972)
1972Po12 J.C.Post, A.H.W.Aten, Jr. – Radiochim.Acta 17, 117 (1972)
1972PoZS J.C.Post – Thesis, Univ.Amsterdam (1972)
1972Sc44 W.–D.Schmidt–Ott, J.C.McGeorge, R.W.Fink – Z.Phys. 255, 161 (1972)
1972Wo07 K.L.Wolf, J.P.Unik – Phys.Lett. 38B, 405 (1972)
1973Es02 P.Eskola, K.Eskola, M.Nurmia, A.Ghiorso – Phys.Fenn. 8, 357 (1973)
1973Fl03 A.Fleury, F.H.Ruddy, M.N.Namboodiri, J.M.Alexander – Phys.Rev. C7, 1231 (1973)
1973Gr26 T.Grotdal, L.Loset, K.Nybo, T.F.Thorsteinsen – Nucl.Phys. A211, 541 (1973)
1973Na35 T.Nagy – Magy.Fiz.Foly. 21, 555 (1973)
1973PaYM S.B.Patel, A.P.Agnihotry, K.P.Gopinathan, P.N.Tandon – INDC(SEC)–35/L, p.92 (1973)
1973PoZA D.N.Poenaru – IFA–CRD–54–1973 (1973)
1973Ta30 K.Takahashi, M.Yamada, T.Kondoh – At.Data Nucl.Data Tables 12, 101 (1973)
1974Ga41 Y.P.Gangrsky, B.N.Markov, Y.M.Tsypenyuk – Fortschr.Phys. 22, 199 (1974)
1974HeYW R.L.Heath – ANCR–1000–2 (1974)
1974Ma27 E.S.Macias, M.R.Zalutsky – Phys.Rev. A9, 2356 (1974)
1974Pa03 S.B.Patel, A.P.Agnihotry, P.N.Tandon, K.P.Gopinathan – Phys.Rev. C9, 1515 (1974)
1974Yu04 L.N.Yurova, A.V.Bushuev, V.I.Petrov, A.G.Inikhov, V.N.Ozerkov, V.V.Chachin – At.Energ. 36, 51 (1974); Sov.At.Energy 36, 52 (1974)
1975Al15 B.M.Aleksandrov, V.T.Antsiferov, L.S.Bulyanitsa, A.M.Geidelman, Y.S.Egorov, L.M.Krizhanskii, A.A.Lipovskii, V.G.Nedovesov, L.D.Preobrazhenskaya, L.A.Razumovskii, V.M.Smirnov, Y.V.Kholnov, Y.L.Chereshkevich, V.I.Sharalapov, G.E.Shchukin, K.I.Yakovlev, G.M.Yanchilenko – Izv.Akad.Nauk SSSR, Ser.Fiz. 39, 482 (1975); Bull.Acad.Sci.USSR, Phys.Ser. 39, No.3, 20 (1975)
1975BoZF H.Borner, W.F.Davidson, Do Huu Phuoc, P.Gottel, D.Heck, H.R.Koch, J.A.Pinston, R.Roussille, P.Van Assche – KFA/IKP–10/75, p.133 (1975)
1975MaXY P.Matussek – Proc.Int.Symp.on Neutron Capture Gamma Ray Spectroscopy and Related Topics, 2nd, Petten, The Netherlands, K.Abrahams, F.Stecher–Rasmussen, P.Van Assche, Eds., Reactor Centrum Nederland, p.655 (1975)
1975Pa04 J.C.Pate, K.R.Baker, R.W.Fink, D.A.McClure, N.S.Kendrick, Jr. – Z.Phys. A272, 169 (1975)
1975Vo01 T.von Egidy, T.W.Elze, J.R.Huizenga – Phys.Rev. C11, 529 (1975)
1975WeZA C.Weitkamp, P.Matussek, H.Ottmar – Proc.Int.Symp.Neutron Capture Gamma Ray Spectroscopy and Related Topics, 2nd, Petten, The Netherlands, K.Abrahams, F.Stecher–Rasmussen, P.Van Assche, Eds., Reactor Centrum Nederland, p.749 (1975)
1975Ya03 S.W.Yates, I.Ahmad, A.M.Friedman, F.J.Lynch, R.E.Holland – Phys.Rev. C11, 599 (1975)
1975Za11 M.R.Zalutsky, E.S.Macias – Phys.Rev. C12, 1076 (1975)
1976BaZZ S.A.Baranov, A.G.Zelenkov, V.M.Kulakov – Proc.Advisory Group Meeting on Transactinium Nucl.Data, Karlsruhe, Vol.III, p.249 (1976); IAEA–186 (1976)
1976BeZM A.G.Belov, Y.P.Gangrsky, B.Dalkhsuren, M.B.Miller – JINR–P6–9397 (1976)
1976BoYH H.Borner – Thesis, Univ.Munchen (1976)
1976GlZY G.Gleason – Priv.Comm. (July 1976)
1976Gu15 G.M.Gurevich, L.E.Lazareva, V.M.Mazur, G.V.Solodukhov, B.A.Tulupov – Nucl.Phys. A273, 326 (1976)
1976Th01 R.C.Thompson, J.R.Huizenga, T.W.Elze – Phys.Rev. C13, 638 (1976)

REFERENCES FOR A=239 (CONTINUED)

1977GoYZ U.Goerlach, D.Habs, M.Just, V.Metag, E.Mosler, J.Pedersen, J.Schukraft, P.Singer, H.J.Specht, G.Ulfert, C.O.Wene – Max–Planck Institut fur Keinphysik (Heidelberg), Jahresbericht 1977, p.51 (1977)

1977GoZH U.Goerlach, D.Habs, M.Just, V.Metag, E.Mosler, B.Neumann, P.Paul, J.Schukraft, P.Singer, H.J.Specht, G.Ulfert, C.O.Wene – Max–Planck Institut fur Keinphysik (Heidelberg), Jahresbericht 1976, p.49 (1977)

1977Ha01 D.Habs, V.Metag, H.J.Specht, G.Ulfert – Phys.Rev.Lett. 38, 387 (1977)

1977Ja08 A.H.Jaffey, H.Diamond, W.C.Bentley, K.F.Flynn, D.J.Rokop, A.M.Essling, J.Williams – Phys.Rev. C16, 354 (1977)

1977Jo09 M.W.Johnson, W.U.Schroder, J.R.Huizenga, W.K.Hensley, D.G.Perry, J.C.Browne – Phys.Rev. C15, 2169 (1977)

1977Li13 H.I.Liou, R.E.Chrien – Nucl.Sci.Eng. 62, 463 (1977)

1977St35 D.I.Starozhukov, Y.S.Popov, P.A.Privalova – At.Energ. 42, 319 (1977); Sov.At.Energy 42, 355 (1977)

1977VaZW V.I.Vakatov, H.Sodan, R.Kalpakchieva, Y.T.Oganesyan, Y.E.Penionzhkevich, V.N.Polyanskii, L.P.Chelnokov – JINR–P7–10123 (1977)

1978Bo12 H.G.Borner, H.R.Koch, H.Seyfarth, T.von Egidy, W.Mampe, J.A.Pinston, K.Schreckenbach, D.Heck – Z.Phys. A286, 31 (1978)

1978Cl03 D.A.Close, J.J.Malanify, J.P.Davidson – Phys.Rev. C17, 1433 (1978)

1978Er03 J.R.Erskine – Phys.Rev. C17, 934 (1978)

1978Ma45 S.F.Marsh, R.M.Abernathey, R.J.Beckman, R.K.Zeigler, J.E.Rein – Int.J.Appl.Radiat.Isotop. 29, 509 (1978)

1978Pr07 A.Prindle, J.Evans, R.Dupzyk, R.Nagle, R.Newbury – Int.J.Appl.Radiat.Isotop. 29, 517 (1978)

1978Se12 P.W.Seabaugh, K.C.Jordan – Int.J.Appl.Radiat.Isotop. 29, 489 (1978)

1979Ba02 H.Backe, L.Richter, D.Habs, V.Metag, J.Pedersen, P.Singer, H.J.Specht – Phys.Rev.Lett. 42, 490 (1979)

1979Bo30 H.G.Borner, G.Barreau, W.F.Davidson, P.Jeuch, T.von Egidy, J.Almeida, D.H.White – Nucl.Instrum.Methods 166, 251 (1979)

1979Mo25 V.K.Mozhaev, V.A.Dulin, Y.A.Kazanskii – At.Energ. 47, 55 (1979); Sov.At.Energy 47, 566 (1979)

1979Po20 Y.S.Popov, D.I.Starozhukov, V.B.Mishenev, P.A.Privalova, A.I.Mishchenko – At.Energ. 46, 111 (1979); Sov.At.Energy 46, 123 (1979)

1979Ry03 A.Rytz – At.Data Nucl.Data Tables 23, 507 (1979)

1980Bj02 S.Bjornholm, J.E.Lynn – Rev.Mod.Phys. 52, 725 (1980)

1980Gu20 W.Gunther, K.Huber, U.Kneissl, H.Krieger, H.Ries, H.Stroher, W.Wilke, H.J.Maier – Nucl.Phys. A350, 1 (1980)

1980Sc26 M.R.Schmorak – Nucl.Data Sheets 31, 283 (1980)

1980Wi06 W.W.Wilcke, M.W.Johnson, W.U.Schroder, D.Hilscher, J.R.Birkelund, J.R.Huizenga, J.C.Browne, D.G.Perry – Phys.Rev. C21, 2019 (1980)

1981Mu12 G.Munzenberg, S.Hofmann, W.Faust, F.P.Hessberger, W.Reisdorf, K.–H.Schmidt, T.Kitahara, P.Armbruster, K.Guttner, B.Thuma, D.Vermeulen – Z.Phys. A302, 7 (1981)

1981Se14 K.Seidel, A.Meister, D.Pabst, L.B.Pikelner – Dok.Akad.Nauk SSSR 256, 360 (1981); Sov.Phys. Doklady 26, No.1, p.54 (1981)

1982Ah04 I.Ahmad – Nucl.Instrum.Methods 193, 9 (1982)

1982Ha34 G.Haouat, J.Lachkar, Ch.Lagrange, J.Jary, J.Sigaud, Y.Patin – Nucl.Sci.Eng. 81, 491 (1982)

1983Ha44 K.Hardt, P.Schuler, C.Gunther, J.Recht, K.P.Blume – Z.Phys. A314, 83 (1983)

1984Ch05 R.E.Chrien, J.Kopecky – Nucl.Phys. A414, 281 (1984)

1984Va41 R.Vaninbroukx, G.Bortels, B.Denecke – Int.J.Appl.Radiat.Isotop. 35, 1081 (1984)

1985Dr09 A.A.Druzhinin, V.N.Polynov, A.M.Korochkin, E.A.Nikitin, L.I.Lagutina – At.Energ. 59, 68 (1985); Sov.At.Energy 59, 628 (1985)

1985Ge08 S.Gerstenkorn, P.Luc, F.Tomkins – Phys.Scr. 32, 195 (1985)

1985Ra28 M.H.Rafailovich, S.Vajda, E.Dafni, G.Schatz, S.Rolston, S.Y.Zhu, G.D.Sprouse – Phys.Lett. 163B, 327 (1985)

1986Be38 B.L.Berman, J.T.Caldwell, E.J.Dowdy, S.S.Dietrich, P.Meyer, R.A.Alvarez – Phys.Rev. C34, 2201 (1986)

1986LoZT A.Lorenz – IAEA Tech.Rept.Ser., No.261 (1986)

1986Ti03 G.A.Timofeev, V.V.Kalygin, P.A.Privalova – At.Energ. 60, 286 (1986); Sov.At.Energy 60, 341 (1986)

1986Zu01 J.D.Zumbro, R.A.Naumann, M.V.Hoehn, W.Reuter, E.B.Shera, C.E.Bemis, Jr., Y.Tanaka – Phys.Lett. 167B, 383 (1986)

1989Ab05 A.Abzouzi, M.S.Antony, V.B.Ndocko Ndongue – J.Radioanal.Nucl.Chem. 135, 1 (1989)

1989Ha27 Y.Hatsukawa, T.Ohtsuki, K.Sueki, H.Nakahara, I.Kohno, M.Magara, N.Shinohara, H.L.Hall, R.A.Henderson, C.M.Gannett, J.A.Leyba, R.B.Chadwick, K.E.Gregorich, D.Lee, M.J.Nurmia, D.C.Hoffman – Nucl.Phys. A500, 90 (1989)

1989Ho24 N.E.Holden – Pure Appl.Chem. 61, 1483 (1989)

1990Ab06 A.Abzouzi, M.S.Antony, V.B.Ndocko Ndongue, D.Oster – J.Radioanal.Nucl.Chem. 145, 361 (1990)

1990GlZZ K.M.Glover, A.L.Nichols – AERE–R–13822 (1990)

1990Iz01 I.N.Izosimov, L.A.Pleskachevsky, A.A.Rimsky–Korsakov, A.V.Stepanov, S.V.Khlebnikov, S.K.Cherezov, Yu.P.Gangrsky, B.N.Markov – J.Radioanal.Nucl.Chem. 143, 93 (1990)

1990Si12 E.Simeckova, P.Cizek, M.Finger, J.John, P.Malinsky, V.N.Pavlov – Hyperfine Interactions 59, 185 (1990)

1990StZZ M.A.Stoyer – Thesis, Univ.California (1990); LBL–29357 (1990)

1991Ad08 Yu.V.Adamchuk, M.A.Voskanyan, G.V.Muradyan, V.A.Stepanov – Yad.Fiz. 54, 3 (1991); Sov.J.Nucl.Phys. 54, 1 (1991)

1991Ka34 M.Kadri, J.J.Schleiffer, J.P.Adloff – J.Radioanal.Nucl.Chem. 154, 139 (1991)

1991Ma40 R.L.Macklin, R.B.Perez, G.de Saussure, R.W.Ingle – Ann.Nucl.Energy 18, 567 (1991)

1991Oi01 H.Oigawa, Y.Fujita, K.Kobayashi, S.Yamamoto, I.Kimura – J.Nucl.Sci.Technol.(Tokyo) 28, 879 (1991)

1991Po17 Yu.S.Popov, D.Kh.Srurov, I.B.Makarov, E.A.Erin, G.A.Timofeev – Radiokhimiya 33, 3 (1991); Sov.J.Radiochemistry 33, 1 (1991)

1991Ry01 A.Rytz – At.Data Nucl.Data Tables 47, 205 (1991)

1991Sh06 Y.Shiokawa, M.Yagi – J.Radioanal.Nucl.Chem. 149, 51 (1991)

1991Sz05 J.J.Szymanski, C.D.Bowman, J.D.Bowman, J.Knudson, S.Penttila, S.J.Seestrom, V.W.Yuan, J.E.Bush, C.M.Frankle, C.R.Gould, D.G.Haase, G.E.Mitchell, P.P.J.Delheij, H.Postma, N.R.Roberson, X.Zhu – Nucl.Phys. A527, 701c (1991)

1992Ga01 E.Garcia–Torano, M.L.Acena, G.Bortels, D.Mouchel – Nucl.Instrum.Methods Phys.Res. A312, 317 (1992)

REFERENCES FOR A=239 (CONTINUED)

1992Ge01 L.P.Geraldo, M.T.F.Cesar, M.A.P.V.Moraes – Nucl.Sci.Eng. 110, 128 (1992)

1992Ja05 N.Janeva, S.Toshkov, G.V.Muradyan, Yu.V.Grigorev, G.Georgiev, I.Sirakov, V.G.Tishin, Yu.S.Zamyatnin – Nucl.Instrum.Methods Phys.Res. A313, 266 (1992)

1992LaZP A.B.Laptev, O.A.Shcherbakov – Leningrad Nucl.Phys.Inst., 1990–1991 Ann.Rept., p.77 (1992)

1992Lo08 G.N.Lovchikova, A.V.Polyakov, S.E.Sukhikh, A.M.Trufanov – Yad.Fiz. 55, 2017 (1992); Sov.J.Nucl.Phys. 55, 1119 (1992)

1992Po13 H.Postma, J.D.Bowman, C.D.Bowman, J.E.Bush, P.P.J.Delheij, C.M.Frankle, C.R.Gould, D.G.Haase, J.Knudson, G.E.Mitchell, S.Penttila, N.R.Roberson, S.J.Seestrom, J.J.Szymanski, S.H.Yoo, V.W.Yuan, X.Zhu, and the TRIPLE Collaboration – Hyperfine Interactions 75, 153 (1992)

1992Qu01 E.Quang, G.F.Knoll – Nucl.Sci.Eng. 110, 282 (1992)

1992Sc18 M.R.Schmorak – Nucl.Data Sheets 66, 839 (1992)

1992Vo13 J.Voignier, S.Joly, G.Grenier – Nucl.Sci.Eng. 112, 87 (1992)

1992Zh12 X.Zhu, J.D.Bowman, C.D.Bowman, J.E.Bush, P.P.J.Delheij, C.M.Frankle, C.R.Gould, D.G.Haase, J.N.Knudson, G.E.Mitchell, S.Penttila, H.Postma, N.R.Roberson, S.J.Seestrom, J.J.Szymanski, V.W.Yuan, and the TRIPLE Collaboration – Phys.Rev. C46, 768 (1992)

1993De12 M.Devlin, D.Cline, K.G.Helmer, R.Ibbotson, C.Y.Wu, P.A.Butler, A.J.Cresswell, G.D.Jones, M.A.Stoyer, J.O.Rasmussen – Phys.Rev. C47, 2178 (1993)

1993De17 M.A.P.V.de Moraes, M.F.Cesar – Phys.Scr. 47, 519 (1993)

1993Ku03 G.A.Kudyaev, Yu.B.Ostapenko, V.V.Pashkevich, M.I.Svirin, G.N.Smirenkin – Yad.Fiz. 56, No 1, 51 (1993); Phys.Atomic Nuclei 56, 29 (1993)

1993ObZZ St.Oberstedt, J.Wartena, H.Weigmann, J.P.Theobald – Proc.Int.Conf.Nuclear Structure and Nuclear Reactions at Low and Intermediate Energies, Dubna, p.353 (1993); JINR E4–93–58 (1993)

1993Ro25 N.R.Roberson, C.D.Bowman, J.D.Bowman, P.P.J.Delheij, C.M.Frankle, C.R.Gould, D.G.Haase, J.N.Knudson, G.E.Mitchell, R.N.Mortensen, S.I.Penttila, H.Postma, S.J.Seestrom, J.J.Szymanski, S.A.Wender, S.H.Yoo, V.W.Yuan, X.Zhu – Nucl.Instrum.Methods Phys.Res. A326, 549 (1993)

1994EfZW A.D.Efimenko – Program and Thesis, Proc.44th Ann.Conf.Nucl.Spectrosc.Struct.At.Nuclei, Kharkov, p.165 (1994)

1994Mu20 G.V.Muradyan, V.A.Stepanov, M.A.Voskanyan – Nucl.Phys. A580, 236 (1994)

1994Ob01 S.Oberstedt, J.P.Theobald, H.Weigmann, J.A.Wartena, C.Burkholz – Nucl.Phys. A573, 467 (1994)

1995Cr01 A.J.Cresswell, M.Devlin, P.A.Butler, D.Cline, K.G.Helmer, R.Ibbotson, G.D.Jones, M.A.Stoyer, J.O.Rasmussen, C.Y.Wu – Phys.Rev. C51, 1025 (1995)

1995Ob01 S.Oberstedt, F.Gunsing – Nucl.Phys. A589, 435 (1995)

1995Ra25 M.U.Rajput, T.D.Mac Mahon – J.Radioanal.Nucl.Chem. 189, 51 (1995)

1995Yu01 S.Yuan, W.Yang, W.Mou, X.Zhang, Z.Li, X.Yu, J.Gu, Y.Guo, Z.Gan, H.Liu, J.Guo – Z.Phys. A352, 235 (1995)

1996Da24 Z.Dai, T.Lu – Z.Phys. A355, 415 (1996)

1996Eg02 I.M.Egorova, D.O.Eremenko, F.Malaguti, S.Yu.Platonov, O.V.Fotina, O.A.Yuminov – Bull.Rus.Acad.Sci.Phys. 60, 772 (1996)

1996Sa02 M.J.Savage, R.P.Springer – Phys.Rev. C53, 441 (1996); Erratum Phys.Rev. C54, 2786 (1996)

1996Sa23 D.Sardari, T.D.Mac Mahon, S.P.Holloway – Nucl.Instrum.Methods Phys.Res. A369, 486 (1996)

1996Sa24 A.M.Sanchez, P.R.Montero, F.V.Tome – Nucl.Instrum.Methods Phys.Res. A369, 593 (1996)

1996Vl01 G.Vladuca, A.Tudora, M.Sin – Roum.J.Phys. 41, 515 (1996)

1996Wo05 S.A.Woods, D.H.Woods, M.J.Woods, S.M.Jerome, M.Burke, N.E.Bowles, S.E.M.Lucas, C.Paton Walsh – Nucl.Instrum.Methods Phys.Res. A369, 472 (1996)

1996Yu05 G.Yue, M.O'Connor, J.J.Egan, G.H.R.Kegel – Nucl.Sci.Eng. 122, 366 (1996)

1996Yu06 S.–G.Yuan, W.–F.Yang, W.–T.Mou, X.–Q.Zhang, Z.–W.Li – Chin.Phys.Lett. 13, 896 (1996)

1997Ar09 J.D.T.Arruda–Neto, M.–L.Yoneama, J.F.Dias, F.Garcia, M.A.V.Reigota, V.P.Likhachev, F.Guzman, O.Rodriguez, J.Mesa – Phys.Rev. C55, 2471 (1997)

1997Gu17 F.Gunsing, K.Athanassopulos, F.Corvi, H.Postma, Yu.P.Popov, E.I.Sharapov – Phys.Rev. C56, 1266 (1997)

1997Li11 A.Likar, T.Vidmar – Nucl.Phys. A619, 57 (1997)

1997Mo25 P.Moller, J.R.Nix, K.–L.Kratz – At.Data Nucl.Data Tables 66, 131 (1997)

1997Vl01 G.Vladuca, M.Sin, A.Tudora – Ann.Nucl.Energy 24, 1127 (1997)

1997Vl02 G.Vladuca, M.Sin, A.Tudora – Ann.Nucl.Energy 24, 1141 (1997)

1998Ak04 Y.A.Akovali – Nucl.Data Sheets 84, 1 (1998)

1998Mi22 M.Mirea, F.Clapier, N.Pauwels, J.Proust – Nuovo Cim. 111A, 267 (1998)

1998Ob01 S.Oberstedt, F.Gunsing – Nucl.Phys. A636, 129 (1998)

1999Ho33 N.E.Holden – Pure Appl.Chem. 71, 2309 (1999)

2000Ho27 N.E.Holden, D.C.Hoffman – Pure Appl.Chem. 72, 1525 (2000); Erratum Pure Appl.Chem. 73, 1225 (2001)

2001Vl02 G.Vladuca, A.Tudora – Ann.Nucl.Energy 28, 689 (2001)

2001Vl04 G.Vladuca, A.Tudora – Ann.Nucl.Energy 28, 1653 (2001)

2002Be89 A.N.Behkami, Z.Kargar, N.Nasrabadi – Phys.Rev. C 66, 064307 (2002)

2002Da21 F.Dayras – Nucl.Instrum.Methods Phys.Res. A490, 492 (2002)

2002ShZS N.Shinohara, Yu.N.Novikov, G.Munzenberg, H.Wollnik, Y.Hatsukawa, M.Asai, K.Tsukada, A.Osa, M.Oshima, H.Haba, S.Ichikawa, Y.Nagame, A.V.Popov, D.M.Seliverstov – Japan Atomic Energy Res.Inst.Tandem VDG Ann.Rept., 2001, p.45 (2002); JAERI–Review 2002–029 (2002)

2002Si26 B.Singh, R.Zywina, R.B.Firestone – Nucl.Data Sheets 97, 241 (2002)

2003Ad31 G.G.Adamian, A.V.Andreev, N.V.Antonenko, S.P.Ivanova, R.V.Jolos, W.Scheid, T.M.Shneidman – Acta Phys.Pol. B34, 2147 (2003)

2003Ad34 G.G.Adamian, A.V.Andreev, N.V.Antonenko, S.P.Ivanova, N.Nenoff, W.Scheid, T.M.Shneidman – Acta Phys.Hung.N.S. 18, 311 (2003)

2003Br12 E.Browne – Nucl.Data Sheets 98, 665 (2003)

REFERENCES FOR A=239 (CONTINUED)

2003De17 D.S.Delion, A.Insolia, R.J.Liotta – Phys.Rev. C 67, 054317 (2003)
2003De44 R.D.Deslattes, E.G.Kessler, Jr., P.Indelicato, L.de Billy, E.Lindroth, J.Anton – Rev.Mod.Phys. 75, 35 (2003)
2003Hi21 S.Hilaire, Ch.Lagrange, A.J.Koning – Ann.Phys.(New York) 306, 209 (2003)
2003Ka23 M.Kaczmarczyk – Yad.Fiz. 66, 837 (2003); Phys.Atomic Nuclei 66, 804 (2003)
2003Ok01 S.Okuducu, H.Ahmadov – Phys.Lett. B 565, 102 (2003)
2004Fr11 W.A.Friedman – Phys.Rev. C 69, 031601 (2004)
2004Ha11 H.Harada, S.Nakamura, T.Fujii, H.Yamana – J.Nucl.Sci.Technol.(Tokyo) 41, 1 (2004)
2004Ko23 O.Koberl, R.Seiler, R.Chawla – Nucl.Sci.Eng. 146, 1 (2004)
2004Pa40 A.Parkhomenko, A.Sobiczewski – Acta Phys.Pol. B35, 2447 (2004)
2004Ro01 Y.Ronen – Ann.Nucl.Energy 31, 323 (2004)
2004Sa55 M.Samyn, S.Goriely, M.Bender, J.M.Pearson – Phys.Rev. C 70, 044309 (2004)
2004St02 S.Stoulos, M.Fragopoulou, M.Manolopoulou, A.Sosnin, M.Krivopustov, W.Westmeier, R.Brandt, M.Debeauvais, M.Zamani – Nucl.Instrum.Methods Phys.Res. A519, 651 (2004)
2005Pa73 A.Parkhomenko, A.Sobiczewski – Acta Phys.Pol. B36, 3115 (2005)
2005Re16 Z.Ren, C.Xu – Nucl.Phys. A759, 64 (2005)
2005Si30 S.K.Singhal, M.Bhatnagar, Prajapati, R.Kumar, G.C.Joshi, H.M.Agrawal – J.Phys.(London) G31, S1959 (2005)
2005Tr08 A.Trkov, G.L.Molnar, Zs.Revay, S.F.Mughabghab, R.B.Firestone, V.G.Pronyaev, A.L.Nichols, M.C.Moxon – Nucl.Sci.Eng. 150, 336 (2005)
2005Zh02 Q.Zhao, F.E.Close – J.Phys.(London) G31, L1 (2005)
2005Zh20 S.Zhu, R.V.F.Janssens, G.J.Lane, I.Wiedenhover, M.P.Carpenter, I.Ahmad, A.P.Byrne, P.Chowdhury, D.Cline, A.N.Deacon, G.D.Dracoulis, S.J.Freeman, N.J.Hammond, G.D.Jones, T.L.Khoo, F.G.Kondev, T.Lauritsen, C.J.Lister, A.O.Macchiavelli, E.F.Moore, D.Seweryniak, J.F.Smith, C.Y.Wu – Phys.Lett. B 618, 51 (2005)
2006An13 S.Antalic, B.Streicher, F.P.Hessberger, S.Hofmann, D.Ackermann, S.Saro, B.Sulignano – Acta Phys.Slovaca 56, 87 (2006)
2006En04 A.Enqvist, I.Pazsit, S.Pozzi – Nucl.Instrum.Methods Phys.Res. A566, 598 (2006)
2006Fr21 J.B.French, S.Rab, J.F.Smith, R.U.Haq, V.K.B.Kota – Can.J.Phys. 84, 677 (2006)
2006MuZX S.F.Mughabghab – Atlas of Neutron Resonances, 5ed., Resonance Parameters and Thermal Cross Sections, Z = 1–100, Elsevier, Amsterdam (2006)
2006Sh19 T.M.Shneidman, G.G.Adamian, N.V.Antonenko, R.V.Jolos – Phys.Rev. C 74, 034316 (2006)
2006Wo03 E.L.Wong, H.C.Griffin – Nucl.Instrum.Methods Phys.Res. A558, 441 (2006)
2007Bo19 L.Bonneau, T.Kawano, T.Watanabe, S.Chiba – Phys.Rev. C 75, 054618 (2007)
2007ChZX H.D.Choi, R.B.Firestone, R.M.Lindstrom, G.L.Molnar, S.F.Mughabghab, R.Paviotti Corcuera, Z.Revay, A.Trkov, V.Zerkin, C.Zhou – IAEA–STI/PUB/1263 (2007)
2007Ro08 G.Royer, C.Bonilla – J.Radioanal.Nucl.Chem. 272, 237 (2007)
2008Be31 W.Bertozzi, J.A.Caggiano, W.K.Hensley, M.S.Johnson, S.E.Korbly, R.J.Ledoux, D.P.McNabb, E.B.Norman, W.H.Park, G.A.Warren – Phys.Rev. C 78, 041601 (2008)
2008BeZV M.–M.Be, V.Chiste, C.Dulieu, E.Browne, V.Chechev, N.Kuzmenko, F.Kondev, A.Luca, M.Galan, A.Pearce, X.Huang – Monographie BIPM–5, Vol.4., Bureau International des Poids et Mesures (2008)
2008Do10 N.Doss, J.Tennyson – J.Phys.(London) B41, 125701 (2008)
2008Do12 T.Dong, Z.Ren – Phys.Rev. C 77, 064310 (2008)
2008Go10 V.M.Gorozhankin, M.–M.Be – Appl.Radiat.Isot. 66, 722 (2008)
2008Gr11 H.C.Griffin, K.Rengan – J.Radioanal.Nucl.Chem. 276, 731 (2008)
2008GrZS H.C.Griffin – Proc.4th.Intern.Conf.Fission and Properties of Neutron–Rich Nuclei, Sanibel Island, Florida (2007); J.H.Hamilton, A.V.Ramayya, H.K.Carter, Eds., p.264 (2008)
2008Ha01 Y.Han – Nucl.Sci.Eng. 158, 78 (2008)
2008Kh10 J.Khuyagbaatar, S.Hofmann, F.P.Hessberger, D.Ackermann, H.G.Burkhard, S.Heinz, B.Kindler, I.Kojouharov, B.Lommel, R.Mann, J.Maurer, K.Nishio, Yu.Novikov – Eur.Phys.J. A 37, 177 (2008)
2008Ku21 S.N.Kuklin, G.G.Adamian, N.V.Antonenko, W.Scheid – Int.J.Mod.Phys. E17, 2020 (2008)
2008Mu23 D.W.Muir, A.Mengoni, I.Kodeli – Nucl.Data Sheets 109, 2874 (2008)
2008ObZZ S.Oberstedt, A.Oberstedt, A.Plompen, V.Semkova, G.Lovestam, M.Gawrys – Proc.Intern.Conf.Nuclear Data for Science and Technology, Nice, France, April 22–27, 2007, O.Bersillon, F.Gunsing, E.Bauge, R.Jacqmin, and S.Leray, Eds., p.53 (2008); EDP Sciences, 2008
2008Qi03 Z.Qin, W.Bruchle, D.Ackermann, K.Eberhardt, F.P.Hessberger, E.Jager, J.V.Kratz, P.Kuusiniemi, D.Liebe, G.Munzenberg, D.Nayak, Yu.N.Novikov, M.Schadel, B.Schausten, E.Schimpf, A.Semchenkov, B.Sulignano, P.Thorle, X.L.Wu – Radiochim.Acta 96, 455 (2008)
2008Re07 Zs.Revay – J.Radioanal.Nucl.Chem. 276, 825 (2008)
2009Ch04 M.B.Chadwick, R.C.Little, T.Kawano, P.Talou, D.Viera, M.Jandel, T.A.Bredeweg, M.C.White, A.P.Tonchev, J.A.Becker – Ann.Nucl.Energy 36, 258 (2009)
2009De04 H.Derrien, A.Courcelle, L.C.Leal, N.M.Larson – Nucl.Sci.Eng. 161, 131 (2009)
2009Dr05 R.Dressler, R.Eichler, D.Schumann, S.Shishkin – Phys.Rev. C 79, 054605 (2009)
2009Go05 S.Goriely, S.Hilaire, A.J.Koning, M.Sin, R.Capote – Phys.Rev. C 79, 024612 (2009)
2009Mi02 N.Minkov, S.Drenska, M.Strecker, W.Scheid – J.Phys.(London) G36, 025108 (2009)
2009Mi28 F.Minato, S.Chiba, K.Hagino – Nucl.Phys. A831, 150 (2009)
2009Ra27 A.A.Raduta, C.M.Raduta, A.Faessler – Phys.Rev. C 80, 044327 (2009)
2009So02 P.C.Sood, O.S.K.S.Sastri, R.K.Jain – Eur.Phys.J. A 39, 101 (2009)
2010Ad13 J.Adam, K.Katovsky, M.Majerle, M.I.Krivopustov, V.Kumar, C.Bhatia, M.Sharma, A.A.Solnyshkin, V.M.Tsoupko–Sitnikov – Eur.Phys.J. A 43, 159 (2010)

REFERENCES FOR A=239 (CONTINUED)

2010An08 S.Antalic, F.P.Hessberger, S.Hofmann, D.Ackermann, S.Heinz, B.Kindler, I.Kojouharov, P.Kuusiniemi, M.Leino, B.Lommel, R.Mann, S.Saro – Eur.Phys.J. A 43, 35 (2010)

2010BeZQ M.–M.Be, V.Chiste, C.Dulieu, X.Mougeot, E.Browne, V.Chechev, N.Kuzmenko, F.Kondev, A.Luca, M.Galan, A.L.Nichols, A.Arinc, X.Huang – Monographie BIPM–5, vol.5., Bureau International des Poids et Mesures (2010)

2010Co02 N.Colonna, and The n_TOF Collaboration – Appl.Radiat.Isot. 68, 643 (2010)

2010Ha06 Y.Han, Y.Xu, H.Liang, H.Guo, Q.Shen – Phys.Rev. C 81, 024616 (2010)

2010Ni02 D.Ni, Z.Ren – Phys.Rev. C 81, 024315 (2010)

2010Ni13 D.Ni, Z.Ren – Phys.Rev. C 82, 024311 (2010)

2010Pr07 B.Pritychenko, S.F.Mughabghab, A.A.Sonzogni – At.Data Nucl.Data Tables 96, 645 (2010)

2011Ad15 G.G.Adamian, N.V.Antonenko, S.N.Kuklin, B.N.Lu, L.A.Malov, S.G.Zhou – Phys.Rev. C 84, 024324 (2011)

2011Ad18 J.Adam, C.Bhatia, K.Katovsky, V.Kumar, M.Majerle, V.S.Pronskikh, A.M.Khilmanovich, B.A.Martsynkevich, I.V.Zhuk, V.M.Golovatiouk, W.Westmeier, A.A.Solnyshkin, V.M.Tsoupko–Sitnikov, A.S.Potapenko – Eur.Phys.J. A 47, 85 (2011)

2011Bu11 J.T.Burke, J.J.Ressler, J.E.Escher, N.D.Scielzo, I.J.Thompson, R.Henderson, J.Gostic, L.Bernstein, D.Bluel, M.Weideking, V.Meot, O.Roig, L.W.Phair, R.Hatarik, J.Munson, C.Angell, B.Goldblum, C.W.Beausang, T.Ross, R.Hughes, M.Aiche, G.Barreau, N.Cappelan, S.Czajkowski, B.Hass, B.Jurado, L.Mathieu, I.Companis – J.Korean Phys.Soc. 59, 1892s (2011)

2011Ch57 M.B.Chadwick, M.Herman, P.Oblozinsky, M.E.Dunn, Y.Danon, A.C.Kahler, D.L.Smith, B.Pritychenko, G.Arbanas, R.Arcilla, R.Brewer, D.A.Brown, R.Capote, A.D.Carlson, Y.S.Cho, H.Derrien, K.Guber, G.M.Hale, S.Hoblit, S.Holloway, T.D.Johnson, T.Kawano, B.C.Kiedrowski, H.Kim, S.Kunieda, N.M.Larson, L.Leal, J.P.Lestone, R.C.Little, E.A.McCutchan, R.E.MacFarlane, M.MacInnes, C.M.Mattoon, R.D.McKnight, S.F.Mughabghab, G.P.A.Nobre, G.Palmiotti, A.Palumbo, M.T.Pigni, V.G.Pronyaev, R.O.Sayer, A.A.Sonzogni, N.C.Summers, P.Talou, I.J.Thompson, A.Trkov, R.L.Vogt, S.C.van der Marck, A.Wallner, M.C.White, D.Wiarda, P.G.Young – Nucl.Data Sheets 112, 2887 (2011)

2011Go05 S.Goriely, S.Hilaire, A.J.Koning, R.Capote – Phys.Rev. C 83, 034601 (2011)

2011Go28 S.Goriely, S.Hilaire, A.J.Koning, R.Capote – J.Korean Phys.Soc. 59, 979s (2011)

2011He12 R.–D.Herzberg, D.M.Cox – Radiochim.Acta 99, 441 (2011)

2011Ho11 S.T.Holloway, T.Kawano, P.Moller – J.Korean Phys.Soc. 59, 875s (2011)

2011Hu06 P.Huber – Phys.Rev. C 84, 024617 (2011); Erratum Phys.Rev. C 85, 029901 (2012)

2011Jo11 M.S.Johnson, J.M.Hall, D.P.McNabb, J.L.McFarland, E.B.Norman, W.Bertozzi, S.E.Korbly, R.J.Ledoux, W.H.Park – J.Korean Phys.Soc. 59, 1414s (2011)

2011Ki09 Y.Kimura, M.Saito, H.Sagara – J.Nucl.Sci.Technol.(Tokyo) 48, 715 (2011)

2011Mu04 T.Mukhopadhyay, J.Lahiri, D.N.Basu – Ann.Nucl.Energy 38, 1452 (2011)

2011Mu07 Th.A.Mueller, D.Lhuillier, M.Fallot, A.Letourneau, S.Cormon, M.Fechner, L.Giot, T.Lasserre, J.Martino, G.Mention, A.Porta, F.Yermia – Phys.Rev. C 83, 054615 (2011)

2011Ro24 D.Rochman, A.J.Koning – Nucl.Sci.Eng. 169, 68 (2011)

2011Ro44 D.Rochman, A.J.Koning, D.F.Dacruz, S.C.van der Marck – J.Korean Phys.Soc. 59, 1191s (2011)

2011Sa40 K.P.Santhosh, B.Priyanka, J.G.Joseph, S.Sahadevan – Phys.Rev. C 84, 024609 (2011)

2011Sh13 Z.–q.Sheng, D.–d.Ni, Z.–z.Ren – J.Phys.(London) G38, 055103 (2011)

2011StZZ N.J.Stone – INDC(NDS)–0594 (2011)

2011Ul01 J.L.Ullmann, A.J.Couture, A.L.Keksis, D.J.Vieira, J.M.O'Donnell, J.M.Wouters, M.Jandel, R.C.Haight, R.S.Rundberg, T.A.Bredeweg, T.Kawano, C.Y.Wu, J.A.Becker, A.Chyzh, B.Baramsai, G.E.Mitchell, M.Krticka – J.Korean Phys.Soc. 59, 1406s (2011)

2011Yo12 T.Yoshida, N.Hagura, R.Umezu, A.Algora, J.L.Tain, D.Jordan, T.Tachibana – J.Korean Phys.Soc. 59, 1543s (2011)

2011Zh36 X.Zhang, C.Xu, Z.Ren – Phys.Rev. C 84, 044312 (2011)

2012Ba35 X.J.Bao, H.F.Zhang, B.S.Hu, G.Royer, J.Q.Li – J.Phys.(London) G39, 095103 (2012)

2012Ba38 E.Bauge, G.Belier, J.Cartier, A.Chatillon, J.M.Daugas, J.P.Delaroche, P.Dossantos–Uzarralde, H.Duarte, N.Dubray, M.Ducauze–Philippe, L.Gaudefroy, G.Gosselin, T.Granier, S.Hilaire, H.–T.P.Chau, J.M.Laborie, B.Laurent, X.Ledoux, C.Le Luel, V.Meot, P.Morel, B.Morillon, O.Roig, P.Romain, J.Taieb, C.Varignon, N.Authier, P.Casoli, B.Richard – Eur.Phys.J. A 48, 113 (2012)

2012Br11 P.A.Bradley, G.P.Grim, A.C.Hayes, Gerard Jungman, R.S.Rundberg, J.B.Wilhelmy, G.M.Hale, R.C.Korzekwa – Phys.Rev. C 86, 014617 (2012)

2012Ch30 V.P.Chechev – Appl.Radiat.Isot. 70, 1871 (2012)

2012Ha06 A.C.Hayes, H.R.Trellue, M.M.Nieto, W.B.Wilson – Phys.Rev. C 85, 024617 (2012)

2012Ku29 R.Kumar – Phys.Rev. C 86, 044612 (2012)

2012Le17 L.Leal, K.Guber, D.Wiarda, G.Arbanas, H.Derrien, R.Sayer, N.Larson, M.Dunn – Nucl.Data Sheets 113, 3101 (2012)

2012Na16 H.Naik, S.V.Surayanarayana, V.K.Mulik, P.M.Prajapati, B.S.Shivashankar, K.C.Jagadeesan, S.V.Thakare, D.Raj, S.C.Sharma, P.V.Bhagwat, S.D.Dhole, S.Ganesan, V.N.Bhoraskar, A.Goswami – J.Radioanal.Nucl.Chem. 293, 469 (2012)

2012Pr13 B.Pritychenko, S.F.Mughabghab – Nucl.Data Sheets 113, 3120 (2012)

2012PrZZ B.Pritychenko – Astrophysics, InTech, I.Kucuk Ed., p.21 (2012)

2012Ro34 G.Royer, M.Jaffre, D.Moreau – Phys.Rev. C 86, 044326 (2012)

2012Sa31 K.P.Santhosh, B.Priyanka, M.S.Unnikrishnan – Nucl.Phys. A889, 29 (2012)

2012Tu03 A.Tudora, F.–J.Hambsch, S.Oberstedt – Nucl.Phys. A890–891, 77 (2012)

2012Wa38 M.Wang, G.Audi, A.H.Wapstra, F.G.Kondev, M.MacCormick, X.Xu, B.Pfeiffer – Chin.Phys.C 36, 1603 (2012)

2013De19 C.L.Dembia, G.D.Recktenwald, M.R.Deinert – Prog.Nucl.Energy 67, 124 (2013)

2013Fe03 A.I.Feoktistov, V.T.Kupryashkin, L.P.Sidorenko, V.A.Lashko – Ukr.J.Phys. 58, 109 (2013)

2013Fr02 C.Fry, M.Thoennessen – At.Data Nucl.Data Tables 99, 96 (2013)

2013Fr03 C.Fry, M.Thoennessen – At.Data Nucl.Data Tables 99, 345 (2013)

2013He11 A.Hernandez–Solis, C.Demaziere, C.Ekberg – Ann.Nucl.Energy 57, 230 (2013)

2013Ni13 D.Ni, Z.Ren – Phys.Rev. C 88, 014325 (2013)

REFERENCES FOR A=239 (CONTINUED)

2013Zd01 A.Zdeb, M.Warda, K.Pomorski – Phys.Rev. C 87, 024308 (2013)