Nuclear Data Sheets for $A = 238^*$

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

General Comments: The evaluators present here spectroscopic data and level schemes from radioactive decay and nuclear reaction studies for nuclei with mass number $A=238$.

This publication, which is an update of the 2002 version of evaluated data for $A=238$, includes recent data for $^{238}\text{U}(\gamma, \gamma')$ from 2012Ha12, and for $^{238}\text{U}(n, n'\gamma)$ from 2014Go06.

The theoretical conversion coefficients for γ rays given in this evaluation are from 2002Ba85 and have been interpolated using the computer code BRICC (Band Raman Internal Conversion Coefficients) (2005KiZT).

Cutoff Date: All data received by June 2014 have been evaluated.

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NUCLEAR DATA SHEETS

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Skeleton Scheme for A=238

Skeleton Scheme for A=238 (continued)

Ground-State and Isomeric-Level Properties					
Nuclide	Level	J π	T _{1/2}	Decay Modes	
²³⁸ Th	0.0	0+	9.4 min 20	%β ⁻ =100	
²³⁸ Pa	0.0	(3-)	2.28 min 10	%β ⁻ =100	
²³⁸ U	0.0	0+	4.468×10 ⁹ y 6	%SF=5.45×10 ⁻⁵ 7; %α=100	
	2557.9	0+	280 ns 6	%IT=97.4 4; %SF=2.6 4	
²³⁸ Np	0.0	2+	2.099 d 2	%β ⁻ =100	
	2300		112 ns 39	%SF≤100	
²³⁸ Pu	0.0	0+	87.7 y 1	%α=100; %SF=1.9×10 ⁻⁷ 1	
	≈2400		0.6 ns 2	%SF≤100	
	≈3500	(0+)	6.0 ns 15	%SF≤100	
²³⁸ Am	0.0	1+	98 min 2	%α=1.0×10 ⁻⁴ 4; %ε+%β ⁺ =100	
	≈2500		35 μs	%SF≤100	
²³⁸ Cm	0.0	0+	2.2 h 4	%α=3.84 18; %ε=96.16 18; %SF=0.048 2	
²³⁸ Bk	0.0		144 s 5	%ε+%β ⁺ =100; %εF=0.048 20	
²³⁸ Cf	0.0	0+	21.1 ms 13	%SF>95; %α<5	
²⁴² Pu	0.0	0+	3.73×10 ⁵ y 3	%α=100	
²⁴² Am	48.63	5-	141 y 2	%α=4.59×10 ⁻¹ 12; ...	
²⁴² Cm	0.0	0+	162.86 d 8	%α=100	
²⁴² Cf	0.0	0+	3.49 min 12	%α=?; ...	
²⁴² Es	0.0		17.8 s 16	%α=43 3; ...	

Adopted Levels

Q(β⁻)=1700 300; S(n)=5400 300; S(p)=8900 500; Q(α)=3300 300 2012Wa38.
Others:
Discovery of ²³⁸Th discussed in 2013Fr03.
Nuclear Structure: 2013Af01, 2013Ic01, 2013Li30, 2010Gu18, 2005Po01, 2003Po15.
Assignment: ²³⁸U(1080-MeV ¹⁸O, ¹⁸Ne) chem, p ²³⁸U (1999He01).

²³⁸Th Levels

E(level)	Jπ	T _{1/2}	Comments
0.0	0+	9.4 min 20	%β ⁻ =100. T _{1/2} : from 1999He01. Value also reported in 1999Yu08 and 1999Xi05 where an 89.0 γ ray with T _{1/2} =8.9 min 15 has been tentatively assigned to the β ⁻ decay of ²³⁸ Th. If this assignment is correct, these two half life measurements could be combined to obtain an improved value.

Adopted Levels

Q(β⁻)=3585 16; S(n)=4705 21; S(p)=6350 22; Q(α)=3628 21 2012Wa38.
Others:
Discovery of ²³⁸Pa discussed in 2013Fr03.
Cluster decay: ²³F, ²⁴Ne (2012Sa31).
Mass measurements: 2012Zh46, 2012Ch19.
Nuclear structure: 2008Do12.
Nuclear Reactions: ²³⁸U(n,p), deduced σ (2011Ha46).
Assignment: ²³⁸U(14-MeV n,p) chem, p ²³⁸U (1968Tr07).

²³⁸Pa Levels

E(level)	Jπ	T _{1/2}	Comments
0.0	(3-)	2.28 min 10	%β ⁻ =100. T _{1/2} : weighted average of 2.3 min 1 (1968Tr07), 1.8 min 6 (1967BeZZ), and 2.1 min 4 (1999Yu08,1999Xi05). Jπ: configuration ([1/2[530]+]) ([5/2[622]+]) as for the 91th proton in the ground states of ²³¹ Pa and ²³³ Pa, and 147th neutron in the ground states of ²⁴¹ Pu and ²³⁹ U.

²³⁸Th β⁻ Decay 1999He01,1999Xi05

Parent ²³⁸Th: E=0.0; Jπ=0+; T_{1/2}=9.4 min 20; Q(g.s.)=1.7×10³ 3; %β⁻ decay=100.

²³⁸Pa Levels

E(level)	Jπ	T _{1/2}	Comments
0.0	(3-)	2.28 min 10	T _{1/2} : From Adopted Levels.

γ(²³⁸Pa)

E_γ

x89

x γ ray not placed in level scheme.

Adopted Levels, Gammas

$Q(\beta^-) = -147.4$ 12; $S(n) = 6154.3$ 13; $S(p) = 7507$ 13; $Q(\alpha) = 4269.7$ 29 2012Wa38.

Discovery of ^{238}U : 2013Fr03.

^{238}U double-beta decay: 2013St19, 2012Ko10, 2012Zu07, 2011Ba28, 2010Ba07, 2008RaZX, 2006Ba35, 2006BaZZ, 2005Tr01, 2004Ra13, 2003Cr04, 2003Fi13, 2002Ba52, 2002Hi09, 2002Tr04.

Cluster decay:

$^{238}\text{U}(^{30}\text{Mg})$: 2012Ku29, 2010Ni13.

$^{238}\text{U}(^{20}\text{O}, ^{22}\text{Ne}, ^{24}\text{Ne}, ^{25}\text{Ne}, ^{26}\text{Ne}, ^{28}\text{Mg}, ^{29}\text{Mg}, ^{30}\text{Mg})$: 2012Sa31.

$^{238}\text{U}(^{34}\text{Si})$: 2013Ta07, 2012Ta10, 2010Si12, 2009Ar11.

$^{238}\text{U}(^{28}\text{Mg})$: 2011Wa30.

$^{238}\text{U}(p, p')$: Measured σ (2010Ha06).

$^{238}\text{U}(p, p')$: $E = 20, 26, 65$ MeV (2005YuZZ).

$^{238}\text{U}(p, p')$: $E = 20-65$ MeV (2004Su12).

$^{238}\text{U}(p, p')$: Others: 2011Ma89, 2008Li05.

$^{238}\text{U}(\text{SF})$: 2010Sa09, 2008Sa24.

Nuclear Structure:

2014Lu01, 2014Ne03, 2014Vi01.

2013Af01, 2013Ag06, 2013Bo24, 2013Gi06, 2013Jo05, 2013Li30, 2013Ni02, 2013Ra05, 2013Se17, 2013To12, 2013Zo02.

2012Bu08, 2012Fr06, 2012Go13, 2012Hi11, 2012Is08, 2012Ja08, 2012Jo02, 2012Ko06, 2012Ku23, 2012Lu02, 2012Na10, 2012Ne04, 2012Pr09, 2012Re06, 2012Ro29, 2012Ro34.

2011Af04, 2011Bo12, 2011Ch65, 2011Du30, 2011Hi13, 2011In03, 2011Ko35, 2011Le21, 2011Li44, 2011Li53, 2011Na24, 2011Ni05, 2011No04, 2011Pe01, 2011Ri05, 2011Wa30, 2011Wu03, 2011Zh36.

2010Ab21, 2010Ab23, 2010Bo25, 2010Bu02, 2010Ko36, 2010Ku17, 2010Pi02, 2010Ra10, 2010To07, 2010Tr08, 2010Vr01, 2010Wa13, 2010Zh09.

2009Bu09, 2009De32, 2009Go05, 2009Ku13, 2009Ni06, 2009Pa46, 2009Ru12, 2009So12, 2009Ve07, 2009Wa01.

2008Bh07, 2008Bu11, 2008Ch15, 2008Ju06, 2008Kl03, 2008Pr05, 2008Sh06, 2008Sk02, 2008So03, 2008Te01, 2008Us02.

2007Ad24, 2007Ba18, 2007Bo46, 2007Bu20, 2007Do03, 2007Do06, 2007Gh11, 2007Ne04.

2006De25, 2006Fr21, 2006Go07, 2006Ne10, 2006Ni17, 2006Ra21.

2005Al40, 2005Ch12, 2005Do10, 2005Du11, 2005En01, 2005Go03, 2005La04, 2005Ma41, 2005Na44, 2005Po01, 2005Sh05, 2005Sh57, 2005Sw02, 2005Za02.

2004Ad15, 2004Ad30, 2004Ba16, 2004Ga03, 2004Hu05, 2004Is05, 2004Ja03, 2004Mo06, 2004Ne12, 2004Ro01, 2004Sa55, 2004Sh47.

2003Ad31, 2003Ad32, 2003Ad34, 2003Bu11, 2003Bu27, 2003De20, 2003Li01, 2003Li25, 2003Mb02, 2003Ne06, 2003Po15, 2003Ra17, 2003Sh02, 2003Za01.

2002Bu13, 2002Ga34, 2002Gi11, 2002Ka53, 2002Ma85, 2002Po16, 2002Ra25, 2002Tr12, 2002Ts01,.

2001Af12, 2001Bu02, 2001De45, 2001Fa07, 2001Go07, 2001Ic02, 2001Ma66, 2001Mi34, 2001Mo13, 2001Mo28, 2001Sa54, 2001Tr19, 2001Tr23.

Antineutrino calculated spectrum: 2012Fa12.

Compilations: 2011Ch65, 2011He12, 2001Be81.

X-ray energies: 2003De44, 2002Ob01.

Systematics of alpha decay: 2006De05, 2006Xu08.

Calculated nuclear moments: 2006Sh37, 2003Ho07.

Alpha decay theory: 2010Wa23, 2010Wa31, 2006De05.

Energies of vibrational states ($K=0+, 2+, 4+, 1-, 2-, 3-$) were calculated in 1965So04, 1970Ne08, 1971Ko31, 1969B113, 1974Du09, 1975IvZZ, 1975LeZR.

 ^{238}U Levels

For calculations of levels see 1994Mi14, 1994Tr09. For calculated rotational level energies, see 1976Az01, 1976Ra04, 1968Ho28, 1978BeYR, 1978To13, 1978Ba46 for example. High-spin rotational states were calculated in 1977Ma23.

Octupole-vibrational band:

Ratios of reduced transition intensities are in agreement with Alaga rule for $K=0$:

$$\begin{aligned} B(E1)(680\gamma)/B(E1)(635\gamma) &= 0.60 \text{ 5 observed in Coul. ex.} \\ &= 0.50 \text{ theory for } K=0 \\ &= 2.0 \text{ theory for } K=1. \\ B(E1)(687\gamma)/B(E1)(583\gamma) &= 0.78 \text{ 3 observed in Coul. ex.} \\ &= 0.75 \text{ theory for } K=0 \\ &= 1.33 \text{ theory for } K=1. \end{aligned}$$

Negative-parity yrast states were calculated by 1976Vo01. The states with low spin were interpreted as octupole states, but the higher spin states become two-quasiparticle decoupled states. Octupole-vibrational states were calculated by 1978Ko03. Levels in yrast band were calculated by 1977Ra25.

Adopted Levels, Gammas (continued)

²³⁸U Levels (continued)

Cross Reference (XREF) Flags

A ²³⁸Pa β⁻ Decay
B ²⁴²Pu α Decay
C ²³⁸U(n,n'γ)
D Coulomb Excitation
E ²³⁸U(d,d')

F ²³⁸U(γ,γ')
G ²³⁶U(t,p)
H ²³⁸U(n,n')
I ²³⁸U IT Decay (280 ns)

E(level) [†]	Jπ [‡]	XREF	T _{1/2}	Comments
0.0 ^d	0+	ABCDEF GHI	4.468×10 ⁹ y 6	%SF=5.45×10 ⁻⁵ 7; %α=100. %SF: from recommended T _{1/2} (SF) of 2000Ho27. Intrinsic electric-quadrupole moment: Q ₀ =13.9 20 deduced by 1978Ge10 from optical isotope shift. Other measurement: Q ₀ =11.12 7 (from Coulomb excitation). Other: 2002Ob01. Δ<r ² >(²³³ U- ²³⁸ U)=-0.432 fm ² 43 (1996El03). T _{1/2} : Weighted average (chi**/n-1=4.0) of 4.468×10 ⁹ y 5, specific activity method (1971Ja07); 4.457×10 ⁹ y , specific activity method (1959St45); 4.51×10 ⁹ y , specific activity of natural uranium (1955Ko13); and 4.495×10 ⁹ y 8, specific activity of enriched uranium (1949Ki26), recommended in 2004Sc03. T _{1/2} : Other values: 4.51×10 ⁹ y (1957Cl16), 4.56×10 ⁹ y 3 (1957Le21),. T _{1/2} : Half-life ratio T _{1/2} (²³⁸ U)/T _{1/2} (²³⁵ U)=6.351 31 (2008Po06). T _{1/2} (SF)=9.86×10 ¹⁵ y 15 (1968Ro15), 8.1×10 ¹⁵ y 3 (1952Se67), 7.19×10 ¹⁵ y 4 (1967Is04), 8.23×10 ¹⁵ y 10 (1967Sp12), 8.19×10 ¹⁵ y 6 (1970Ga27), 11×10 ¹⁵ y 2 (1971Co35), 10.2×10 ¹⁵ y 9 (1971Kl14), 9.50×10 ¹⁵ y 21 (1971Le11), 8.7×10 ¹⁵ y 10 (1971Sa08), 8.0×10 ¹⁵ y 4 (1971Th17), 9.9×10 ¹⁵ y 5 (1972Ni19), 10.2×10 ¹⁵ y 8 (1973Kh10), 9.73×10 ¹⁵ y 44 (1974Iv04), 9.6×10 ¹⁵ y 3 (1975Em03), 8.0×10 ¹⁵ y 6 (1975Wa37), 8.09×10 ¹⁵ y 40 (1976Th12), 8.43×10 ¹⁵ y 21 (1978Ka40), 6.77×10 ¹⁵ y 15 (1978Ri07), 8.8×10 ¹⁵ y 4 (1980Po09), 7.48×10 ¹⁵ y 15 (1980Sp10), 10.5×10 ¹⁵ y 3 (1981Ba70), 5.9×10 ¹⁵ y 4 (1982De22), 8.3×10 ¹⁵ y 4 (1983Be66), 8.42×10 ¹⁵ y 44 (1984Va35), 8.29×10 ¹⁵ y 27 (1985Iv01). 8.30×10 ¹⁵ y 16 (weighted average). 2000Ho27 recommend T _{1/2} (SF)=8.2×10 ¹⁵ y 1 based on a weighted average of a selected set of the above values. Other values: 8.00×10 ¹⁵ y 35 (2003Gu18); 8.15×10 ¹⁵ y 17, "Solid State Nuclear Track Detectors (SSNTD)" (2005Yo12). Calculated T _{1/2} (SF): 2005De44, 2005Re16, 2005Xu01, 1976Ra02. Other T _{1/2} (SF) measurements: 2010Sa09, 2003Ha06, 1966Ra25, 1964F107, 1963Me14, 1959Ku81, 1959Ge30, 1984Va34. The effects of boron and lithium on the ratio of induced to spontaneous fission in natural uranium were measured by 1979At01. μ=0.51 3 (1998Ts13). μ: 1998Ts13 quote μ=0.254 15 in the abstract, but in the body of the paper, this same value is given as the g factor. Q(²³⁸ U)/Q(²³⁴ U)=1.13 10; μ(²³⁸ U)/μ(²³⁴ U)= 0.94 9 (1974Me18). T _{1/2} : from B(E2)=12.30 15 in Coul. ex. and α=609. Other: 225 ps 20 from (α)(ce 45γ)(t) in ²⁴² Pu α decay (1960Be25).
44.916 ^d 13	2+	ABCDEF GHI	206 ps 3	
148.38 ^d 3	4+	ABCDE GH		
307.18 ^d 8	6+	ABCDE H		
518.1 ^d 3	8+	CDE	23 ps 3	T _{1/2} : from BE2=4.7 6 in Coulomb excitation.
680.11 ^e 4	1-	A CDEF HI	35 fs +19-9	T _{1/2} : from B(E1)=0.00049 17 in Coulomb excitation and %Iγ(680γ)=43 3. B(E3) [†] =0.570 36 (1994Mc03). T _{1/2} : from BE2=5.6 2 in Coulomb excitation.
731.93 ^e 3	3-	A CDEF H		Jπ: member of K=0 band.
775.9 ^d 4	10+	CD	9.0 ps 10	Jπ: gammas to 0+,2+,1- levels, γ from 3- level, fit to a band.
826.64 ^e 11	5-	A CDE H		Jπ: fit to a band.
927.21 ⁿ 19	0+	CD F		
930.55 ^p 9	(1-)	A CDEF H		
950.12 ^f 20	2-	A CD F		

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued)

²³⁸U Levels (continued)

E(level) [†]	Jπ [‡]	XREF	T _{1/2}	Comments
966.13 ⁿ 4	2+	A CD F	2.4 ps +17-7	T _{1/2} : from B(E2)=0.017 7 and Iγ(967γ)=12.0% 5. Jπ: 921.19γ to 2+ is E0+M1+E2. The ratio of reduced transition intensities of 966, 818 gammas is in better agreement with the Alaga rule for K=0 than for K=1 or K=2: B(E2)(966γ)/B(E2)(818γ)=0.118 8 observed in Coul. ex., 0.389 theory for K=0, 0.875 theory for K=1, 14.0 theory for K=2.
966.31 ^e 21	7-	CD		
997.23 ^o 24	0+	CD H		Jπ: E0 transition to g.s.
997.58 ^p 7	3-	A CDEF H		B(E3)↑=0.184 18 (1994Mc03). Jπ: from (d,d'), fit to a band.
1028 ^f	4-	CD		
1037.25 ^o 7	2+	A CDEF H	1.13 ps 12	T _{1/2} : from B(E2)=0.0645 64 in Coulomb excitation and %Iγ(1037γ)=30.8 8. Jπ: 993.0γ to 2+ is E0+M1+E2.
1056.38 ⁿ 21	4+	CD G		Jπ: fit to a band. E2 γ to 6+.
1059.66 ^m 17	(3+)	A C F		Jπ: γ's to 2+,4+ levels; suggested as 3+ bandhead in β ⁻ decay.
1060.27 ^j 14	2+	A CDEF H	0.64 ps 4	T _{1/2} : from B(E2)=0.133 8 in Coulomb excitation and %Iγ(1060γ)=40.0 7. Jπ: gammas to 0+,2+,4+ levels.
1076.7 ^d 5	12+	D	4.4 ps 4	T _{1/2} : weighted average of 4.5 ps 5 from B(E2) and 4.2 ps 6 from DSA in Coulomb excitation.
1105.71 ⁱ 7	3+	A CD		Jπ: fit to a band.
1128.84 ^l 7	(2-)	A CD F		Jπ: gammas to 2+,1-,3- levels, fit to a band.
1130.75 ^o 24	4+	A CDE H		
1135.77 [?] 4		A C		
1150.7 ^e 4	9-	D		
1151 ^f	6-	D		
1163 ^j	(4+)	D		
1167.99 9	4+	A CD gH		Jπ: from γ(θ) and yield in Coulomb excitation. Assigned by 1994Mc04 as the 4+ member of the K=2 γ-vibrational band; however, 1996Wa11 show that this band member has an energy of 1163. Jπ: fit to a band. B(E3)↑=0.166 23. Jπ: from (d,d'), fit to a band.
1168.88 ^l 23	3-	A CDE g		
1209.3 3		C		
1223.78 14	2+ ^c	A CD	3.5 ps 4	T _{1/2} : from B(E2)=0.0123 12 in Coulomb excitation and %Iγ(1224γ)=41.6. The evaluators assume that the uncertainty in the branching is negligible compared with that in the B(E2) value.
1232 ⁱ	5+	D		
1239.3 [?] 2		C		
1242.9 [?]		A		
1260.9 [?] 2		C		
1269.2 ^o 10	6+	CD		Jπ: fit to a band.
1278.54 12	2+ ^c	A CD	2.9 ps 3	B(E2)↑=0.0043 4. T _{1/2} : from B(E2)=0.00428 43 in Coulomb excitation and %Iγ(1278γ)=15.0. The evaluators have assigned an uncertainty of 5% to this branching to get an uncertainty on T _{1/2} .
1311 ^j	6+	CD		
1318 ^f	8-	D		
1354.79 24	(1,2+)	C		Jπ: γ's to 0+,2+ levels.
1375		E		
1378.8 ^e 5	11-	D		
1381.19 9		A C		
1403 ⁱ	7+	CD		The existence of this level in (n,n'γ) is not definite, since it is based on the observation of an 885.8 2 transition that is doubly placed.
1414.0 6	2+ ^c	A CD	1.18 ps 13	T _{1/2} : from B(E2)=0.00549 55 in Coulomb excitation and %Iγ(1413.3γ)=12.9. The evaluators have assigned an uncertainty of 5% to this branching to get an uncertainty for T _{1/2} .
1415.5 ^d 6	14+	D	2.55 ps 20	T _{1/2} : weighted average of 2.54 ps 23 from B(E2) in Coul Ex and 2.56 ps 28 from DSA (1981Gr10).

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued) ^{238}U Levels (continued)

E(level) [†]	Jπ [‡]	XREF	T _{1/2}	Comments
1446.4 ^k 9	(7-)	D		
1455.39 18		C		
1482.41 8		C		
1504 ^j	8+	D		
1516.5? 2		C		
1528 ^f	10-	D		
1530.2 4	2+ ^c	CDE	0.150 ps 15	T _{1/2} : from B(E2)=0.0105 11 in Coulomb excitation and %Iγ(1530γ)=4.67. The evaluators have assigned an uncertainty of 5% to this branching to get an uncertainty for T _{1/2} .
1545.8 ^q 14	8+	D		
1561.6		A C		
1594.80 12	(4+)	C		
1617.5		A		
1619 ⁱ	9+	D		
1630 ^h		E		
1643.73 12		C		
1644 ^k	(9-)	D		
1645.0		A E		
1649.2 ^e 5	13-	D		
1665 ^h		E		
1672.01 15		C		
1675.7 3		A C		
1712 ^h		E		
1741 ^j	10+	D		
1760.9 4	(4+)	C E		Jπ: γ's to 2+,6+ levels.
1774.7 [§]	(3-, 4, 5-)	A C E		Jπ: γ's to 3-,5-.
1778 ^f	12-	D		
1782 ^{&}	1@	F	33 fs ^b 4	
1782.3 ^{&} 4	2+ ^c	CD	0.39 ps 4	T _{1/2} : from B(E2)=0.0179 18 in Coulomb excitation, and %Iγ(1782.0γ)=44.8. The evaluators have assigned an uncertainty of 5% to the branching to get an uncertainty for T _{1/2} .
1786.7 ^q 15	10+	D		
1788.4 ^d 6	16+	D	1.74 ps 13	
1793	1@	C F	80 fs ^b +40-20	
1846	1@	C F	31 fs ^b 4	
1866 ^k	(11-)	D		
1875 ⁱ	11+	D		
1934.3	(3-)	A C		
1959.2 ^e 6	15-	D		
1992.2	(3-)	A C		E(level): level proposed in β decay, but two common transitions suggest population in (n,n'γ) also; however, the branchings are not in agreement. The evaluators have added several transitions from (n,n'γ) based on energy fit alone.
1996.7 ^a 3	1-	F		
2017.7 ^a 4	1+	F		
2018 ^j	12+	D		
2033 ^h	(12+)	D		
2048.7 ^q 15	12+	D		
2063.9	(2-)	A		
2066 ^f	14-	D		
2079.3 ^a 4	1+	F		
2080.7 ^a 4	1-	F		
2093.3 ^a 4	1-	F		
2122 ^k	(13-)	D		
2125.3 6	2+	C		
2145.6 ^a 3	1-	F		
2163.5 3		C		
2171 ⁱ	13+	D		
2175.8 ^a 3	1+ [#]	F	0.058 eV ^b 5	
2191.1 ^d 7	18+	D	1.18 ps 11	T _{1/2} : From DSA (1981Gr10).
2208.8 ^a 3	1+ [#]	C F		
2244.4 ^a 3	1+ [#]	F	0.00142 eV ^b 3	
2294.1 ^a 3	1+ [#]	F	0.0040 eV ^b 5	

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued)

 ^{238}U Levels (continued)

E(level) [†]	Jπ [‡]	XREF	T _{1/2}	Comments
2306.7 ^e 7	17-	D		
2332.7 ^a 3	1-	F		
2333j	14+	D		
2346.4 ^q 16	14+	D		
2356 ^h	(14+)	D		
2365.6 ^a 3	1-	F		
2389 ^f	16-	D		
2410.0 ^a 3	1+ [#]	F	0.011 eV 2	
2418 ^k	(15-)	D		
2422.8 ^a 3	1- [#]	F	0.0062 eV ^b 7	
2467.8 ^a 5	1+ [#]	F	0.048 eV ^b 5	
2491.5 ^a 5	1-	F		
2499.4 ^a 3	1+	F		
2502 ⁱ	15+	D		
2529.0 ^a 3	1-	F		
2557.9 5	0+	C HI	280 ns 6	%IT=97.4 4; %SF=2.6 4. Intrinsic electric quadrupole moment=29 3 (1979U101). %ternary fission =0.1 (1989Ma54) %α<0.5 (1971Be62). Jπ: 2558γ to 0+ is E0. T _{1/2} : from IT DECAY.
2578.5 3	2+	C		
2593.7 ^a 6	1-	F		
2602.5 ^a 4	1-	F		
2619.1 ^d 8	20+	D	0.91 ps 8	T _{1/2} : from Coulomb excitation.
2624.6 6	4+	C		
2638.3 ^a 3	1+	F		
2645 ^g	(14+)	D		
2647.3 ^a 8	1+	F		
2675.2 ^q 17	16+	D		
2683j	16+	D		
2689.4 ^e 8	19-	D		
2702.2 ^a 3	1+	F		
2712 ^h	(16+)	D		
2738.9 ^a 9	1+	F		
2744 ^f	18-	D		
2751 ^k	(17-)	D		
2756.4 ^a 3	1+	F		
2773.0 ^a 3	1+	F		
2816.8 ^a 4	1+	F		
2844.2 ^a 9	1-	F		
2862.2 ^a 5	1-	F		
2868 ⁱ	17+	D		
2877.1 ^a 3	1-	F		
2881.4 ^a 5	1+	F		
2896.6 ^a 3	1-	F		
2908.9 ^a 3	1-	F		
2910.0 ^a 4	1-	F		
2932.6 ^a 6	1+	F		
2951.2 ^a 3	1+	F		
2963.9 ^a 8	1+	F		
2991 ^g	(16+)	D		
3005.9 ^a 4	1-	F		
3014.5 ^a 3	1+	F		
3018.9 ^a 3	1-	F		
3030.6 ^a 3	1+	F		
3031.2 ^q 19	18+	D		
3037.7 ^a 3	1+	F		
3042.5 ^a 6	1+	F		
3043.6 ^a 3	1-	F		
3046.9 ^a 3	1-	F		
3051.7 ^a 3	1-	F		
3057.1 4	1-	F		
3060.6 ^a 3	1-	F		

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued) ^{238}U Levels (continued)

E(level) [†]	J $\pi^{\ddagger}$	XREF	T _{1/2}	Comments
3065j	18+	D		
3068.1 ^d 9	22+	D	0.76 ps 10	T _{1/2} : from Coulomb excitation.
3086.7 ^a 5	1-	F		
3091.0 ^a 3	1-	F		
3095 ^h	(18+)	D		
3096.4 ^a 3	1-	F		
3101.7 ^a 4	1-	F		
3104.3 ^e 12	21-	D		
3117.7 ^a 4	1-	F		
3120 ^k	(19-)	D		
3128 ^f	20-	D		
3135.0 ^a 3	1+	F		
3153.7 ^a 3	1+	F		
3172.9 ^a 3	1+	F		
3207.8 ^a 4	1-	F		
3217.6 ^a 6	1+	F		
3234.5 ^a 7	1+	F		
3239.6 ^a 3	1-	F		
3253.194 ^a 15	1-	F	0.24 ps 8	J π : J=1 from angular correlation, $\pi=-$ based on the relative intensities of the deexciting γ transitions.
3265 ⁱ	19+	D		
3274.4 ^a 3	1-	F		
3297.2 ^a 4	1-	F		
3303.6 ^a 3	1-	F		
3307.32 ^a 3	1+	F		
3329.1 ^a 6	1-	F		
3348.33 ^a 3	1+	F		
3366.0 ^a 5	1+	F		
3368 ^g	(18+)	D		
3384.3 ^a 3	1-	F		
3397.9 ^a 8	1-	F		
3411.2 ^q 22	20+	D		
3416.0 ^a 4	1-	F		
3421.5 ^a 5	1-	F		
3441.0 ^a 9	1-	F		
3448.3 ^a 6	1+	F		
3454.1 ^a 4	1-	F		
3460.7 ^a 3	1+	F		
3467.8 ^a 6	1-	F		
3470.7 ^a 3	1-	F		
3474j	20+	D		
3475.2 ^a 3	1-	F		
3479.0 ^a 3	1-	F		
3489.0 ^a 3	1-	F		
3500.5 ^a 3	1-	F		
3502 ^h	(20+)	D		
3509.1 ^a 9	1-	F		
3521 ^k	(21-)	D		
3528.0 ^a 4	1-	F		
3535.3 ^d 12	24+	D	0.51 ps 8	T _{1/2} : from B(E2) in Coulomb excitation.
3538 ^f	22-	D		
3547.7 ^e 13	23-	D		
3548.0 ^a 6	1-	F		
3562.8 ^a 3	1-	F		
3594.9 ^a 5	1-	F		
3608.7 ^a 3	1-	F		
3615.9 ^a 3	1-	F		
3623.9 ^a 3	1-	F		
3640.1 ^a 3	1-	F		
3650.5 ^a 3	1-	F		
3659.7 ^a 6	1-	F		
3673.7 ^a 6	1-	F		
3686 ⁱ	21+	D		

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Adopted Levels, Gammas (continued) ^{238}U Levels (continued)

E(level) [†]	J $\pi^{\ddagger}$	XREF	T _{1/2}	Comments
3728.0 ^a 9	1-	F		
3738.5 ^a 8	1-	F		
3759.9 ^a 3	1-	F		
3773 ^g	(20+)	D		
3805.1 ^a 3	1-	F		
3809 ^a	(1, 2+)	F		
3811.2 ^q 24	22+	D		
3819.0 ^a 6	1-	F		
3828.7 ^a 3	1-	F		
3906 ^j	22+	D		
3947 ^k	(23-)	D		
3965.7 ^a 4	1-	F		
3971 ^f	24-	D		
3990.7 ^a 9	1-	F		
3995.8 ^a 3	1-	F		
4017 ^e	25-	D		
4018.1 ^d 16	26+	D	0.40 ps 7	T _{1/2} : from Coulomb excitation.
4023.7 ^a 7	1-	F		
4031.4 ^a 7	1-	F		
4046.7 ^a 3	1-	F		
4065.3 ^a 3	1-	F		
4072.1 ^a 6	1-	F		
4088.9 ^a 7	1-	F		
4093.4 ^a 3	1-	F		
4100.2 ^a 3	1-	F		
4105.2 ^a 3	1-	F		
4122.9 ^a 5	1-	F		
4127 ⁱ	23+	D		
4138.9 ^a 7	1-	F		
4145.8 ^a 3	1-	F		
4151.3 ^a 6	1-	F		
4155.4 ^a 3	1-	F		
4175.8 ^a 4	1-	F		
4181.5 ^a 7	1-	F		
4205 ^g	(22+)	D		
4217.3 ^a 8	1-	F		
4232 ^q 3	24+	D		
4239.1 ^a 3	1-	F		
4358 ^j	24+	D		
4393 ^k	(25-)	D		
4424 ^f	26-	D		
4495 ^a	(1, 2+)	F		
4504 ^e	27-	D		
4517 ^d	28+	D	0.36 ps 9	T _{1/2} : from Coulomb excitation.
4586 ⁱ	25+	D		
4592 ^a	(1, 2+)	F		
4677 ^q 3	26+	D		
4807 ^a	(1)	F		
4825 ^j	26+	D		
4895 ^f	28-	D		
5003 ^e	29-	D		
5035.1 ^d 21	30+	D	<0.9 ps	
5063 ⁱ	27+	D		
5140 ^a		F		
5144 ^q 3	28+	D		
5206 ^a	(1, 2+)	F		
5513 ^e	31-	D		
5581 ^d 3	32+	D		
6037 ^e 3	33-	D		
6146 ^d 4	34+	D		

[†] Level energies are from a least-squares fit to the γ energies.

Adopted Levels, Gammas (continued)

²³⁸U Levels (continued)

- ‡ From excitation in Coulomb excitation, γ deexcitation pattern, and assignment to a rotational band. Band assignments are mainly from 1996Wa11.
- § Data are from ²³⁸Pa β^- decay. This level may be populated also in (n,n' γ); however, the agreement in branchings is poor. From (n,n' γ) one has $E_\gamma=606.6$ 2, 647.7 4, 1043.0 10, and 1627.8 6 with I_γ values of 100 12, 24 8, 4 4, and 12 4. The 1094.5 (placement in the decay scheme is uncertain) and 1730 γ 's have not been observed.
- # From $\gamma(0)$ in (γ,γ') and form factor in (e,e') (1988He02).
- @ From $\gamma(0)$ in (γ,γ') (1995Zi02).
- & J=1 for a 1782 level in (γ,γ'), and J=2 for a 1782 level in Coulomb excitation, both spins determined by $\gamma(0)$. Both reactions report transitions to the 45 level and the g.s. It is possible that both reactions are exciting both levels, in which case the branching ratios may be incorrect.
- a From ²³⁸U(γ,γ').
- b From Γ data in (γ,γ') and adopted branching ratios.
- c Level is Coulomb excited and J=2 from $\gamma(0)$ in Coulomb excitation.
- d (A): $K\pi=0+$ ground-state band. Coulomb excitation. Member of ground-state rotational band based on γ -deexcitation pattern and energy fit to rotational formula.
- e (B): $K\pi=0-$ octupole-vibrational band. Coulomb excitation. Member of octupole-vibrational band based on γ deexcitation pattern and energy fit.
- f (C): $K\pi=1-, \alpha=0$. Coulomb excitation. Member of $K\pi=1-, \alpha=0$ band based on γ deexcitation pattern and energy fit.
- g (D): Unassigned, but possibly built on the 1414 or 1530 2+ levels.
- h (E): Possibly associated with the 1037 2+ level, assigned by 1994Mc03 as the second K=0 β -vibrational bandhead.
- i (F): $K\pi=2+$ γ -vibrational band. $\alpha=1$.
- j (G): $K\pi=2+$ γ -vibrational band. $\alpha=0$.
- k (H): Probably associated with the octupole band built on the 1129 2- level, and thus probably $K\pi=2-$ with $\alpha=1$.
- l (I): $K\pi=2-$.
- m (J): $K\pi=3+$ v 1/2[631]+v 5/2[622].
- n (K): $K\pi=0+$ band.
- o (L): $K\pi=0+$ second β -vibrational band.
- p (M): $K\pi=1-, \alpha=1$.
- q (N): Band based on $J\pi=8+$ (2010Zh09).

$\gamma(^{238}\text{U})$

E(level)	$E_\gamma^\dagger$	$I_\gamma^\ddagger$	Mult.§	$\delta^\#$	α	I($\gamma+ce$)	Comments
44.916	44.915@ 13	100	E2		609		B(E2)(W.u.)=281 4. α : theoretical values of α , $\alpha(L)$, and $\alpha(M)$ are reduced by 2% (see 1987Ra01).
148.38	103.50@ 4	100	[E2]		11.6		
307.18	159.018@ 16	100	[E2]		1.871		
518.1	210.6 4	100	[E2]		0.626		B(E2)(W.u.)=410 60.
680.11	635.3& 3	100.0 20	[E1] c o		0.020 4		E_γ : From Coulomb excitation. $\alpha(K)_{\text{exp}}=0.016$ 4; B(E1)(W.u.)=0.011 4.
	680.2& 5	79 4	[E1] c o		0.020 5		E_γ : From Coulomb excitation. $\alpha(K)_{\text{exp}}=0.016$ 5; B(E1)(W.u.)=0.0070 24.
731.93	51.8 a						
	583.55 3	81.4 16	E1 o		0.01003		
	686.99 3	100.0 20	[E1]				
775.9	257.8& 4	100	[E2]		0.313		B(E2)(W.u.)=480 60.
826.64	519.46 8	50 3	[E1]				
	678.3& 3	100 6	[E1]				
927.21	882.3 6	100	[E2]				
930.55	251.2 7	13.1 14					
	885.46& 10	100 4	[E1]		0.00465		
	931.1 2	25.2 13	[E1]		0.00426		
950.12	218.1 3	53 6					
	270.1 4	48 8					
	905.5 5	100 6	[E1]		0.00447		
966.13	234.5& 10	13.9 14	[E1]		0.0689		B(E1)(W.u.)= 3.5×10^{-4} 15.
	286.3& 10	8.1 7	[E1]		0.0438		B(E1)(W.u.)= 1.1×10^{-4} 5.
	818.06 13	100 4	[E2] o		0.0166		B(E2)(W.u.)=3.3 14. $\alpha(K)_{\text{exp}}=0.012$ 8.

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Adopted Levels, Gammas (continued) $\gamma(^{238}\text{U})$ (continued)

E(level)	$E\gamma^{\dagger}$	$I\gamma^{\dagger}$	Mult. [§]	$\delta^{\#}$	α	I(γ +ce)	Comments
966.13	921.19& 3	60 3	E2+M1+E0 ^o		0.23 4		B(M1) $\downarrow$ = 1.1×10^{-4} 8; B(E2)(W.u.)=1.0 4. α (K)exp=0.191 30. α : from α (K)exp and α/α (K)=1.19 (E0 theory). δ : δ (E2/M1)=+4.1 +6-5 from Coulomb excitation (1994Mc03). ρ^2 =0.0099 18 from Coulomb excitation (2001Ga55). B(E2)(W.u.)=0.38 16.
966.31	966.9 3 449	27.3 14	[E2]		0.0120		B(E2)(W.u.)=0.38 16. E γ ,I γ : from Coulomb excitation. E=448.4 9 is reported in (n,n' γ), but the transition is multiply placed with most of the intensity being placed from the 1129 2- level.
997.23	659.1 ^e 2 952.06 5	100 14					
997.58	997.23& 24 67.1 ^a		E0 ^o				
	318.0& 10 849.1& 4	8.0 4 100 3	[E2] E1 ^o		0.1611 0.00502		B(E2)(W.u.)=2.8 5 (1994Mc03). α (K)exp=0.0046 27.
	952.65 7	56.8 13	[E1]		0.00409		I γ : I(952.7 γ)/I(849 γ)=1.1 4 from (n,n' γ).
1028	78.1 ^e 4 295.86 ^e 6	64 ^f 42 <190 ^f					
	879.63 ^e 11	100 ^f 6					
1037.25	305.5& 6 357.5& 6	11.8 5 9.5 4	E1 E1		0.0379 0.0270		B(E1)(W.u.)= 2.00×10^{-4} 22. B(E1)(W.u.)= 1.00×10^{-4} 12.
	888.9& 3 992.32& 7	71.7 15 72.9 15	E2 E2+M1+E0 ^o		0.0141 0.78 4		B(E2)(W.u.)=2.28 23. B(E2)(W.u.)=1.23 14; B(M1)(W.u.)= 3.4×10^{-4} 6. α (K)exp=0.653 33. δ : δ (E2/M1)=+3.50 +20-25 from Coulomb excitation (1994Mc03). ρ^2 =0.175 26 from Coulomb excitation (2001Ga55). α : from α (K)exp and α/α (K)=1.19 (E0 theory).
	1037.3 2	100.0 21	E2		0.0105		B(E2)(W.u.)=1.47 16.
1056.38	749.2 2 908&	100 41	E2		0.01978		
1059.66	911.3 ^d 2 1015 ^b						
1060.27	911.9& 4 1015.3&b 2	3.57 20 100.0 20	E2 M1+E2 ^o	10.0 +15-14	0.0134 0.0109		B(E2)(W.u.)=0.33 3. B(E2)(W.u.)=5.3 4; B(M1)(W.u.)= 2.0×10^{-4} 6. α (K)exp=0.0075 7.
	1060.3&h 2	69.8 14	E2		0.0101		B(E2)(W.u.)=3.04 18.
1076.7	300.6& 9	100	[E2]		0.191		B(E2)(W.u.)=500 50.
1105.71	957.80 ^e 4 1060.32 ^e h 2	30 2 100					
1128.84	68.1 ^g 68.8 ^g 130.7 ^g 178.2 ^g						
		36	[M1]		4.51		

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Adopted Levels, Gammas (continued) $\gamma(^{238}\text{U})$ (continued)

E(level)	$E\gamma^{\dagger}$	$I\gamma^{\dagger}$	Mult. [§]	$\delta^{\#}$	α	I($\gamma+ce$)	Comments
1128.84	198.6 ^e 3	15					$I\gamma$: masked by an impurity line in Coulomb excitation. From $I\gamma/I\gamma(1084\gamma)=0.18$ in β decay.
	396.3 2	26.0 13					
	448.1 ^q 2	100 ^q 4					
	1084.08 7	81 4					
1130.75	982.44 ^{&} 24	100					
1135.7?	208.3 ^e gr 10	100 29					
	1090.9 ^e gr 2	71 6					
1150.7	184 ^{&}						
	374.8 ^{&} 4						
	632.6 ^{&} 4						
1151	123 ^{&}						
	324 ^{&}						
	843 ^{&}						
1163	855 ^{&}						
	1015 ^{&}						
1167.99	861 ^{&}	13.5	E2		0.01504		
	1018.88 ^e j 3	100	E2		0.01085		
	1123 ^{&} j	6.8	E2		0.00904		
1168.88	41.4 ⁱ						
	109.4 ^g r						
	172 ^{&}	44.3	[M1]		5.05		
	202.6 ^{&}	16.8	[E1]		0.0957		
	436.9 3	100	M1+E2	+0.23 +11-8	0.366 17		
	489.0 ^{&} 10	23.4	E2		0.0505		
	1021 ^{&} j	49.6	[E1]		0.00362		
	1123 ^{&} j	27.0	[E1]		0.00307		
1209.3	282.2 ^e 8	100 ^f 43					
	1060.98 ^e 3	<1014 ^f					
	1209.3 ^e 3	86 ^f 14					
1223.78	258 ^{&}	4.7	E2		0.312		B(E2)(W.u.)=32.
	274 ^{&}	17.8	E1		0.0483		B(E1)(W.u.)=1.8 $\times 10^{-4}$.
	293 ^{&}	7.2	E1		0.0416		B(E1)(W.u.)=6.0 $\times 10^{-5}$.
	296 ^{&}	8.0	E2		0.2004		B(E2)(W.u.)=27.
	1076 ^{&}	3.2	E2		0.00980		B(E2)(W.u.)=0.017.
	1179.3 3	96	M1+E2				$E\gamma$: weighted average of 1179.2 4 from Coulomb excitation, and 1179.4 2 from 1984B1ZS, 1179.6 3 from 1978De41, and 1179.0 2 from 1972Mc19 in (n,n' γ). δ : $\delta=+7.0 +14-10$ or -0.295 from $\gamma(0)$ in Coulomb excitation.
	1223.3 2	100	E2		0.00770		B(E2)(W.u.)=0.29.
1232	69 ^{&}						
	127 ^{&}						
	925 ^{&}						
	1084 ^{&}						
1239.3?	932.30 ^e 7	$\leq 156^f$					
	1090.9 ^e r 2	100					
1242.9?	1094.5 ^g rs						
1260.9?	1112.0 ^r 5	29 3					
	1215.31 ^r 5	100 6					
1269.2	962.0 ^e 10	100					
1278.54	546.93 ^e 10	48	E1		0.01136		B(E1)(W.u.)=4.8 $\times 10^{-5}$ 7.
	1130.31 ^e 12	60 4	E2		0.00893		B(E2) $\downarrow$ =0.29 3. $E\gamma$: from 1994Mc03.

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Adopted Levels, Gammas (continued)
 $\gamma(^{238}\text{U})$ (continued)

E(level)	E $\gamma^{\dagger}$	I $\gamma^{\dagger}$	Mult. [§]	$\delta^{\#}$	α	I(γ +ce)	Comments
1278.54	1233.65 ^e 7	82	E2		0.00758		B(E2)(W.u.)=0.37 5. E γ : E=1233 in Coulomb excitation.
1311	1278.57 ^e 7 79& 149& 793& 1004&	100 60	E2		0.00709		B(E2)(W.u.)=0.098 9.
1318	167& 352&						
1354.79	405.8 ^e 10 423.8 ^e 3 1310.5 ^e 4 1354.5 ^{ek} 10	40 20 100 20 50 10 30 10					
1378.8	228.1& 4 302.3& 4 602.9& 4						
1381.19	554.28 ^e 7 1073.82 ^e 11	100					
1403	92& 171& 885&						E γ : E=885.8 2 is reported in (n,n' γ) for a doubly-placed transition.
1414.0	354& 1370& 1413.4 ^e 2	4.3 100 15.5	E2		0.1194		B(E2)(W.u.)=36.
1415.5	338.8& 4	100	E2 [E2]		0.00589 0.134		B(E2)(W.u.)=0.125. B(E2)(W.u.)=491 38.
1446.4	480&	100					
1455.39	1306.5 ^e 1 1410.1 ^e 1	81 9 100 9					
1482.41	422.1 ^e 3 551.63 ^e 8 802.9 ^e 2 1437.39 ^e 8	4 21 32 100					
1504	102& 193&						
1516.5?	1367.3 ^{ks} 2 1470.56 10	95 ^s 100					
1528	210& 377&						
1530.2	400.6& 564& 599& 798.4& 1382.11 ^e 12	8.5 17.8 41.7 23.9 100 8	E1 [E2] [E1] [E1] E2		0.0213 0.0362 0.00955 0.00560 0.00615		B(E1)(W.u.)=6.4 $\times 10^{-4}$. B(E2)(W.u.)=55. B(E1)(W.u.)=9.4 $\times 10^{-4}$. B(E1)(W.u.)=2.3 $\times 10^{-4}$. B(E2)(W.u.)=3.57 43 (1994Mc03).
	1485.3 ^e 3	35 6	M1+E2				δ : $\delta=-30$ 10 or -0.51 from $\gamma(\theta)$ in Coulomb excitation.
	1530&	11.3	E2		0.00401		B(E2)(W.u.)=0.240 24 (1994Mc03).
1545.8	1028 ^p	100					
1561.6	501.9 ^g 1413 ^g 1516.5 ^g	100 12 <15					
1594.80	768.40 ^e 7 1287.0 ^e 5 1446.12 ^e 11 1549.88 ^e 12	<50 22 5 ≤ 100 100 8					
1617.5	448.3 ^{gqr}	=7 ^q					I γ : most of the intensity belongs with the 1129 level.

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Adopted Levels, Gammas (continued) $\gamma(^{238}\text{U})$ (continued)

E(level)	$E\gamma^{\dagger}$	$I\gamma^{\dagger}$	Mult. [§]	$\delta^{\#}$	α	I($\gamma+ce$)	Comments
1617.5	489.0g	100					
	557.9g	=25					I γ : estimated by evaluators.
1619	114&						
	216&						
	843&						
1643.73	1336.34 ^{e 12}	100					
1644	197&						
	493&						
1645.0	476.2g	100 ¹					
	1496.6g	42 ¹					
	1600g	16 ¹					
1649.2	234&						
	270.5& 4						
	572.4& 4						
1672.01	566.20 ^{e 11}	50					
	1523.63 ^{e 15}	100 8					
	1627.0 ^{e 2}	<53					
1675.7	547.0 ^{e 3}	100 ¹					
	943.5g	17.5 ¹					
	995.4g	25 ¹					
	1527.1g	9 ¹					
	1630.5g	7.5 ¹					
1741	122&						
	237&						
1760.9	655.3 3	<1.4					
	701.9 2	0.5					
	1454.8 2	<0.4					
	1613.2 3	0.6					
	1716.2 4	100 15					
1774.7	605.7g	100 ¹					
	646.4g	90 ¹					
	1042.4g	80 ¹					
	1094.5g ^s	≤ 50 1s					Placement in level scheme is uncertain.
	1626g	30 ¹					
	1730g	30 ¹					
1778	250&						
	399&						
1782	1737m	55m 5					
	1782m	100m					
1782.3	1737.8 ^{e 5}	89 10	M1+E2	11 +19-4			B(E2)(W.u.)=0.57 6. B(M1)(W.u.)=5 $\times 10^{-5}$ +7-4. B(E2)(W.u.)=0.41 4.
	1782.3 ^{e 4}	100 11	E2				
1786.7	241p						
	259p						
	408p						
	636p						
	1011p						
1788.4	372.9& 4	100	[E2]		0.102		B(E2)(W.u.)=490 21.
1793	1748m	100m					
	1793m	90m 23					
1846	1802m	51m 5					
	1846m	100m					
1866	222&						
	487&						
1875	134&						
	256&						
	798&						
1934.3	289.1g	9 ¹					
	317.0g	16 ¹					
	373g	≤ 14 1					
	765.3g	9 ¹					
	805.7g	100 ¹					

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued)

 $\gamma(^{238}\text{U})$ (continued)

E(level)	$E\gamma^{\dagger}$	$I\gamma^{\ddagger}$	Mult. [§]	α	I(γ +ce)	Comments
1934.3	874.4g 984.6g 1003.6g 1785.7g 1889.1g	20 ¹ 16 ¹ 39 ¹				
1959.2	309.9& 4 543.7& 4					
1992.2	375 768.3 2 823.2 863.7 2 932.30 7					E γ ,I γ : reported only in β^- decay. I γ /I γ (863.5 γ)<0.11. E γ ,I γ : E=769 is seen in β^- with I γ /I γ (863.5 γ)=0.02, unplaced by authors. E γ ,I γ : reported only in β^- decay. I γ /I γ (863.5 γ)=0.17. E γ ,I γ : from (n,n' γ). E=863.3 in β^- decay. E γ ,I γ : from (n,n' γ), with I γ /I γ (863.5 γ)<10. E=932.5 in β^- decay, with I γ /I γ (863.5 γ)<0.11.
1996.7	1951.8m 1996.7m 3	18m 2 100m				
2017.7	1972.8m 2017.7m 4	187m 47 100m				
2018	143& 277&					
2033	957&	100				
2048.7	262p 271p 400p 670p 973p					
2063.9	1332.0g 1383.9g 2019g	70 100 100				
2066	288&	100				
2079.3	2079.3m 4	100m				
2080.7	2035.8m 2080.7m 4	150m 19 100m				
2093.3	2093.3m 4	100m				
2122	257& 473&					
2125.3	1394.1e 9 1976.7e 6 2080.9e 6 2124.9e 6	51 ^f 27 100 ^f 26 87 ^f 25 40 ^f 11				
2145.6	2145.6m 3	100m				
2163.5	1857.1e 4 2015.8e 2	100 ^f 13 78 ^f				
2171	153& 296& 755&					
2175.8	2130.9m 2175.8m 3	54m 3 100m				
2191.1	402.6& 4	100	[M1] [E2]			B(M1)(W.u.)=0.173 16. B(E2)(W.u.)=480 30.
2208.8	2163.9m 3 2208.8m 3	21m 8 100m				
2244.4	2199.5m 2244.4m 3	14m 1 100m				
2294.1	2249.2m 2294.1m 3	103m 6 100m				
2306.7	347.5& 4 518.3& 4					
2332.7	2287.8m 2332.7m 3	132m 9 100m				
2333	162&					

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued)

 $\gamma(^{238}\text{U})$ (continued)

E(level)	$E\gamma^{\dagger}$	$I\gamma^{\dagger}$	Mult. [§]	α	$I(\gamma+ce)$	Comments
2333	315&					
2346.4	281P					
	298P					
	387P					
	698P					
	931P					
2356	323&					
	941&					
2365.6	2365.6m 3	100m	[E1]			
2389	323&	100				
2410.0	2365.1m	170m 9				
	2410.0m 3	100m	[M1]			B(M1)(W.u.)=0.061 7.
2418	296&					
2422.8	2422.8m 3	100m				
2467.8	2467.8m 5	100m	[M1]			B(M1)(W.u.)=0.066 9.
2491.5	2446.6m	66m 28				
	2491.5m 5	100m				
2499.4	2454.5m	47m 5				
	2499.4m 3	100m				
2502	169&					
	332&					
	713&					
2529.0	2484.1m	28m 9				
	2529.0m 3	100m				
2557.9	1879n	49n 13	[E1]			B(E1)(W.u.)=3.1×10 ⁻¹¹ 8.
	2512.7n 5	100n 19	[E2]			B(E2)(W.u.)=1.54×10 ⁻⁷ 19.
	2558 2		E0		0.34 6	I(γ+ce): from IT decay.
2578.5	2430.0e 3	97 18				
	2533.6e 3	100 15				
2593.7	2548.8m	17m 4				
	2593.8m 6	100m				
2602.5	2557.6m	38m 9				
	2602.5m 4	100m				
2619.1	427.9& 4	100	[E2]	0.0707		B(E2)(W.u.)=460 40.
2624.6	2317.3e 9	62 23				
	2476.2e 6	100 23				
2638.3	2593.4m	133m 9				
	2638.3m 3	100m				
2645	857&	100				
2647.3	2602.4m	80m 8				
	2647.3m 8	100m				
2675.2	329P					
	368P					
	716P					
2683	182&					
	350&					
2689.4	382.7& 4					
	498.3&					
2702.2	2702.2m 3	100m				
2712	356&					
	924&					
2738.9	2694.0m	143m 48				
	2738.9m 9	100m				
2744	355&	100				
2751	333&	100				
2756.4	2756.4m 3	100m				
2773.0	2728.1m 3	105m 29				
	2773.0m 3	100m				
2816.8	2816.8m 4	100m				
2844.2	2844.2m 9	100m				
2862.2	2817.3m	143m 29				
	2862.2m 5	100m				
2868	184&					

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued)
 $\gamma(^{238}\text{U})$ (continued)

E(level)	$E\gamma^{\dagger}$	$I\gamma^{\dagger}$	Mult. [§]	α	Comments
2868	365& 677&				
2877.1	2877.1m 3	100m			
2881.4	2836.5m	134m 29			
	2881.4m 5	100m			
2896.6	2851.7m	76m 19			
	2896.6m 3	100m			
2908.9	2864.0m	76m 19			
	2908.9m 3	100m			
2910.0	2865.1m	105m 10			
	2910.0m 4	100m			
2932.6	2887.7m	143m 38			
	2932.6m 6	100m			
2951.2	2906.3m	86m 10			
	2951.2m 3	100m			
2963.9	2963.9m 8	100m			
2991	346& 800& 1203&				
3005.9	2961.0m	67m 76			
	3005.9m 4	100m			
3014.5	2969.6m	38m 10			
	3014.5m 3	100m			
3018.9	2974.0m	96m 29			
	3018.9m 3	100m			
3030.6	3030.6m 3	100m			
3031.2	356P 724P				
3037.7	2992.8m	115m 19			
	3037.7m 3	100m			
3042.5	3042.5m 6	100m			
3043.6	3043.6m 3	100m			
3046.9	3046.9m 3	100m			
3051.7	3006.8m	67m 10			
	3051.7m 3	100m			
3057.1	3012.2m	3m 1			
	3057.1m 4	100m			
3060.6	3015.7m	55m 5			
	3060.6m 3	100m			
3065	197& 382&				
3068.1	448.9& 4	100	[E2]	0.0626	B(E2)(W.u.)=490 75.
3086.7	3041.8m	28m 3			
	3086.7m 5	100m			
3091.0	3046.1m 4	23m 2			
	3091.0m 4	100m			
3095	383& 904&				
3096.4	3051.5m	105m 29			
	3096.4m 3	100m			
3101.7	3056.8m	62m 6			
	3101.7m 4	100m			
3104.3	415.1& 4	100			
3117.7	3072.8m	96m 10			
	3117.7m 4	100m			
3120	369&	100			
3128	384&	100			
3135.0	3090.1m	86m 29			
	3135.0m 3	100m			
3153.7	3108.8m	37m 5			
	3153.7m 3	100m			
3172.9	3128.0m	105m 10			
	3172.9m 3	100m			

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued) $\gamma(^{238}\text{U})$ (continued)

E(level)	$E\gamma^{\dagger}$	$I\gamma^{\dagger}$	Mult. [§]	α	Comments
3207.8	3162.9m	40m 6			
	3207.8m 4	100m			
3217.6	3172.7m	58m 19			
	3217.6m 6	100m			
3234.5	3189.6m	163m 38			
	3234.5m 7	100m			
3239.6	3194.7m	249m 67			
	3239.6m 3	100m			
3253.194	2125m	44m			
	2217m	9m	[E1]		B(E1)(W.u.)=4.2×10 ⁻⁷ .
	2256m	8m	[E2]		B(E2)(W.u.)=0.0025 9.
	2288m	91m	[E1]		B(E1)(W.u.)=3.8×10 ⁻⁶ 13.
	2303m	16m			
	2323m	32m			
	2327m	33m	[E1]		B(E1)(W.u.)=1.3×10 ⁻⁶ 5.
	2522m	14m	[E2]		B(E2)(W.u.)=0.0025 9.
	2574m	28m			
	3209m	22m	[E1]		B(E1)(W.u.)=3.3×10 ⁻⁷ 12.
	3253m	100m	[E1]		B(E1)(W.u.)=1.5×10 ⁻⁶ 5.
3265	397&	100			
3274.4	3229.5m	86m 10			
	3274.4m 3	100m			
3297.2	3297.2m 4	100m			
3303.6	3258.7m	106m 10			
	3303.6m 3	100m			
3307.32	3262.4m	58m 19			
	3307.3m 3	100m			
3329.1	3284.2m	85m 9			
	3329.1m 6	100m			
3348.33	3303.4m	192m 19			
	3348.3m 3	100m			
3366.0	3321.1m	53m 6			
	3366.0m 5	100m			
3368	377&				
	749&				
	1177&				
3384.3	3339.4m	41m 5			
	3384.3m 3	100m			
3397.9	3353.0m	37m 4			
	3397.9m 8	100m			
3411.2	380P	100			
3416.0	3371.1m	384m 38			
	3416.0 4	100			
3421.5	3421.5m 5	100m			
3441.0	3396.1m	48m 19			
	3441.0m 9	100m			
3448.3	3403.4m	106m 10			
	3448.3m 6	100m			
3454.1	3409.2m	250m 29			
	3454.1m 4	100m			
3460.7	3415.8m	56m 7			
	3460.7m 3	100m			
3467.8	3422.9m	58m 10			
	3467.8m 6	100m			
3470.7	3425.8m	29m 29			
	3470.7m 3	100m			
3474	409&	100			
3475.2	3430.3m	58m 29			
	3475.2m 3	100m			
3479.0	3434.1m	43m 9			
	3479.0m 3	100m			
3489.0	3444.1m	144m 58			
	3489.0m 3	100m			

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued)
 $\gamma(^{238}\text{U})$ (continued)

E(level)	$E\gamma^{\dagger}$	$I\gamma^{\dagger}$	Mult. [§]	α	Comments
3500.5	3500.5m 3	100m			
3502	408& 882&				
3509.1	3464.2m 3509.1m 9	67m 19 100m			
3521	401&	100			
3528.0	3528.0m 4	100m			
3535.3	467& 1	100	[E2]	0.0568	B(E2)(W.u.)=530 85.
3538	410&	100			
3547.7	443.6& 4	100			
3548.0	3503.1m 3548.0m 6	193m 29 100m			
3562.8	3517.9m 3562.8m 3	125m 29 100m			
3594.9	3550.0m 3594.9m 5	116m 19 100m			
3608.7	3563.8m 3608.7m 3	48m 8 100m			
3615.9	3571.0m 3615.9m 3	250m 48 100m			
3623.9	3579.0m 3623.9m 3	144m 29 100m			
3640.1	3595.2m 3640.1m 3	77m 19 100m			
3650.5	3605.6m 3650.5m 3	87m 10 100m			
3659.7	3614.8m 3659.7m 6	67m 10 100m			
3673.7	3628.8m 3673.7m 6	193m 39 100m			
3686	421&	100			
3728.0	3683.1m 3728.0m 9	87m 29 100m			
3738.5	3693.6m 3738.5m 8	77m 19 100m			
3759.9	3715.0m 3759.9m 3	87m 19 100m			
3773	405& 1154&				
3805.1	3760.2m 3805.1m 3	87m 10 100m			
3809	2882m 3128m 3764m 3809m	55m 22 28m 22 96m 14 100m			
3811.2	400p	100			
3819.0	3774.1m 3819.0m 6	106m 19 100m			
3828.7	3828.7m 3	100m			
3906	432&	100			
3947	426&	100			
3965.7	3920.8m 3965.7m 4	47m 4 100m			
3971	433&	100			
3990.7	3945.8m 3990.7m 9	116m 10 100m			
3995.8	3950.9m 3995.8m 3	58m 39 100m			
4017	469& 481&				
4018.1	482.8& 10	100	[E2]	0.0524	B(E2)(W.u.)=585 60.
4023.7	3978.8m 4023.7m 7	97m 10 100m			

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued) $\gamma(^{238}\text{U})$ (continued)

E(level)	$E\gamma^\dagger$	$I\gamma^\dagger$	Mult. [§]	α	Comments
4031.4	3986.5m	48m 10			
	4031.4m 7	100m			
4046.7	4001.8m	126m 39			
	4046.7m 3	100m			
4065.3	4020.4m	164m 39			
	4065.3m 3	100m			
4072.1	4027.2m	58m 10			
	4072.1m 6	100m			
4088.9	4044.0m	97m 29			
	4088.9m 7	100m			
4093.4	4048.5m	39m 4			
	4093.4m 3	100m			
4100.2	4055.3m	174m 19			
	4100.2m 3	100m			
4105.2	4105.2m 3	100m			
4122.9	4078.0m	81m 9			
	4122.9m 5	100m			
4127	441&	100			
4138.9	4094.0m	40m 7			
	4138.9m 7	100m			
4145.8	4100.9m	58m 58			
	4145.8m 3	100m			
4151.3	4106.4m	97m 29			
	4151.3m 6	100m			
4155.4	4155.4m 3	100m			
4175.8	4130.9m	27m 3			
	4175.8m 4	100m			
4181.5	4136.6m	97m 10			
	4181.5m 7	100m			
4205	432&	100			
4217.3	4172.4m	107m 10			
	4217.3m 8	100m			
4232	421p	100			
4239.1	4239.1m 3	100m			
4358	452&	100			
4393	446&	100			
4424	453&	100			
4495	4450mr	32m 28			
	4495m	100m			
4504	487&	100			
4517	499.3& 8	100	[E2]	0.0483	B(E2)(W.u.)=540 130.
4586	459&	100			
4592	4546m	190m			
	4592m	100m			
4677	445p	100			
4807	3840m	47m 17			
	4807m	100m			
4825	467&	100			
4895	471&	100			
5003	499&	100			
5035.1	517.7& 10	100	[E2]	0.0436	B(E2)(W.u.)=185 2.
5063	477	100			
5140	5140m	100m			
5144	467p	100			
5206	4148mr	33m 26			
	5160m	90m 28			
	5206m	100m			
5513	510&	100			
5581	542&	100			
6037	524&	100			
6146	565&	100			

[†] Weighted average from Coulomb excitation and (n,n' γ), except where noted otherwise.

Footnotes continued on next page

Adopted Levels, Gammas (continued) $\gamma(^{238}\text{U})$ (continued)

- ‡ From Coulomb excitation, except where noted otherwise.
 § From $\alpha(\text{K})\text{exp}$, except where noted otherwise.
 # From Coulomb excitation (1994Mc03).
 @ From ^{242}Pu α decay.
 & From Coulomb excitation.
 a From Coulomb excitation. Transition not directly observed, but required to account for the yield of transitions from the J-2 member of this band.
 b E=1015.06 2 in (n,n' γ) for a transition placed from the 1060 3+ and 1060 2+ levels. The division of the intensity between these two levels cannot be determined.
 c Anomalous E1 transition. $\alpha(\text{K})\text{exp}$ is larger than E1 theory and agrees with E2 theory. Similar anomalous E1 transitions have been observed in ^{236}U . See 1983Fa15.
 d E=911.3 2 in (n,n' γ) for a transition placed from the 1060 3+ and 1060 2+ levels. From branching in Coulomb excitation, most of the intensity belongs with the 1060 3+ level.
 e From (n,n' γ).
 f From (n,n' γ).
 g From ^{238}Pa β decay.
 h From Coulomb excitation. E=1060.98 3 is reported in (n,n' γ) for a transition placed from the 1060 2+ and 1106 3+ levels.
 i From Coulomb excitation. Transition not directly observed, but required to account for the yield of transitions from the J-1 member of this band.
 j E=1019.61 8 and 1123.1 2 in (n,n' γ) for transitions doubly placed from the 1169 4+ and 1169 3- levels. From branching in Coulomb excitation, most of the intensity of the 1019 γ belongs with the 1169 4+ level. The 1123 γ is more evenly divided between the two levels.
 k The 1368.3 γ 2 is placed by 1984BlZS from the 1368 level. It may belong also with the 1414 and/or 1515 level, as suggested by 1978De41, all from (n,n' γ).
 l Branching is from ^{238}Pa β^- decay.
 m From (γ,γ').
 n From ^{238}U IT decay.
 o From Coulomb excitation.
 p From Coulomb excitation (2010Zh09).
 q Multiply placed; intensity suitably divided.
 r Placement of transition in the level scheme is uncertain.
 s Multiply placed; undivided intensity given.

Adopted Levels, Gammas (continued) $^{238}_{92}\text{U}_{146}$

Adopted Levels, Gammas (continued)

 (N) Band based on $J\pi=8+$ (2010Zh09)

^{238}Pa β^- Decay

Parent ^{238}Pa : $E=0.0$; $J\pi=(3-)$; $T_{1/2}=2.28$ min 10; $Q(\text{g.s.})=3585$ 16; % β^- decay=100.

The Gamow-Teller β^- -decay strength function has been calculated in 1978Iz04 and 1979KIZT.

The decay scheme is that given in 1970HeZX. It is the same as that given in 1969KaZP except that 1969KaZP show a level at 1160, not adopted here, and 1970HeZX show a level at 1243.

Delayed fission activity observed ($T_{1/2}=2.3$ min 1) from ^{238}Pa source was interpreted in 1978Ga07 as due to a spontaneously fissioning level in the second minimum of ^{238}U nuclear potential, populated in ^{238}Pa β^- decay.

Delayed fission probability was determined to be $\approx 1 \times 10^{-8}$. Delayed fission probability more than 5×10^{-7} from 1977BoZO. Delayed fission probability less than 2.6×10^{-8} obtained by 1985Ba57. This result rules out positive evidence for this decay mode of ^{238}Pa reported in 1977BoZO and 1978Ga07.

 ^{238}U Levels

E(level)	$J\pi^\dagger$	$T_{1/2}$	E(level)	$J\pi^\dagger$
0.0 ‡	0+	4.468 $\times 10^9$ y 6	1167.8	(4+)
45.0 ‡	2+		1168.9 $^{\text{d}}$	3-
148.6 ‡	4+		1223.9 $^\#$	2+
307.3 ‡	6+		1243.1 $^{\text{d}}$	(4-)
680.0 §	1-		1381.1 $^?$	
732.0 §	3-		1412.95 $^?^\#$ 12	2+
826.6 §	5-		1561.4	
930.5 $^{\text{@}}$	(1-)		1617.2	
949.9 $^\&$	2-		1645.1	
997.6 $^{\text{@}}$	3-		1675.5	(3-)
1037 $^\#$	2+		1774.6	
1059.5 $^{\text{a}}$	(3+)		1934.2	(3-)
1060.0 $^{\text{b}}$	2+		1992.1	(3-)
1105.7 $^{\text{c}}$	(3+)		2063.9	(2-)
1128.2 $^{\text{d}}$	(2-)			

† From adopted levels.

‡ (A): $K\pi=0+$ ground-state band.

§ (B): $K\pi=0-$ octupole-vibrational band.

$^\#$ Level proposed by evaluators based on data in Coulomb excitation and (n,n' γ).

$^{\text{@}}$ (C): $K\pi=1-$, $\alpha=1$.

$^\&$ (D): $K\pi=1-$, $\alpha=0$.

$^{\text{a}}$ (E): $K\pi=3 \vee 1/2[631]+v 5/2[622]$.

$^{\text{b}}$ (F): $K\pi=2+$ γ -vibrational band. $\alpha=0$.

$^{\text{c}}$ (G): $K\pi=2+$ γ -vibrational band. $\alpha=1$.

$^{\text{d}}$ (H): $K\pi=2-$.

 β^- radiations

$E\beta^-^\dagger$	$I\beta^-^\ddagger$
1200	35
1700	40
2200	20
2900	5

† From 1968Tr07 (scin).

‡ From 1968Tr07. Intensities are per 100 β^- decays.

^{238}Pa β^- Decay (continued)

 $\gamma(^{238}\text{U})$
 $\gamma\gamma$: see 1969KaZP, 1970TrZZ.

 x-rays (relative to $I_\gamma(1015\gamma)=100$ (1969KaZP, 1968Tr07)):

E_γ	I_γ	
13.53		$L\alpha_1$ x ray + $L\alpha_2$ x ray
17.17		$L\beta_1$ x ray
16.44		$L\beta_2$ x ray
20.13		$L\gamma_1$ x ray
94.67	60	$K\alpha_2$ x ray
98.42	83	$K\alpha_1$ x ray
110.42		$K\beta_3$ x ray
111.28	33	$K\beta_1$ x ray
114.39	11	$K\beta_2$ x ray

 the intensity given for $K\beta_1$ x ray includes $K\beta_3$ x ray

$E_\gamma^\dagger$	E(level)	$I_\gamma^{\ddagger\S}$	Comments
(41.4)	1168.9		E_γ : from Coulomb excitation. Not seen in β^- decay.
45.02 ^c	45.0		
68.1 [@]	1128.2		
68.8	1128.2	7	
103.4	148.6	12	
109.4 [@]	1168.9		
x114.8 ^c			
x115.23 ^c			
x115.55 ^c			
130.7	1128.2		
x142.64 ^c			
x154.4		3	
158.7	307.3	4	
x164.5			
171.1	1168.9		
178.2	1128.2	11	
x189.4		$\leq 2^g$	
x193.3		$\leq 2^g$	
197.8	1128.2	9	
x212.9			
217.9	949.9	14	
x221.9		4	
x228.8			
x238.3			E_γ : placed by 1970HeZX from the 1169 3- level; however, this transition is not reported in Coulomb excitation or in (n,n' γ).
250.6	930.5	7	
x258.5		8	
x265.5			E_γ : placed by 1970HeZX from the 998 3- level; however, this transition is not reported in Coulomb excitation or in (n,n' γ).
269.8	949.9	12	
x276			
289.1	1934.2	4	
x293.0		12	
x301.8		2	
317.0	1934.2	7	
x322.0			
x329.5			
x347.3			
x353.3			
373	1934.2	$\leq 6^\#$	
375	1992.1	$\leq 6^\#$	
x377		$\leq 6^\#$	
396.5	1128.2	18	
x407.5		9	
x422.2		6	
x433.0			
437.0	1168.9	16	
x442.9			
448.3	1128.2	69 ^o	

Continued on next page (footnotes at end of table)

$^{238}\text{Pa} \beta^-$ Decay (continued)

 $\gamma(^{238}\text{U})$ (continued)

$E\gamma^{\dagger}$	E(level)	$I\gamma^{\ddagger\S}$	Comments
448.3	1617.2	$\approx 7^0$	E γ : taken from author's spectrum. The value given on the decay scheme is 448.4.
$\times 456.2$		7	
$\times 459.6$			
$\times 465.6$		2	
476.2	1645.1	19	
489.0	1168.9	4 ^p	
	1617.2	16 ^p	
501.9	1561.4	26	
$\times 508.4$			
$\times 511$			
519.3	826.6	$\approx 1.5^m$	
547.2	1675.5	40	
557.9	1617.2	$\leq 4^{\&}$	557.9 γ may feed the 1059.5- or 1060.0-keV level.
$\times 569.6$		$\leq 6^k$	
$\times 572.1$		$\leq 6^k$	
583.5	732.0	41	
605.7	1774.6	10	
$\times 615.2$		8	
$\times 623.6$		19	
635.0	680.0	88	
646.4	1774.6	9	
$\times 659.8$			
$\times 667.7$			
678 ^e	826.6	$\approx 3^m$	
679.9	680.0	70 ^m	
686.8	732.0	54	
$\times 744$			
$\times 749$			
765.3	1934.2	4	
$\times 769$			
$\times 797.5$			
805.7	1934.2	44	
$\times 818.1$			
823.2	1992.1	9	
$\times 836.7$			
$\times 839.6$			
849.1	997.6	20	I γ : 1968Tr07 assign I γ =14 and I γ =6 to peaks at 849.3 and 851.9, respectively. Only a single peak is shown in 1970HeZX.
863.6	1992.1	54	
874.4	1934.2	9	
885.5	930.5	45	
905.0	949.9	23	
911.1	1059.5	17 ^{1 3}	
	1060.0	2 ^{1 2}	
930.5	930.5	$\leq 6^a$	
932.5	1992.1	$\leq 6^a$	
943.5	1675.5	7	
952.4	997.6	21	
957.2	1105.7	18	
$\times 961$			
$\times 967$		$\leq 4^b$	
$\times 969$		$\leq 4^b$	
$\times 979.6$			
984.6	1934.2	7	
$\times 991.1$			
991.1 ^d	1037		
995.4	1675.5	10	
1003.6	1934.2		
1014.5	1059.5	$\leq 100^r$	
1015.2	1060.0	$\leq 100^r$	
1019	1167.8	$\approx 2^q$	
1020	1168.9	8 ^q	
$\times 1032.9$			

Continued on next page (footnotes at end of table)

$^{238}\text{Pa} \beta^-$ Decay (continued)

 $\gamma(^{238}\text{U})$ (continued)

$E_{\gamma}^{\dagger}$	E(level)	$I_{\gamma}^{\ddagger\S}$	Comments
$^{x1036.1}$			
1036.1 ^d	1037		
1042.4	1774.6	8	
1060.1	1060.0	$\leq 45^s$	
1060.6	1105.7	$\leq 45^s$	
x1071			
x1074			
1083.4	1128.2	50	
$^{x1090.2}$			
1094.5 ^t	1243.1	$\leq 5^t$	
	1774.6	$\leq 5^t$	
x1112		$\leq 6^i$	
x1113		$\leq 6^i$	
1123	1167.8	$\approx 1^n$	
1124	1168.9	4^n	
$^{x1159.5}$		$\leq 5^j$	
$^{x1161.5}$		$\leq 5^j$	
$^{x1178.8}$		6	
1178.8 ^d	1223.9	6	
$^{x1214.8}$		6	
$^{x1224.0}$		6	
1224.0 ^d	1223.9	6	
$^{x1233.5}$			
$^{x1306.4}$			
$^{x1311.7}$			
$^{x1325.2}$			
1332.0	2063.9	5	
$^{x1336.7}$			
1336.7 ^{hu}	1381.1?	≈ 1	
$^{x1359.3}$			
x1364			
$^{x1368.8}$		5	
1368.8 ^{hu}	1412.95?	5	
$^{x1377.1}$		4	
1383.9	2063.9	7	
x1394			
x1410		$\leq 3^f$	
1413 ^{hu}	1412.95?	3	
	1561.4	$\leq 3^f$	
x1420			
1496.6	1645.1	8	
$^{x1507.1}$			
1516.5	1561.4		
1527.1	1675.5	4	
1600	1645.1	$3\&$	
x1611		3	
x1620			
1626	1774.6	$3\&$	
1630.5	1675.5	$3\&$	
$^{x1647.5}$			
1730	1774.6	$3\&$	
x1737			
x1752			
1785.7	1934.2		
x1804			
x1841			
$^{x1872.5}$			
1889.1	1934.2	17	
$^{x1907.0}$			
x1976			
$^{x1985.5}$			
x1997		4	
x2013		3	

Continued on next page (footnotes at end of table)

²³⁸Pa β⁻ Decay (continued)

γ(²³⁸U) (continued)

E _γ [†]	E(level)	I _γ ^{‡§}	Comments
2019	2063.9	7	
^x 2048			
^x 2081			
^x 2089			
^x 2126			
^x 2529 2			E _γ : reported only by 1968Tr07.

[†] From 1970HeZX, except where noted otherwise. Others: 1968Tr07 and 1969KaZP. These three references refer to work by the same group, but the spectrum of 1970HeZX is a sum of more runs than the others, and more transitions are reported. All spectra were recorded with a 60 α Ge(Li) detector. In addition, 1969KaZP show a low-energy spectrum, 5–170 keV, taken with a 0.5 α Ge(Li) detector. Only 1968Tr07 report intensities.

[‡] From 1968Tr07. No uncertainties are given.

[§] From 1968Tr07. No uncertainties are given. The decay scheme cannot be normalized since the schemes given in the papers 1970HeZX, 1969KaZP, 1968Tr07 are not complete. In particular, the intensities of several of the transitions among the low-lying levels are not known, and a comparison of the measured E(β⁻) of 1968Tr07 with the Q(β⁻) value of 1985Ba57 and known level energies does not allow one to determine to which levels the measured I(β⁻) correspond.

I(373γ+375γ+377γ)=6.

@ Peak not labeled in spectrum of 1970HeZX, but placed in decay scheme. Peak is present in low-energy spectrum of 1969KaZP.

& Estimated by evaluators from authors' spectrum.

a I(930.5γ+932.5γ)=6.

b I(967γ+969γ)=4.

c Reported only in 1969KaZP in their low-energy spectrum.

d Unplaced by 1970HeZX, but energy agrees with transition seen in Coulomb excitation and in (n,n'γ).

e Peak not labeled in spectrum of 1970HeZX, but placed in decay scheme. This weak transition would not be resolved in singles from a strong close-lying peak.

f I(1410γ+1413γ)=3.

g I_γ(189.4γ+193.3γ)=2.

h Unplaced by authors. Placement suggested by evaluators on the basis of data in Coulomb excitation or (n,n'γ).

i I_γ(1112+1113γ)=6.

j I_γ(1159.5γ+1161.5γ)=5.

k I_γ(569.6γ+572.1γ)=6.

l 1968Tr07 report I_γ=19 for the 911γ, deexciting the 1060 doublet. From branching in Coulomb excitation, one obtains I_γ≤4 for placement from the 1060 2+. If one assigns an uncertainty of 10% to I_γ(911γ), then, with the component from the 1060 2+ taken as 2 2, one obtains I_γ=17 3 for the component from the 1060 3+.

m I_γ(678γ+679.9γ)=73. The 678γ is placed from the 827 level, and the 679.9γ from the 680 level. From I_γ/I_γ(635γ)=0.79 4 for the 680 level in Coulomb excitation, one obtains I_γ(679.9γ)=70. Leaving I_γ(678γ)=3. From I_γ(519γ)/I_γ(678γ)=0.50 5 for the 827 level in Coulomb excitation, one can deduce I_γ(519γ)=1.5 in β decay. 1968Tr07 do not report an intensity for this transition.

n 1968Tr07 report I_γ=5 for the 1123+1124 doublet. From Coulomb excitation, I_γ(1124γ)/I_γ(437γ)=0.27 3 for the 1169 3- level, giving I_γ(1124γ)=4, thus leaving I_γ(1123)=1 for the 1168 4+ level.

o 1968Tr07 report I_γ=76 for the 448.3γ placed by them from the 1129 2- and 1617 levels. From Coulomb excitation, I_γ/I_γ(396γ)=3.84 25 for placement from the 1129 level, giving I_γ(448.3γ)=69 for this placement, leaving I_γ=7 for placement from the 1617 level. No uncertainties are given in 1970HeZX, but if the uncertainties were greater than about 5%, the data would be consistent with placing the 448γ entirely from the 1129 level.

p 1970HeZX report a 489.0 transition with I_γ=20 (1967Tr07) which they place from the 1169 3- and 1617 levels. From branching in Coulomb excitation, I_γ/I_γ(437γ)=0.234 19 for placement from the 1169 level which gives I_γ(489γ)=4 for this placement, leaving I_γ=26 for placement from the 1617 level.

q 1968Tr07 report I_γ=10 for the 1019+1020 transitions. From Coulomb excitation, I_γ(1020γ)/I_γ(437γ)=0.50 6 for the 1169 3- level, giving I_γ(1020γ)=8, thus leaving I_γ(1019γ)=2 for the 1168 4+ level.

r I_γ(1014.5γ+1015.2γ)=100.

s I_γ(1060.1γ+1060.6γ)=45.

t Multiply placed; undivided intensity given.

u Placement of transition in the level scheme is uncertain.

x γ ray not placed in level scheme.

Decay Scheme

(3-) 0.0 2.28 min
 $^{238}_{91}\text{Pa}_{147}$
 $Q^- = 3585^{16}$
 $\% \beta^- = 100$

$^{238}\text{Pa} \beta^-$ Decay (continued)

Decay Scheme (continued)

(3-) 0.0 2.28 min
 $^{238}_{91}\text{Pa}_{147}$
 $\beta^- = 100$
 $Q = 3585^{16}$

& Multiply placed; undivided intensity given
 Intensities: relative I_γ

(2-)	2063.9
(3-)	1992.1
(3-)	1934.2
	1774.6
(3-)	1675.5
	1617.2
	1561.4

----- 1381.1 -----

2+	1223.9
(2-)	1128.2
(3+)	1105.7
2+	1060.0
(3+)	1059.5
2+	1037
3-	997.6
2-	949.9
(1-)	930.5
5-	826.6
3-	732.0
1-	680.0
6+	307.3
4+	148.6
2+	45.0
0+	0.0

4.468×10⁹ y

$^{238}_{92}\text{U}_{146}$

²³⁸U IT Decay (280 ns)

Parent ²³⁸U: E=2557.9 5; J π =0+; T_{1/2}=280 ns 6; %IT decay=97.4 4.

Shape isomer.

Conversion electrons from electromagnetic transitions preceding the fission decay of the shape isomer have been measured. A highly converted transition is observed which is tentatively interpreted as the decay of the lowest β -vibrational band, via E0 transition, at excitation energy of 647.8 9 (1982Go02).

See 1983Ha29 for other γ transitions that are tentatively interpreted as deexcitation of the β -vibrational band in the second minimum.

Isomer not excited by muon capture (3% limit) (1976Ka37).

²³⁸U Levels

E(level) [‡]	J π [†]	T _{1/2} [‡]	Comments
0.0	0+	4.468×10 ⁹ y 6	
44.916 13	2+	206 ps 3	
680.11 4	1-		
2557.9 5	0+	280 ns 6	%IT=97.4 4; %SF=2.6 4. Intrinsic electric-quadrupole moment: Q ₀ =29 3 (1979U101). J π : 2558 γ to 0+ is E0. σ (d,pn γ)/ σ (d,pnSF)=15 to 25 (1975Ru03). Γ (45 γ)/ Γ (SF)=10 (1976Be55). See 1972We09 for predicted T _{1/2} (SF) and T _{1/2} (γ). T _{1/2} : weighted average of (n,n') values of 270 ns 40 (1974WoZW), 300 ns 32 (1977VoZU), 290 ns 30 (1983Dm04), 267 ns 13 (1989Ma54), 274 ns 10 (1991Ku23) and (d,pn) values of 295 ns 15 (1974WoZW), and 298 ns 18 (1992St05). Others: (d,pn) values of 200 ns 70 (1970Po01), 195 ns 30 (1970Wo06), 191 ns 44 (1975Ru03), 184 ns 13 (reference 13 of 1991Ku23) and 211 ns 60 (1982Go02) cluster around 200 ns, and (d,pn) values of 110 ns 30 (1970Re05) and 130 ns 50 (reference 13 of 1991Ku23), the (n,n') value of 125 ns 35 (1977ArZZ) and the (γ,γ') values of 146 ns 22 (1983Dr14) and 155 ns 33 (1985Dr01) are lower still. See 1991Ku23 for a discussion of these data. These authors argue against the earlier suggestions that there could be two isomers. See also the discussion in 1992St05 of the T _{1/2} discrepancies. For calculated energy, see 1969Ni13, 1971Pa33, 1972Mo27, 1972Ma11, 1972We09, 1994Kr06. %SF: 1992St05 report σ (μ b)(1879 γ +2513 γ)=132 26, and 1975Ru03 report 130 32. 1992St05 estimate σ (μ b)=80 30 for unobserved decay to the six known 1- and 2+ states and 1975Ru03 estimate 70 20. 1983Ka11 report 0.230 μ b 50 for decay of the 2558 E0 transition via ce(K). A weighted average for decay from the isomer based on these data is 206 μ b 28. With σ =5.4 μ b 4 for delayed fission as quoted by 1992St05 from 1980Ti03 and 1970Wo06, one gets %SF=2.6 4 and %IT=97.4 4. Other: 1983Ka11 report σ (2513 γ)<50 μ b, and 1984Ka10 report 42 μ b 12.

[†] From adopted levels, unless otherwise noted.

[‡] From Adopted levels.

γ (²³⁸U)

I γ normalization: From Σ (1879 γ + 2513 γ + 2558 γ)=97.4 % 4.

E γ	E(level)	I γ [†]	Mult.	I(γ +ce) [†]	Comments
(44.915)	44.916		E2		L and M conversion lines were observed following the photofission reaction on ²³⁸ U. They were identified by 1976Be55 as belonging to the 44.9 γ from decay of the 44.9 level following IT decay of the shape isomer. They showed a half-life of 300 ns. Half-life = 202 ps, calculated value (2008Pa04).
(635.18 3)	680.11		[E1]		
(680.1 3)	680.11		[E1]		
1879	2557.9	49 13	[E1]		E γ : from 1975Ru03, also confirmed by 1992St05. I γ : weighted average from 1975Ru03 and 1992St05 is 43 μ b 11. % γ =32 7. % γ =65 7.
2512.7 5	2557.9	100 19	[E2]		E γ : from 1984Ka10, also confirmed by 1992St05. I γ : weighted average from 1975Ru03 and 1992St05 is 88 μ b 17. %e=0.22 6.
2558 2	2557.9		E0	0.34 6	E γ : from 1983Ka11. Energy of the E0 K-conversion electrons is 2442.4 20. No photons were observed. I(γ +ce): 1983Ka11 report σ (ce(K))=0.230 μ b 50. The authors add 16% to account for the higher shell conversion electrons, and 15% to account

Continued on next page (footnotes at end of table)

²³⁸U IT Decay (280 ns) (continued)

$\gamma(^{238}\text{U})$ (continued)

E_γ	E(level)	$I_\gamma^\dagger$	Mult.	$I(\gamma+ce)^\dagger$	Comments
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for internal pair production. The total ce intensity is thus 0.30 μb 5.

† For absolute intensity per 100 decays, multiply by 0.65 11.

Decay Scheme

Intensities: $I(\gamma+ce)$ per
100 parent decays
%IT=97.4 4

²⁴²Pu α Decay 2013KeZZ,2011Be01

Parent ²⁴²Pu: E=0.0; $J\pi=0+$; $T_{1/2}=3.73\times 10^5$ y 3; Q(g.s.)=4984.7 10; % α decay=100.

Other:2005ChZU.

Others: 2013De12, 2013Is13, 2013Ra05, 2013Se17, 2012Is08, 2009De32, 2009Dr05.

Theory: 2012Pr09, 2011Qi06, 2011Zh36, 2010Wa23, 2010Wa31, 2009Ni06, 2009Wa01, 2007Pe30, 2006De05, 2006Xu08,

2005De44, 2005Re16, 2005Xu01, 2004Ro01.

x-ray: $M_{\alpha,\beta}$: L_e : L_α : $L_{\eta,\beta}$: L_γ = 41 4:5.6 9: 71.7 72: 100 10: 24.5 25 (1990Po14).

²³⁸U Levels

E(level) †	$J\pi$	$T_{1/2}$	Comments
0.0	0+	4.468×10^9 y 6	$T_{1/2}$: From Adopted Levels.
44.915 13	2+	225 ps 20	$T_{1/2}$: From $\alpha - ce$ (t) delayed coincidence measurement (1960Be25).
148.42 4	4+		
307.44 4	6+		

† From 2011Be01.

α radiations

$E\alpha^\ddagger$	E(level)	$I\alpha^\ddagger$ §	HF	Comments
4600.1 10	307.44	6.20×10^{-4} 3	821	
4756.2 10	148.42	0.0304 14	238	
4858.2 10	44.915	23.4 6	1.6	$E\alpha$: Other value: 4858.1 keV 9, recommended in 1991Ry01.
4902.3 10	0.0	76.5 6	1.000	$E\alpha$: Other value: 4902.2 keV 14, recommended in 1991Ry01.

† Absolute intensity per 100 decays.

‡ From 2013KeZZ.

§ From 2011Be01 and 1972Sc01, deduced by evaluators from $I(\gamma+ce)$.

²⁴²Pu α Decay

2013KeZZ,2011Be01 (continued)

$\gamma(^{238}\text{U})$

$E\gamma^\ddagger$	E(level)	$I\gamma^{\ddagger\S}$	Mult.	α	Comments
44.915 13	44.915	0.0384 8	E2	610	
103.50 4	148.42	0.0253 12	[E2]	11.36	
159.018 16	307.44	2.20×10^{-4} 8	[E2]	1.81	$E\gamma, I\gamma$: From 2011Be01.

† Absolute intensity per 100 decays.
‡ From 1972Sc01, unless otherwise specified.
§ From 2013KeZZ, unless otherwise specified.

²³⁶U(t,p) 1973Ba72

E=15 MeV. FWHM==15-20 keV.
The 0+ level at 997 keV reported in Coulomb excitation was looked for but not observed by 1972Ca19 or 1973Ba72.
Q(t,p)=2900 20 1964Mi15.
Q(t,p)=2782 10 1967Er02.
Q(t,p)=2780 20 1969Br11.

²³⁸U Levels

E(level)
0.0
45 2
154 5
1054 5
1169 5
1237 8

²³⁸U(γ, γ') 2012Ha12

Nuclear resonance fluorescence (NRF) experiment performed with 100% linearly-polarized photon beams with energies of 2.0–6.2 MeV at the HIγS facility. Beams created through Compton backscattering of free-electron-laser photons.

Gamma rays detected with HPGe detectors. Measured E γ , I γ , angular distribution, polarization. Deduced levels, J, π , widths, B(E1), B(M1) values.

Others: 2014Gu04, 1983Zu04, 1983Ru03, 1978Ka29.

²³⁸U Levels

E(level)	J π^S	Γ^2_0/Γ^{ab}	I _s eVb ^c	Comments
0.0	0+			E(level), J π : from Adopted Levels.
44.90	2+			
680.1 [†]	1- [‡]			
731.9 [†]	3- [‡]			
927	0+ [‡]			
931	1- [‡]			
951	2- [‡]			
966	2+ [‡]			
998	3- [‡]			
1037	2+ [‡]			
1059	3+ [‡]			
1061	2+ [‡]			
1129	2- [‡]			
1782	1 [#]	33 fs 4	21.9 25	Γ^2_0/Γ : From $\Gamma(\gamma_0)$ and branching (1995Zi02).
1793	1 [#]	80 fs +40-20	5.1 10	Γ^2_0/Γ : From $\Gamma(\gamma_0)$ and branching (1995Zi02).
1846	1 [#]	31 fs 4	23.0 26	Γ^2_0/Γ : From $\Gamma(\gamma_0)$ and branching (1995Zi02).
1996.7 3	1-	2.8×10 ⁻³ eV 3	7.0 8	Γ^2_0/Γ : Γ^2_0/Γ = ≈5×10 ⁻³ eV (2011Qu01).
2017.7 4	1+	1.5×10 ⁻³ eV 3	2.6 6	
2079.3 4	1+	2.4×10 ⁻³ eV 5	6 1	
2080.7 4	1-	8×10 ⁻³ eV 1	14 2	
2093.3 4	1-	3.1×10 ⁻³ eV 6	7 1	
2145.6 3	1-	3.6×10 ⁻³ eV 6	8 1	
2175.8 3	1+ [@]	24×10 ⁻³ eV 1	40 2	
2208.8 3	1+ [@]	18×10 ⁻³ eV 1	29 2	
2244.4 3	1+ [@]	14.2×10 ⁻³ eV 8	27 2	
2294.1 3	1+ [@]	4.0×10 ⁻³ eV 5	6.6 9	
2332.7 3	1-	5.4×10 ⁻³ eV 9	10 2	Γ^2_0/Γ : Γ^2_0/Γ = ≈10×10 ⁻³ eV (2011Qu01).
2365.6 3	1-	23×10 ⁻³ eV 3	44 6	
2410.0 3	1+ [@]	11×10 ⁻³ eV 1	18 2	
2422.8 3	1-	6.2×10 ⁻³ eV 7	12 1	
2467.8 5	1+ [@]	48×10 ⁻³ eV 5	80 8	
2491.5 5	1-	5.2×10 ⁻³ eV 8	9 1	
2499.4 3	1+	20×10 ⁻³ eV 1	32 2	
2529.0 3	1-	7×10 ⁻³ eV 1	12 2	
2593.7 6	1-	4.1×10 ⁻³ eV 4	6.6 7	
2602.5 4	1-	1.9×10 ⁻³ eV 2	3.1 3	
2638.3 3	1+	7.3×10 ⁻³ eV 7	10 1	Γ^2_0/Γ : Γ^2_0/Γ = ≈24×10 ⁻³ eV (2011Qu01).
2647.3 8	1+	18×10 ⁻³ eV 1	25 2	
2702.2 3	1+	10×10 ⁻³ eV 1	16 2	
2738.9 9	1+	8×10 ⁻³ eV 2	11 3	
2756.4 3	1+	5×10 ⁻³ eV 1	7 2	
2773.0 3	1+	6×10 ⁻³ eV 1	8 1	
2816.8 4	1+	19×10 ⁻³ eV 4	26 5	
2844.2 9	1-	2.6×10 ⁻³ eV 4	3.5 5	
2862.2 5	1-	3.6×10 ⁻³ eV 4	4.3 5	
2877.1 3	1-	3.1×10 ⁻³ eV 4	4.1 6	
2881.4 5	1+	2.3×10 ⁻³ eV 5	2.8 6	Γ^2_0/Γ : Γ^2_0/Γ = ≈24×10 ⁻³ eV (2011Qu01).
2896.6 3	1-	4.4×10 ⁻³ eV 6	5.4 8	
2908.9 3	1-	6.2×10 ⁻³ eV 8	7.5 9	
2910.0 4	1-	11×10 ⁻³ eV 1	11 1	
2932.6 6	1+	2.5×10 ⁻³ eV 5	2.8 6	
2951.2 3	1+	5.7×10 ⁻³ eV 5	6.8 5	
2963.9 8	1+	1.8×10 ⁻³ eV 4	2.2 5	
3005.9 4	1-	5.8×10 ⁻³ eV 6	6.2 7	
3014.5 3	1+	3.9×10 ⁻³ eV 7	4.5 8	
3018.9 3	1-	2.6×10 ⁻³ eV 5	2.9 6	
3030.6 3	1+	6.2×10 ⁻³ eV 6	7.3 7	

Continued on next page (footnotes at end of table)

²³⁸U(γ, γ') 2012Ha12 (continued)

²³⁸U Levels (continued)

E(level)	J $\pi^{\S}$	Γ^2_0/Γ^{ab}	I _s eVb ^c	Comments
3037.7 3	1+	7 $\times 10^{-3}$ eV 1	7 1	
3042.5 6	1+	22 $\times 10^{-3}$ eV 6	24 6	
3043.6 3	1-	4.4 $\times 10^{-3}$ eV 5	5.0 6	
3046.9 3	1-	22 $\times 10^{-3}$ eV 3	5.0 6	
3051.7 3	1-	7.2 $\times 10^{-3}$ eV 6	7.8 7	
3057.1 4	1-	14 $\times 10^{-3}$ eV 1	15 2	
3060.6 3	1-	7 $\times 10^{-3}$ eV 1	7 1	
3086.7 5	1-	4.5 $\times 10^{-3}$ eV 9	4.8 9	
3091.0 3	1-	7 $\times 10^{-3}$ eV 1	8 1	
3094.2 3	1-	7.8 $\times 10^{-3}$ eV 7	7.2 8	
3096.4 3	1-	13 $\times 10^{-3}$ eV 2	11 1	
3101.7 4	1-	3.7 $\times 10^{-3}$ eV 7	3.8 7	
3117.7 4	1-	9 $\times 10^{-3}$ eV 2	8 2	
3135.0 3	1+	4.9 $\times 10^{-3}$ eV 8	5.1 9	
3153.7 3	1+	4.8 $\times 10^{-3}$ eV 6	5.0 6	
3172.9 3	1+	2.0 $\times 10^{-3}$ eV 3	1.9 3	
3207.8 4	1-	2.8 $\times 10^{-3}$ eV 6	2.8 5	
3217.6 6	1+	2.5 $\times 10^{-3}$ eV 5	2.6 5	
3234.5 7	1+	4.1 $\times 10^{-3}$ eV 8	3.8 8	
3239.6 3	1-	4.0 $\times 10^{-3}$ eV 9	3.6 8	
3253.394 15	1	0.24 ps 8		J π : from $\gamma(\theta)$ (1981Mu05). E(level): from line shape analysis using E γ (⁵⁶ Co source)=3253.417 14 (1981Mu05). Γ^2_0/Γ : from σ , with $\Gamma_{\gamma 0}/\Gamma=0.25$ 5. Value is from 1982Ru03, and corresponds to $\Gamma_{\gamma 0}=5.2\times 10^{-4}$ eV 19. The earlier publication, 1981Mu05, gives $\Gamma_{\gamma 0}=4.9\times 10^{-4}$ eV 18 and T _{1/2} =0.23 ps 8.
3274.4 3	1-	9 $\times 10^{-3}$ eV 2	7 1	
3297.2 4	1-	7 $\times 10^{-3}$ eV 1	6 1	
3303.6 3	1-	3.5 $\times 10^{-3}$ eV 5	2.5 4	
3307.32 3	1+	10 $\times 10^{-3}$ eV 1	9 1	
3329.1 6	1-	9 $\times 10^{-3}$ eV 1	7 1	
3348.33 3	1+	13 $\times 10^{-3}$ eV 2	6.3 8	
3366.0 5	1+	8 $\times 10^{-3}$ eV 1	6 1	
3384.3 3	1-	13 $\times 10^{-3}$ eV 2	10 2	
3397.9 8	1-	12 $\times 10^{-3}$ eV 2	10 1	
3416.0 4	1-	12 $\times 10^{-3}$ eV 2	2.7 6	
3421.5 5	1-	3.5 $\times 10^{-3}$ eV 6	3.0 6	
3441.0 9	1-	6 $\times 10^{-3}$ eV 1	6 1	
3448.3 6	1+	5 $\times 10^{-3}$ eV 1	4 1	
3454.1 4	1-	7 $\times 10^{-3}$ eV 2	3 1	
3460.7 3	1+	8 $\times 10^{-3}$ eV 1	6.4 8	
3467.8 6	1-	10 $\times 10^{-3}$ eV 1	9 1	
3470.7 3	1-	9 $\times 10^{-3}$ eV 2	7 2	
3475.2 3	1-	10 $\times 10^{-3}$ eV 2	7 2	
3479.0 3	1-	14 $\times 10^{-3}$ eV 1	12 1	
3489.0 3	1-	24 $\times 10^{-3}$ eV 7	13 4	
3500.5 3	1-	16 $\times 10^{-3}$ eV 2	14 2	
3509.1 9	1-	18 $\times 10^{-3}$ eV 4	12 3	
3528.0 4	1-	5.5 $\times 10^{-3}$ eV 8	4.8 7	
3548.0 6	1-	7 $\times 10^{-3}$ eV 1	5.7 8	
3562.8 3	1-	6.8 $\times 10^{-3}$ eV 8	5.4 6	
3594.9 5	1-	8 $\times 10^{-3}$ eV 1	6.4 8	
3608.7 3	1-	14 $\times 10^{-3}$ eV 1	12 1	
3615.9 3	1-	5.1 $\times 10^{-3}$ eV 7	3.7 5	
3623.9 3	1-	4.5 $\times 10^{-3}$ eV 6	3.4 4	
3640.1 3	1-	4.5 $\times 10^{-3}$ eV 7	3.5 6	
3650.5 3	1-	11 $\times 10^{-3}$ eV 1	8.2 9	
3659.7 6	1-	4.4 $\times 10^{-3}$ eV 7	3.5 5	
3673.7 6	1-	5.8 $\times 10^{-3}$ eV 9	4.1 7	
3728.0 9	1-	5 $\times 10^{-3}$ eV 1	4 1	
3738.5 8	1-	18 $\times 10^{-3}$ eV 2	13 2	
3759.9 3	1-	23 $\times 10^{-3}$ eV 2	16 2	
3805.1 3	1-	26 $\times 10^{-3}$ eV 2	18 2	

Continued on next page (footnotes at end of table)

²³⁸U(γ, γ') 2012Ha12 (continued)

²³⁸U Levels (continued)

E(level)	J π [§]	Γ^2_0/Γ^{ab}	I _s eVb ^c	Comments
3809	(1, 2+)			$\Gamma_{\gamma 0} \geq 1.6 \times 10^{-3}$ eV.
3819.0 6	1-	16 $\times 10^{-3}$ eV 2	11 1	
3828.7 3	1-	7 $\times 10^{-3}$ eV 1	5.2 8	
3965.7 4	1-	18 $\times 10^{-3}$ eV 3	10 2	
3990.7 9	1-	9.5 $\times 10^{-3}$ eV 8	4.7 4	
3995.8 3	1-	11 $\times 10^{-3}$ eV 2	6 1	
4023.7 7	1-	10 $\times 10^{-3}$ eV 2	5 1	
4031.4 7	1-	15 $\times 10^{-3}$ eV 2	7.5 8	
4046.7 3	1-	11 $\times 10^{-3}$ eV 2	5.0 8	
4065.3 3	1-	9 $\times 10^{-3}$ eV 2	3.8 7	
4072.1 6	1-	14 $\times 10^{-3}$ eV 2	8 1	
4088.9 7	1-	7 $\times 10^{-3}$ eV 1	3.3 5	
4093.4 3	1-	15 $\times 10^{-3}$ eV 2	8.4 7	
4100.2 3	1-	10 $\times 10^{-3}$ eV 1	4.1 4	
4105.2 3	1-	6.5 $\times 10^{-3}$ eV 8	3.9 5	
4122.9 5	1-	7 $\times 10^{-3}$ eV 2	3.7 9	
4138.9 7	1-	10 $\times 10^{-3}$ eV 1	5.2 6	
4145.8 3	1-	6 $\times 10^{-3}$ eV 1	2.7 5	
4151.3 6	1-	7 $\times 10^{-3}$ eV 2	3.3 9	
4155.4 3	1-	20 $\times 10^{-3}$ eV 4	12 2	
4175.8 4	1-	21 $\times 10^{-3}$ eV 3	11 2	
4181.5 7	1-	16 $\times 10^{-3}$ eV 3	7 1	
4217.3 8	1-	12 $\times 10^{-3}$ eV 2	5 1	
4239.1 3	1-	26 $\times 10^{-3}$ eV 3	14 2	
4495	(1, 2+)			$\Gamma_{\gamma 0} \geq 4.7 \times 10^{-5}$ eV.
4592	(1, 2+)			IG $_{\gamma 0} \geq 2.8 \times 10^{-4}$ eV.
4807	1&			$\Gamma_{\gamma 0} = 2.5 \times 10^{-4}$ eV 5.
5140?				
5206	(1, 2+)			$\Gamma_{\gamma 0} \geq 4.1 \times 10^{-4}$ eV.
5666?	(1, 2+)			
5843?	(1, 2+)			

[†] Rounded-off value from adopted levels.

[‡] From adopted levels.

[§] J π for levels directly excited in (γ, γ') will have J=1 or J π =2+.

From $\gamma(0)$ (1995Zi02).

@ From $\gamma(0)$ in (γ, γ') and form factor in (e,e') (1988He02).

& From $\gamma(0)$ (1982Ru03).

a From 1982Ru03.

b 1988He02 give Γ^2_0/Γ and $\Gamma_{\gamma 1}/\Gamma_{\gamma 0}$ from 1982Ru03. Although not explicitly stated in the paper, the authors have allowed for possible branchings to higher levels by writing $\Gamma = (1.05 \text{ } ^5\Gamma_{\gamma 0} + \Gamma_{\gamma 1})$, and have used this expression in deducing their B(M1) and $\Gamma_{\gamma 0}$ values (private communication from the second author). The basis for introducing this 5% term is given in Phys. Lett. 149B, 59 (1984), Nucl. Phys. A492, 411 (1989), and Ann. of Phys. 171, 253 (1986). The evaluators have included this additional branching in deducing the total Γ and B(M1)(W.u.) values.

c Integrated cross section (2012Ha12).

 $\gamma(^{238}\text{U})$

B(E1) and B(M1) values listed here with the ground state transitions are from 0+, g.s. to excited 1- and 1+, respectively, i.e. "up" values.

E(level)	E γ [‡]	I γ [†]	Mult.	Comments
1782	1737 [#]	55 [#] 5		
	1782 [#]	100 [#]		
1793	1748 [#]	100 [#]		
	1793 [#]	90 [#] 23		
1846	1802 [#]	51 [#] 5		
	1846 [#]	100 [#]		
1996.7	1951.8	18 2		
	1996.7 3	100	[M1]	B(E1)($\uparrow$) = 1.2 $\times 10^{-5}$ 2 R _{exp} = 0.19 2.
2017.7	1972.8	187 47		
	2017.7 4	100	[M1]	B(M1)($\uparrow$) = 0.14 5 R _{exp} = 2.0 5.

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$^{238}\text{U}(\gamma, \gamma')$ 2012Ha12 (continued) $\gamma(^{238}\text{U})$ (continued)

E(level)	$E_{\gamma}^{\ddagger}$	$I_{\gamma}^{\ddagger}$	Mult.	Comments
2079.3	2079.3 4			B(M1)($\uparrow$)=0.07 2 R_{exp} =0.0 1.
2080.7	2035.8	150 19		
	2080.7 4	100	[E1]	B(E1)($\uparrow$)=6 $\times$ 10 ⁻⁵ 1 R_{exp} =1.6 2.
2093.3	2093.3 4		[E1]	B(E1)($\uparrow$)=1.0 $\times$ 10 ⁻⁵ 2 R_{exp} =0.0 1.
2145.6	2145.6 3		[E1]	B(E1)($\uparrow$)=1.1 $\times$ 10 ⁻⁵ 2 R_{exp} =0.0 1.
2175.8	2130.9@	54@ 3		
	2175.8@ 3	100@	[M1]	B(M1)($\uparrow$)=0.96 8 R_{exp} =0.57 3.
2208.8	2163.9@ 3	21@ 8		
	2208.8@ 3	100@	[M1]	B(M1)($\uparrow$)=0.7 1 R_{exp} =0.22 8.
2244.4	2199.5@	14@ 1		
	2244.4@ 3	100@	[M1]	B(M1)($\uparrow$)=0.41 3 R_{exp} =0.15 1.
2294.1	2249.2@	103@ 6		
	2294.1@ 3	100@	[M1]	B(M1)($\uparrow$)=0.18 3 R_{exp} =1.09 6.
2332.7	2287.8	132 9		
	2332.7 3	100	[E1]	B(E1)($\uparrow$)=2.6 $\times$ 10 ⁻⁵ 5 R_{exp} =1.4 1.
2365.6	2365.6 3		[E1]	B(E1)($\uparrow$)=5.1 $\times$ 10 ⁻⁵ 7 R_{exp} =0.0 1.
2410.0	2365.1@	170@ 9		
	2410.0@ 3	100@	[M1]	B(M1)($\uparrow$)=0.61 7 R_{exp} =1.8 1.
2422.8	2422.8 3		[E1]	B(E1)($\uparrow$)=1.2 $\times$ 10 ⁻⁵ 1 R_{exp} =0.0 1.
2467.8	2467.8 5		[M1]	B(M1)($\uparrow$)=0.83 8 R_{exp} =0.0 1.
2491.5	2446.6	66 28		
	2491.5 5	100	[E1]	B(E1)($\uparrow$)=1.6 $\times$ 10 ⁻⁵ 8 R_{exp} =0.7 3.
2499.4	2454.5	47 5		
	2499.4 3	100	[M1]	B(M1)($\uparrow$)=0.48 4 R_{exp} =0.50 5.
2529.0	2484.1	28 9		
	2529.0 3	100	[E1]	B(E1)($\uparrow$)=1.8 $\times$ 10 ⁻⁵ 5 R_{exp} =0.3 1.
2593.7	2548.8	17 4		
	2593.7 6	100	[E1]	B(E1)($\uparrow$)=0.8 $\times$ 10 ⁻⁵ 2 R_{exp} =0.18 4.
2602.5	2557.6	38 9		
	2602.5 4	100	[E1]	B(E1)($\uparrow$)=0.4 $\times$ 10 ⁻⁵ 1 R_{exp} =0.4 1.
2638.3	2593.4	133 9		
	2638.3 3	100	[M1]	B(M1)($\uparrow$)=0.25 3 R_{exp} =1.4 1.
2647.3	2602.4	80 8		
	2647.3 8	100	[M1]	B(M1)($\uparrow$)=0.46 5 R_{exp} =0.84 8.
2702.2	2702.2 3		[M1]	B(M1)($\uparrow$)=0.14 2 R_{exp} =0.0 1.
2738.9	2694.0	143 48		
	2738.9 9	100	[M1]	B(M1)($\uparrow$)=0.3 1 R_{exp} =1.5 5.
2756.4	2756.4 3		[M1]	B(M1)($\uparrow$)=0.06 1 R_{exp} =0.0 1.
2773.0	2728.1 3	105 29		
	2773.0 3	100	[M1]	B(M1)($\uparrow$)=0.16 5 R_{exp} =1.1 3.
2816.8	2816.8 4		[M1]	B(M1)($\uparrow$)=0.22 4 R_{exp} =0.0 1.
2844.2	2844.2 9		[E1]	B(E1)($\uparrow$)=0.33 $\times$ 10 ⁻⁵ 4 R_{exp} =0.0 1.
2862.2	2817.3	143 29		
	2862.2 5	100	[E1]	B(E1)($\uparrow$)=1.1 $\times$ 10 ⁻⁵ 2 R_{exp} =1.5 3.
2877.1	2877.1 3		[E1]	B(E1)($\uparrow$)=0.37 $\times$ 10 ⁻⁵ 6 R_{exp} =0.0 1.
2881.4	2836.5	134 29		
	2881.4 5	100	[M1]	B(M1)($\uparrow$)=0.06 2 R_{exp} =1.4 3.
2896.6	2851.7	76 19		
	2896.6 3	100	[E1]	B(E1)($\uparrow$)=0.9 $\times$ 10 ⁻⁵ 3 R_{exp} =0.8 2.
2908.9	2864.0	76 19		
	2908.9 3	100	[E1]	B(E1)($\uparrow$)=1.3 $\times$ 10 ⁻⁵ 3 R_{exp} =0.8 2.
2910.0	2865.1	105 10		
	2910.0 4	100	[E1]	B(E1)($\uparrow$)=2.6 $\times$ 10 ⁻⁵ 4 R_{exp} =1.1 1.
2932.6	2887.7	143 38		
	2932.6 6	100	[M1]	B(M1)($\uparrow$)=0.06 2 R_{exp} =1.5 4.
2951.2	2906.3	86 10		
	2951.2 3	100	[M1]	B(M1)($\uparrow$)=0.12 2 R_{exp} =0.9 1.
2963.9	2963.9 8		[M1]	B(M1)($\uparrow$)=0.02 1 R_{exp} =0.0 1.
3005.9	2961.0	67 76		
	3005.9 4	100	[E1]	B(E1)($\uparrow$)=1.0 $\times$ 10 ⁻⁵ 2 R_{exp} =0.7 8.
3014.5	2969.6	38 10		
	3014.5 3	100	[M1]	B(M1)($\uparrow$)=0.05 2 R_{exp} =0.4 1.
3018.9	2974.0	96 29		

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²³⁸U(γ,γ') 2012Ha12 (continued)

γ(²³⁸U) (continued)

E(level)	Eγ [‡]	Iγ [†]	Mult.	Comments
3018.9	3018.9 3	100	[E1]	B(E1)(↑)=0.6×10 ⁻⁵ 2 R _{exp} =1.0 3.
3030.6	3030.6 3		[M1]	B(M1)(↑)=0.06 1 R _{exp} =0.0 1.
3037.7	2992.8	115 19		
	3037.7 3	100	[M1]	B(M1)(↑)=0.15 3 R _{exp} =1.2 2.
3042.5	3042.5 6		[M1]	B(M1)(↑)=0.20 4 R _{exp} =0.0 1.
3043.6	3043.6 3	100	[E1]	B(E1)(↑)=0.40×10 ⁻⁵ 7 R _{exp} =0.1 9.
3046.9	3046.9 3		[E1]	B(E1)(↑)=2.2×10 ⁻⁵ 3 R _{exp} =0.0 1.
3051.7	3006.8	67 10		
	3051.7 3	100	[E1]	B(E1)(↑)=1.4×10 ⁻⁵ 2 R _{exp} =0.7 1.
3057.1	3012.2	3 1		
	3057.1 4	100	[E1]	B(E1)(↑)=1.9×10 ⁻⁵ 2 R _{exp} =0.03 1.
3060.6	3015.7	55 5		
	3060.6 3	100	[E1]	B(E1)(↑)=1.1×10 ⁻⁵ 2 R _{exp} =0.58 5.
3086.7	3041.8	28 3		
	3086.7 5	100	[E1]	B(E1)(↑)=0.6×10 ⁻⁵ 1 R _{exp} =0.29 3.
3091.0	3046.1 4	23 2		
	3091.0 4	100	[E1]	B(E1)(↑)=0.9×10 ⁻⁵ 1 R _{exp} =0.24 2.
3094.2	3049.3	134 19		
	3094.2 3	100	[E1]	B(E1)(↑)=1.8×10 ⁻⁵ 2 R _{exp} =1.4 2.
3096.4	3051.5	105 29		
	3096.4 3	100	[E1]	B(E1)(↑)=2.8×10 ⁻⁵ 4 R _{exp} =1.1 3.
3101.7	3056.8	62 6		
	3101.7 4	100	[E1]	B(E1)(↑)=0.6×10 ⁻⁵ 2 R _{exp} =0.65 6.
3117.7	3072.8	96 10		
	3117.7 4	100	[E1]	B(E1)(↑)=1.7×10 ⁻⁵ 4 R _{exp} =1.0 1.
3135.0	3090.1	86 29		
	3135.0 3	100	[M1]	B(M1)(↑)=0.08 3 R _{exp} =0.9 3.
3153.7	3108.8	37 5		
	3153.7 3	100	[M1]	B(M1)(↑)=0.08 2 R _{exp} =0.39 5.
3172.9	3128.0	105 10		
	3172.9 3	100	[M1]	B(M1)(↑)=0.06 1 R _{exp} =1.1 1.
3207.8	3162.9	40 6		
	3207.8 4	100	[E1]	B(E1)(↑)=0.5×10 ⁻⁵ 1 R _{exp} =0.42 6.
3217.6	3172.7	58 19		
	3217.6 6	100	[M1]	B(M1)(↑)=0.03 1 R _{exp} =0.6 2.
3234.5	3189.6	163 38		
	3234.5 7	100		B(M1)(↑)=0.09 3 [M1] R _{exp} =1.7 4.
3239.6	3194.7	249 67		
	3239.6 3	100	[E1]	B(E1)(↑)=1.2×10 ⁻⁵ 4 R _{exp} =2.6 7.
3253.394	2125\$	44\$		
	2217\$	9\$		
	2256\$	8\$		
	2288\$	91\$		
	2303\$	16\$		
	2323\$	32\$		
	2327\$	33\$		
	2522\$	14\$		
	2574\$	28\$		
	3209\$	22\$		
	3254	100		
3274.4	3229.5	86 10		
	3274.4 3	100	[E1]	B(E1)(↑)=1.5×10 ⁻⁵ 3 R _{exp} =0.9 1.
3297.2	3297.2 4		[E1]	B(E1)(↑)=0.53×10 ⁻⁵ 9 R _{exp} =0.0 1.
3303.6	3258.7	106 10		
	3303.6 3	100	[E1]	B(E1)(↑)=0.6×10 ⁻⁵ 1 R _{exp} =1.1 1.
3307.32	3262.4	58 19		
	3307.3 3	100	[M1]	B(M1)(↑)=0.11 4 R _{exp} =0.6 2.
3329.1	3284.2	85 9		
	3329.1 6	100	[E1]	B(E1)(↑)=1.4×10 ⁻⁵ 2 R _{exp} =0.89 9.
3348.33	3303.4	192 19		
	3348.3 3	100	[M1]	B(M1)(↑)=0.23 4 R _{exp} =2.0 2.
3366.0	3321.1	53 6		
	3366.0 5	100	[M1]	B(M1)(↑)=0.08 2 R _{exp} =0.55 6.

Continued on next page (footnotes at end of table)

²³⁸U(γ, γ') ²⁰¹²Ha12 (continued)

 $\gamma(^{238}\text{U})$ (continued)

E(level)	E $\gamma^{\ddagger}$	I $\gamma^{\ddagger}$	Mult.	Comments
3384.3	3339.4	41 5		
	3384.3 3	100	[E1]	B(E1)($\uparrow$)=1.4 $\times$ 10 ⁻⁵ 3 R _{exp} =0.43 5.
3397.9	3353.0	37 4		
	3397.9 8	100	[E1]	B(E1)($\uparrow$)=1.3 $\times$ 10 ⁻⁵ 2 R _{exp} =0.38 4.
3416.0	3371.1	384 38		
	3416.0 4	100	[E1]	B(E1)($\uparrow$)=2.0 $\times$ 10 ⁻⁵ 5 R _{exp} =4.0 4.
3421.5	3421.5 5		[E1]	B(E1)($\uparrow$)=0.25 $\times$ 10 ⁻⁵ 5 R _{exp} =0.0 1.
3441.0	3396.1	48 19		
	3441.0 9	100	[E1]	B(E1)($\uparrow$)=0.7 $\times$ 10 ⁻⁵ 2 R _{exp} =0.5 2.
3448.3	3403.4	106 10		
	3448.3 6	100	[M1]	B(M1)($\uparrow$)=0.07 2 R _{exp} =1.1 1.
3454.1	3409.2	250 29		
	3454.1 4	100	[E1]	B(E1)($\uparrow$)=1.8 $\times$ 10 ⁻⁵ 6 R _{exp} =2.6 3.
3460.7	3415.8	56 7		
	3460.7 3	100	[M1]	B(M1)($\uparrow$)=0.07 1 R _{exp} =0.58 7.
3467.8	3422.9	58 10		
	3467.8 6	100	[E1]	B(E1)($\uparrow$)=1.2 $\times$ 10 ⁻⁵ 3 R _{exp} =0.6 1.
3470.7	3425.8	29 29		
	3470.7 3	100	[E1]	B(E1)($\uparrow$)=0.8 $\times$ 10 ⁻⁵ 8 R _{exp} =0.3 3.
3475.2	3430.3	58 29		
	3475.2 3	100	[E1]	B(E1)($\uparrow$)=1.1 $\times$ 10 ⁻⁵ 7 R _{exp} =0.6 3.
3479.0	3434.1	43 9		
	3479.0 3	100	[E1]	B(E1)($\uparrow$)=1.4 $\times$ 10 ⁻⁵ 3 R _{exp} =0.45 9.
3489.0	3444.1	144 58		
	3489.0 3	100	[E1]	B(E1)($\uparrow$)=4 $\times$ 10 ⁻⁵ 2 R _{exp} =1.5 6.
3500.5	3500.5 3		[E1]	B(E1)($\uparrow$)=1.1 $\times$ 10 ⁻⁵ 1 R _{exp} =0.0 1.
3509.1	3464.2	67 19		
	3509.1 9	100	[E1]	B(E1)($\uparrow$)=2.0 $\times$ 10 ⁻⁵ 7 R _{exp} =0.7 2.
3528.0	3528.0 4		[E1]	B(E1)($\uparrow$)=0.36 $\times$ 10 ⁻⁵ 5 R _{exp} =0.0 1.
3548.0	3503.1	193 29		
	3548.0 6	100	[E1]	B(E1)($\uparrow$)=1.3 $\times$ 10 ⁻⁵ 3 R _{exp} =2.0 3.
3562.8	3517.9	125 29		
	3562.8 3	100	[E1]	B(E1)($\uparrow$)=0.9 $\times$ 10 ⁻⁵ 2 R _{exp} =1.3 3.
3594.9	3550.0	116 19		
	3594.9 5	100	[E1]	B(E1)($\uparrow$)=1.1 $\times$ 10 ⁻⁵ 2 R _{exp} =1.2 2.
3608.7	3563.8	48 8		
	3608.7 3	100	[E1]	B(E1)($\uparrow$)=1.3 $\times$ 10 ⁻⁵ 2 R _{exp} =0.50 8.
3615.9	3571.0	250 48		
	3615.9 3	100	[E1]	B(E1)($\uparrow$)=1.0 $\times$ 10 ⁻⁵ 2 R _{exp} =2.6 5.
3623.9	3579.0	144 29		
	3623.9 3	100	[E1]	B(E1)($\uparrow$)=0.6 $\times$ 10 ⁻⁵ 1 R _{exp} =1.5 3.
3640.1	3595.2	77 19		
	3640.1 3	100	[E1]	B(E1)($\uparrow$)=0.5 $\times$ 10 ⁻⁵ 1 R _{exp} =0.8 2.
3650.5	3605.6	87 10		
	3650.5 3	100	[E1]	B(E1)($\uparrow$)=1.1 $\times$ 10 ⁻⁵ 2 R _{exp} =0.9 1.
3659.7	3614.8	67 10		
	3659.7 6	100	[E1]	B(E1)($\uparrow$)=0.4 $\times$ 10 ⁻⁵ 1 R _{exp} =0.7 1.
3673.7	3628.8	193 39		
	3673.7 6	100	[E1]	B(E1)($\uparrow$)=1.0 $\times$ 10 ⁻⁵ 3 R _{exp} =2.0 4.
3728.0	3683.1	87 29		
	3728.0 9	100	[E1]	B(E1)($\uparrow$)=0.5 $\times$ 10 ⁻⁵ 2 R _{exp} =0.9 3.
3738.5	3693.6	77 19		
	3738.5 8	100	[E1]	B(E1)($\uparrow$)=1.7 $\times$ 10 ⁻⁵ 5 R _{exp} =0.8 2.
3759.9	3715.0	87 19		
	3759.9 3	100	[E1]	B(E1)($\uparrow$)=2.3 $\times$ 10 ⁻⁵ 5 R _{exp} =0.9 2.
3805.1	3760.2	87 10		
	3805.1 3	100	[E1]	B(E1)($\uparrow$)=2.5 $\times$ 10 ⁻⁵ 4 R _{exp} =0.9 1.
3809	2882 $\frac{1}{2}$	55 $\frac{1}{2}$ 22		
	3128 $\frac{1}{2}$	28 $\frac{1}{2}$ 22		
	3764 $\frac{1}{2}$	96 $\frac{1}{2}$ 14		
	3809 $\frac{1}{2}$	100 $\frac{1}{2}$		
3819.0	3774.1	106 19		
	3819.0 6	100	[E1]	B(E1)($\uparrow$)=1.9 $\times$ 10 ⁻⁵ 4 R _{exp} =1.1 2.

Continued on next page (footnotes at end of table)

²³⁸U(γ, γ') 2012Ha12 (continued)

 $\gamma(^{238}\text{U})$ (continued)

E(level)	E $\gamma^{\ddagger}$	I $\gamma^{\ddagger}$	Mult.	Comments
3828.7	3828.7 3		[E1]	B(E1)($\uparrow$)=0.36 $\times 10^{-5}$ 5 R _{exp} =0.0 1.
3965.7	3920.8	47 4		
	3965.7 4	100	[E1]	B(E1)($\uparrow$)=1.2 $\times 10^{-5}$ 2 R _{exp} =0.49 4.
3990.7	3945.8	116 10		
	3990.7 9	100	[E1]	B(E1)($\uparrow$)=0.9 $\times 10^{-5}$ 1 R _{exp} =1.2 1.
3995.8	3950.9	58 39		
	3995.8 3	100	[E1]	B(E1)($\uparrow$)=0.8 $\times 10^{-5}$ 1 R _{exp} =0.6 4.
4023.7	3978.8	97 10		
	4023.7 7	100	[E1]	B(E1)($\uparrow$)=0.9 $\times 10^{-5}$ 2 R _{exp} =1.0 1.
4031.4	3986.5	48 10		
	4031.4 7	100	[E1]	B(E1)($\uparrow$)=1.2 $\times 10^{-5}$ 3 R _{exp} =0.5 1.
4046.7	4001.8	126 39		
	4046.7 3	100	[E1]	B(E1)($\uparrow$)=1.0 $\times 10^{-5}$ 4 R _{exp} =1.3 4.
4065.3	4020.4	164 39		
	4065.3 3	100	[E1]	B(E1)($\uparrow$)=1.1 $\times 10^{-5}$ 3 R _{exp} =1.7 4.
4072.1	4027.2	58 10		
	4072.1 6	100	[E1]	B(E1)($\uparrow$)=1.0 $\times 10^{-5}$ 2 R _{exp} =0.6 1.
4088.9	4044.0	97 29		
	4088.9 7	100	[E1]	B(E1)($\uparrow$)=0.6 $\times 10^{-5}$ 2 R _{exp} =1.0 3.
4093.4	4048.5	39 4		
	4093.4 3	100	[E1]	B(E1)($\uparrow$)=0.9 $\times 10^{-5}$ 1 R _{exp} =0.40 4.
4100.2	4055.3	174 19		
	4100.2 3	100	[E1]	B(E1)($\uparrow$)=1.2 $\times 10^{-5}$ 2 R _{exp} =1.8 2.
4105.2	4105.2 3		[E1]	B(E1)($\uparrow$)=0.27 $\times 10^{-5}$ 3 R _{exp} =0.0 1.
4122.9	4078.0	81 9		
	4122.9 5	100	[E1]	B(E1)($\uparrow$)=0.6 $\times 10^{-5}$ 2 R _{exp} =0.84 9.
4138.9	4094.0	40 7		
	4138.9 7	100	[E1]	B(E1)($\uparrow$)=0.5 $\times 10^{-5}$ 1 R _{exp} =0.41 7.
4145.8	4100.9	58 58		
	4145.8 3	100	[E1]	B(E1)($\uparrow$)=0.7 $\times 10^{-5}$ 1 R _{exp} =0.6 6.
4151.3	4106.4	97 29		
	4151.3 6	100	[E1]	B(E1)($\uparrow$)=0.5 $\times 10^{-5}$ 2 R _{exp} =1.0 3.
4155.4	4155.4 3		[E1]	B(E1)($\uparrow$)=0.8 $\times 10^{-5}$ 2 R _{exp} =0.0 1.
4175.8	4130.9	27 3		
	4175.8 4	100	[E1]	B(E1)($\uparrow$)=1.1 $\times 10^{-5}$ 2 R _{exp} =0.28 3.
4181.5	4136.6	97 10		
	4181.5 7	100	[E1]	B(E1)($\uparrow$)=1.2 $\times 10^{-5}$ 3 R _{exp} =1.0 1.
4217.3	4172.4	107 10		
	4217.3 8	100	[E1]	B(E1)($\uparrow$)=0.9 $\times 10^{-5}$ 2 R _{exp} =1.1 1.
4239.1	4239.1 3		[E1]	B(E1)($\uparrow$)=1.0 $\times 10^{-5}$ 1 R _{exp} =0.0 1.
4495	4450 $\S$ &	32 $\S$ 28		
	4495 $\S$	100 $\S$	[E1]	
4592	4546 $\S$	190 $\S$ 110		
	4592 $\S$	100 $\S$		
4807	3840 $\S$	47 $\S$ 17		
	4807 $\S$	100 $\S$		
5140?	5140 $\&$			
5206	4148 $\S$ &	33 $\S$ 26		
	5160 $\S$	90 $\S$ 28		
	5206	100		
5666?	5666 $\&$			E γ : From 1982Ru03.
5843?	5843 $\&$			E γ : From 1982Ru03.

$\dagger$ Deduced by the evaluators from $R_{\text{exp}}=(\Gamma_1/\Gamma_0)(E_0/E_1)^3$, where R_{exp} values are listed in 2012Ha12 and in comments with ground-state transitions in this dataset, unless otherwise specified.

$\ddagger$ From 2012Ha12, except where noted otherwise; or deduced by evaluators from data in 2012Ha12.

$\S$ Energy and relative photon branching from each level are from 1982Ru03. Data for the 3253 level are also given in 1981Mu05, an earlier publication by the same group.

From 1995Zi02.

@ Other:1988He02.

& Placement of transition in the level scheme is uncertain.

²³⁸U(n,n')

E=0.075-1.62 MeV; measured $\sigma(E, E(n), \theta)$	(1966Ba09)
E=0.3-1.5 MeV	(1963Sm09)
E=0.5-2 MeV	(1958Cr83)
E=0.6-2.2 MeV; measured $\sigma(E(n), \theta)$	(1979Yu01)
E=0.6-3.4 MeV; measured $\sigma(\theta)$	(1978HaYS, 1982Ha34)
E=0.7-1.5 MeV; measured $\sigma(E)$	(1983Ka38)
E=0.2-5 MeV; analyzed $\sigma(E)$	(1985Ho03)
E=0.9-2.2 MeV; measured $\sigma(\theta), \sigma(E(n))$	(1986Sh05)

²³⁸U Levels

E(level) [†]	J $\pi^{\ddagger}$	Comments
0.0		
45	2+	
149 2	4+	
300 15	6+	
681 3	1-	
732 3	3-	
838 5	5-	
939 5	(2, 3, 1)	J π : level probably corresponds to known 1- level at 931.
968 6	(2, 3, 1)	J π : level probably corresponds to known 2+ level at 966.
1006 6		J π : level may correspond to the known 997 0+, 3- doublet. The authors were not aware of the 997 3- level, discovered later. They point out that $\sigma(E)$ does not agree well with 0+, but that a good fit is obtained for 1+. No 1+ level is known in this energy region from other experiments.
1047 7	(2+)	E(level): the level may correspond to the known 2+ level at 1037.
1076 7	(2+)	E(level): the level may correspond to the known 2+ level at 1060.
1123 8	(1+)	
1150 8	(4+)	E(level): the level may correspond to the known 4+ level at 1129.
1190 10	(4+)	E(level): the level may correspond to the known 4+ level at 1167 or 1169.
1210 10		
1246 12		
1272 12		
1313 15		
1361 17		
1401 20		
1437 22		
1470 25		

[†] Measurements by 1966Ba09 (tof). The association of levels reported by these authors can be correlated uniquely with adopted levels only up to about the 1076 level. Above this energy the association is uncertain. The two (4+) peaks at 1150 and 1190 may correspond to known 4+ levels at 1131 and 1163 or 1168, respectively. Above this energy, any correspondence is uncertain. Other measurements: 1958Cr83, 1963Sm09, 1957Al34, 1959Ba21, 1959Ev82, 1975GuZF, 1971Kn03, 2009Ro21, 2006Ma07, 2004Ma35, 2004Su12.

[‡] Assignments made by 1966Ba09 from comparison of measured cross sections at $\theta=90^\circ$ with optical-model calculations. Others: 2011Mu04, 2011Ro44, 2009Mu14, 2001Na01.

²³⁸U(n,n' γ) 2014Go06

2014Go06: reactor fast neutrons; measured E_γ, I_γ .
 1988FiZS: E=3 MeV; measured γ -yield of fission products.
 1984BlZS: E=3 MeV; measured E_γ, I_γ .
 1979Ko13: E=1060 keV; measured I_γ .
 1979OlZX: E=0.6-5 MeV; measured I_γ .
 1978De41: E is fast reactor neutrons; measured E_γ, I_γ .
 1972Mc19: E=700-1900 keV; measured E_γ, I_γ .
 1982Ch21: E=0.8-2.5 MeV; measured γ -yield.

Others: 2009Hu09, 2008HuZW, 2004Fo01, 2011Mu11.

The 1179 γ was proposed by 1972Mc19 and 1978De41 to deexcite a level at 1179 keV. The 1179 γ was also observed in Coulomb excitation with $I(1179\gamma)/I(1223\gamma)=0.93$ 6, both gammas deexciting the level at 1224.

$I(1179\gamma)/I(1224\gamma)=0.93$ 28 (1978De41); 1.5 4 (1984BlZS); $I(1179\gamma)/I(1224\gamma)=0.92$ 8 (2014Go06) suggests that the 1179 γ observed in (n,n' γ) deexcites mainly the 1224.2 level. The evaluator assigns the 1179 γ entirely to the 1224 level.

²³⁸U(n,n'γ) 2014Go06 (continued)

²³⁸U Levels

E(level)	Jπ	E(level)	Jπ	E(level)	Jπ
0.0	0+	1239.69 10		1693.3?‡ 4	
44.92 1	2+	1244.98?‡ 11	(0+)	1709.6?‡ 2	
148.38 3	4+	1260.23 6	3+	1754.7?‡ 3	6+
307.39 6	6+	1265.5?‡ 4	(4+)	1761.1 4	(4+)
518.04 13	8+	1269.2 4	6+	1774.7?‡ 3	6+
680.14 2	1-	1278.57 7	2+	1775.9 6	(3-, 4, 5-)
731.88 2	3-	1308.18?‡ 9	(4+)	1782.5 4	1 and 2+
776.5? 2	(10+)	1312.5 2	6+	1793.3 4	1
826.84 4	(5-)	1354.1?‡ 16	0+	1797.5?‡ 6	
926.96 3	0+	1354.9† 3		1805.3?‡ 3	(2+)
930.66? 3	1-	1357.58?‡ 10	4+	1805.5?‡ 2	(2-)
950.16 2	2-	1368.4?‡ 2		1814.5?‡ 3	
966.30 5	2+	1381.16 9	(6-)	1824.52?‡ 14	(2-)
966.75 11	7-	1413.29 10	2+	1845.7 4	1
996.98 11	0+	1454.91 18		1866.0?‡ 3	(4+)
997.68 4	3-	1458.1?‡ 4		1892.09 13	(4+, 5-)
1027.7 11	4-	1482.41 8		1907.4?‡ 4	
1037.40 6	2+	1491.04?‡ 11	0+	1918.5?‡ 2	
1056.52 7	4+	1515.48 10		1933.7 2	3-
1059.65 4	3+	1530.49 12	2+	1975.7?‡ 3	
1060.32 2	2+	1552.18?‡ 13	4+	1992.0 2	(3-)
1105.28?‡ 5	(4+)	1561.39?‡ 11	(3-)	2003.1?‡ 4	
1106.15 3	3+	1561.8 2		2125.3 6	2+
1128.31 5	2-	1594.80 12	(4+)	2131.7?‡ 3	
1129.19?‡ 6	(4+)	1606.3?‡ 2		2145.3?‡ 2	
1135.8?†‡		1615.3?‡ 5	(4+)	2164.5 4	
1167.26 4	4+	1643.73 12		2209.0 5	1+
1168.95 9	3-	1645.0 2		2559.0 4	0+
1209.3† 3		1672.01 15		2578.5 3	2+
1223.95 3	2+	1676.0† 3		2624.6 6	4+

† Average value from 1984BlZS, 1978De41, and 1972Mc19.

‡ Uncertain level (2014Go06), not in Adopted Levels.

γ(²³⁸U)

E, I_γ are from 2014Go06, unless otherwise specified. See also table below with relative branching ratios for some intensities by other authors with a comparison to values in Coulomb excitation.

732 level:

I_γ(583γ)/I_γ(687γ)=0.79 11 (1972Mc19)
=0.74 13 (1978De41)
=0.27 5 (1979Ko13)
=0.90 6 (1984BlZS)
=0.814 23 (Coulomb excitation)
=0.85 (2014Go06)

950 level:

I_γ(270γ)/I_γ(906γ)=0.75 15 (1978De41)
=0.21 7 (1979OlZX)
=0.37 14 (1984BlZS)
=0.47 9 (Coulomb excitation)
=0.37 (2014Go06)

I_γ(219γ)/I_γ(906γ)=0.80 24 (1978De41)
=0.50 17 (1984BlZS)
=0.52 6 (Coulomb excitation)
=0.36 (2014Go06)

Continued on next page (footnotes at end of table)

²³⁸U(n,n'γ) 2014Go06 (continued)

γ(²³⁸U) (continued)

966 level:

$I\gamma(922\gamma)/I\gamma(818\gamma)=0.52\ 8\ (1972Mc19)$
 $=0.31\ 9\ (1978De41)$
 $=0.47\ 8\ (1984BlZS)$
 $=0.60\ 4\ (Coulomb\ excitation)$
 $>0.61\ (2014Go06)$

$I\gamma(967\gamma)/I\gamma(818\gamma)=0.15\ 2\ (1972Mc19)$
 $=0.65\ 14\ (1984BlZS)$
 $=0.27\ 2\ (Coulomb\ excitation)$
 $>0.14\ (2014Go06)$

998 3- level:

$I\gamma(317\gamma)/I\gamma(849\gamma)=0.12\ 4\ (1978De41)$
 $=0.19\ 6\ (1979OlZX)$
 $=0.079\ 5\ (Coulomb\ excitation)$
 $<0.09\ (2014Go06)$

$I\gamma(317\gamma)/I\gamma(953\gamma)=0.10\ 3\ (1978De41)$
 $=0.0.13\ 3\ (1979OlZX)$
 $=0.140\ 8\ (Coulomb\ excitation)$
 $<0.16\ (2014Go06)$

$I\gamma(849\gamma)/I\gamma(953\gamma)=0.89\ 13\ (1972Mc19)$
 $=0.89\ 25\ (1978De41)$
 $=0.70\ 13\ (1979OlZX)$
 $=0.93\ 12\ (1984BlZS)$
 $1.76\ 7\ (Coulomb\ excitation)$
 $1.8\ 1\ (2014Go06)$

1037 level:

$I\gamma(306\gamma):I\gamma(358\gamma):I\gamma(889\gamma):I\gamma(992\gamma):I\gamma(1037\gamma)=$
 $- : - : - : 82\ 9:100\ 7\ (1972Mc19)$
 $98\ 21: 405\ 48: - : 162\ 29:100\ 24\ (1978De41)$
 $- : 88\ 25: - : 38\ 13:100\ 13\ (1984BlZS)$
 $11.8\ 5: 9.5\ 4: 71.7\ 15: 72.9\ 15:100\ 2\ (Coulomb\ excitation)$
the 358γ, reported by 1978De41 and 1984BlZS and placed by 1984BlZS from
the 1037 level is identified by 1988FiZS as a fission-fragment γ

1128 2- level:

$I\gamma(448\gamma)/I\gamma(1084\gamma)=0.89\ 13\ (1972Mc19)$
 $=1.1\ 3\ (1978De41)$
 $=1.04\ 14\ (1984BlZS)$
 $=1.24\ 14\ (Coulomb\ excitation)$
 $>1.7\ (2014Go06)$

1224 level:

$I\gamma(1179\gamma)/I\gamma(1224\gamma)=1.08\ 28\ (1978De41)$
 $0.93\ 5\ (1984BlZS)$
 $0.96\ (Coulomb\ excitation)$
 $0.92\ 7\ (2014Go06)$

1278 level:

$I\gamma(1130\gamma):I\gamma(1233\gamma):I\gamma(1279\gamma)=59\ 6:100\ 12: 68\ 7\ (1972Mc19)$
 $- :100\ 21:190\ 26\ (1978De41)$
 $- :100\ 13:125\ 13\ (1984BlZS)$
 $50 :100 :32\ (Coulomb\ excitation)$

Eγ	E(level)	Iγ	Comments
44.915 13	44.92		Eγ: From 242Pu α Decay (1972Sc01).
78.1 4	1027.7	3 2	
*94.65			
*98.42			
103.46 3	148.38	228 10	
*110.39		879 38	
*111.28		2238 95	

Continued on next page (footnotes at end of table)

$^{238}\text{U}(\text{n},\text{n}'\gamma)$ 2014Go06 (continued) $\gamma(^{238}\text{U})$ (continued)

$E\gamma$	$E(\text{level})$	$I\gamma$	$E\gamma$	$E(\text{level})$	$I\gamma$
$^{x}114.59$		964 41	759.3 $\S$ 3	1709.6?	1.77
$^{x}154.6$ 3		3.5 14	$^{x}764.3$ 4		0.78 24
159.01 5	307.39	49	764.3 $\S$ 4	1824.52?	0.78
164.8 5	1223.95	3.9	768.40 7	1594.80	<2
171.6 3	1168.95	3.3		1992.0	<2
178.1 3	1128.31	7.2 11	775.03 13	1454.91	1.0
198.38 4	1128.31	<31	793.37 12	1312.5	0.4
208.2 $\dagger\S$ 10	1135.8?	100 $\ddagger$ 29	798.54 6	1530.49	≤ 5.8
210.65 12	518.04	14	802.9 2	1482.41	2.2
218.09 14	950.16	7.3	805.38 8	1933.7	3.7
221.9 $\S$ 2	1774.7?	<6.5	817.88 3	966.30	≤ 23
234.5 6	966.30	≤ 2	$^{x}821.7$ 4		1.4 3
$^{x}237.6$ 4		4.6 7	821.7 $\S$ 4	1129.19?	1.4
237.6 $\S$ 4	1265.5?	4.6	849.27 2	997.68	28.7 12
250.5 2	930.66?	3.3 3	$^{x}855.3$ 2		2.3 3
258.53 $\S$ 6	776.5?	7	855.3 $\S$ 2	1805.5?	2.3
267.5 $\S$ 2	1265.5?	≤ 1.8	863.7 2	1992.0	0.7
269.92 8	950.16	10.2	879.63 11	1027.7	4.7 3
282.2 $\dagger$ 6	1209.3	7 $\ddagger$ 3	882.04 3	926.96	14.8 7
285.9 3	966.30	1.6	885.74 $\S$ 2	930.66?	63 3
295.86 5	1027.7	≤ 9	888.96 5	1037.40	9.0 5
316.87 10	997.68	≤ 2.6	905.24 2	950.16	27.4 12
357.92 6	1037.40	≤ 1	908.14 6	1056.52	9.5 5
$^{x}365.8$ 3		1.4 4	911.27 3	1059.65	18.2 8
397.13 5	1128.31	7.8	912.58 7	1060.32	3.4
405.8 $\dagger$ 10	1354.9	<6 $\ddagger$	921.38 5	966.30	10.4 5
418.13 $\S$ 18	1368.4?	3.3	$^{x}928.1$ 5		1.15 24
422.1 3	1482.41	0.3	930.9 $\S$ 2	930.66?	5.5
423.8 $\dagger$ 3	1354.9	10 $\ddagger$ 2	932.30 $\#$ 7	1239.69	≤ 6.7
432.94 13	1561.8	≤ 4.8		1992.0	<6.7
437.08 12	1168.95	8.0 5	947.9 $\S$ 3	1774.7?	0.3
448.17 4	1128.31	18.1 8	952.06 5	996.98	13.5
448.74 10	966.75	<5.7	952.80 5	997.68	15.8 7
455.67 12	1561.8	2.3	$^{x}956.90$ 4		11.8 6
$^{x}478.13$ 18		4.2 3	956.90 $\S$ 4	1105.28?	11.8
482.1 $\S$ 3	1413.29	2.4	957.80 4	1106.15	10.8 5
488.79 14	1168.95	3.9 4	962.0 2	1269.2	≤ 3.3
501.74 $\S$ 10	1561.39?	3.0	966.45 11	966.30	3.3
519.48 2	826.84	12.8	980.59 $\S$ 13	1129.19?	3.5
$^{x}533.6$ 4		0.92 25	$^{x}987.7$ 3		1.24 23
533.6 $\S$ 4	1265.5?	0.92	987.7 $\S$ 3	1814.5?	1.24
546.93 10	1278.57	3.8	992.51 5	1037.40	≥ 5.7
547.0 $\dagger$ 3	1676.0	8 $\ddagger$ 2	1000.85 $\S$ 18	1308.18?	≤ 2.8
551.63 8	1482.41	1.4	1005.1 2	1312.5	0.43 20
554.28 7	1381.16	≤ 4.2	1014.60 3	1059.65	≈ 39
	1552.18?		1015.41 2	1060.32	49 2
564.20 11	1530.49	2.8	1018.88 3	1167.26	16.7 7
566.20 11	1672.01	1.8	1020.54 9	1168.95	5.7 3
$^{x}579.2$ 6		1.8 3	1022.7 $\S$ 2	1754.7?	1.8
583.50 2	731.88	65.5	1037.46 6	1037.40	12.3 7
635.22 2	680.14	100	1044.0 6	1775.9	1.27 24
655.3 3	1761.1	<2	1050.8 3	1782.5	0.80 23
659.36 9	966.75	3.4	$^{x}1056.8$ 3		1.42 24
673.96 $\S$ 16	1354.1?	1.8	1060.32 2	1060.32	36
678.44 2	826.84	23		1105.28?	≤ 36
680.13 2	680.14	61	1060.98 $\dagger$ 3	1209.3	$\leq 71\ddagger$
686.96 2	731.88	77.4 33	1061.23 2	1106.15	29.0 15
701.9 2	1761.1	0.7	$^{x}1070.7$ 12		0.34 22
$^{x}726.1$ 12		0.52 25	1073.82 11	1381.16	4.0 3
726.1 $\S$ 12	1458.1?	0.52	$^{x}1077.2$ 6		0.35 22
733.4 3	1413.29	<2.5	1083.30 5	1128.31	<10.7
733.7 2	1793.3	<2.5	$^{x}1084.32$ 6		11.7 6
748.99 8	1056.52	2.2	1084.32 $\S$ 6	1129.19?	11.7

Continued on next page (footnotes at end of table)

²³⁸U(n,n'γ) 2014Go06 (continued)

γ(²³⁸U) (continued)

Eγ	E(level)	Iγ	Eγ	E(level)	Iγ
1090.9†§ 2	1135.8?	71 [±] 6	1470.56 10	1515.48	4.2
1091.31 7	1239.69	4.3	1485.3 3	1530.49	1.30 21
1112.0 5	1260.23	3.0 3	^x 1490.4 4		1.23 22
1120.8 4	1269.2	≤1.41	1496.6 2	1645.0	1.98 23
1122.28 10	1167.26	5.8 4	1507.26§ 13	1552.18?	4.1
1123.93 12	1168.95	2.4		1814.5?	4.1
1130.31 12	1278.57	4.7 3	1517.0 7	1561.8	≤0.7
^x 1150.7 4		2.0 3	1523.63 15	1672.01	3.6 3
1150.7§ 4	1458.1?	2.0	^x 1527.7 4		0.41 20
^x 1155.5 8		0.41 21	1530.0 7	1530.49	0.74 20
1159.80§ 9	1308.18?	4.5	^x 1547.6 5		1.52 23
1160.8 3	1892.09	1.9	1549.88 12	1594.80	4.0 3
^x 1172.3 5		0.81 24	^x 1558.0 7		0.66 20
^x 1175.7 4		0.99 20	1558.0§ 7	1866.0?	0.66
1175.7§ 4	1907.4?	0.99	^x 1561.2 2		2.49 25
1179.03 3	1223.95	8.1 5	1561.2§ 2	1709.6?	2.49
^x 1184.3 3		0.79 22	^x 1570.1 5		0.99 21
^x 1194.3 11		0.48 22	1570.1§ 5	1615.3?	0.99
1200.06§ 11	1244.98?	4.2	1584.70 12	1892.09	3.7 3
1209.20§ 10	1357.58?	5.1	^x 1585.7 8		1.96 23
1215.31 5	1260.23	10.5 6	1600.1 3	1645.0	1.98 23
1220.13§ 10	1368.4?	2.5	^x 1606.4 2		2.17 23
1223.97 6	1223.95	8.8 5	1606.4§ 2	1606.3?	2.17
1233.65 7	1278.57	6.4		1754.7?	2.17
^x 1236.6 5		0.74 22	^x 1611.2 2		1.67 22
^x 1239.2 3		1.5 3	1611.2§ 2	1918.5?	1.67
^x 1247.7 2		1.73 23	1613.2 3	1761.1	0.86
^x 1257.8 4		1.09 22	1627.0# 2	1672.01	<1.92
^x 1263.3 4		1.87 23		1775.9	<1.92
1263.3§ 4	1308.18?	1.87	^x 1630.7 11		0.33 20
1265.4 3	1413.29	1.0	^x 1635.4 8		0.28 18
1278.57 7	1278.57	7.8 5	^x 1648.64 17		3.2 3
1287.0 5	1594.80	0.87 21	1648.64§ 17	1693.3?	3.2
1306.53 18	1454.91	2.6 3		1797.5?	3.2
1309.44§ 15	1354.1?	>0.5	^x 1657.0 3		1.70 23
1310.5† 4	1354.9	5 [±] 1	1657.0§ 3	1805.3?	1.70
1336.34 12	1643.73	5.3 3	^x 1675.8 6		1.37 21
^x 1346.0 8		0.77 22	^x 1677.4 2		1.80 21
1354.5† 10	1354.9	3 [±] 1	^x 1684.7 5		1.37 21
^x 1356.1 8		1.02 22	^x 1690.7 8		0.88 21
^x 1359.9 2		4.6 3	1693.3§ 4	1693.3?	≤0.69
1367.3 2	1515.48	4	^x 1695.8 8		0.64 22
1368.37 10	1413.29	7.8 5	1695.8§ 8	2003.1?	0.64
^x 1380.2 3		1.63 21	^x 1698.3 5		1.11 22
1382.11 12	1530.49	3.7 3	^x 1702.5 11		0.76 22
^x 1388.9 6		0.94 21	1716.2 4	1761.1	1.44 22
1394.1 9	2125.3	0.39 21	^x 1717.6 3		2.9 3
1399.5§ 5	2131.7?	≤1.24	1717.6§ 3	1866.0?	2.9
1404.4§ 9	1552.18?	0.2	^x 1723.9 7		0.93 20
1410.1 2	1454.91	3.2 3	^x 1733.6 14		0.52 19
1413.4 2	1413.29	<3.2	1737.8 5	1782.5	2.16 23
	2145.3?	<3.2	1748.8 6	1793.3	1.57 22
1413.8 2	1561.8	≤0.5	1752.6§ 6	1797.5?	0.79
^x 1417.9 3		2.20 24	1760.5§ 2	1805.5?	2.7
1437.39 8	1482.41	6.8	^x 1776.3 3		1.18 21
1446.12§ 11	1491.04?	≤4.1	1779.60§ 14	1824.52?	3.6
	1594.80	≤4.1	1782.3 4	1782.5	2.43 26
^x 1447.5 8		0.32	1793.1 4	1793.3	1.01 19
1447.5§ 8	1754.7?	0.32	1801.4 3	1845.7	≤2.27
1454.8§ 2	1761.1	<0.6	1805.2§ 3	1805.3?	2.55
1457.92§ 8	1606.3?	3.5	^x 1815.0 4		1.09 22
^x 1467.1 5		0.63 21	1821.0§ 6	1866.0?	0.79
1467.1§ 5	1615.3?	0.63	1824.4§ 3	2131.7?	1.54

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$^{238}\text{U}(\text{n},\text{n}'\gamma)$ 2014Go06 (continued) $\gamma(^{238}\text{U})$ (continued)

$E\gamma$	$E(\text{level})$	$I\gamma$	$E\gamma$	$E(\text{level})$	$I\gamma$
1827.4 § 3	1975.7?	1.72	2080.9 6	2125.3	0.66 19
1845.7 4	1845.7	1.66 22	*2085.8 7		0.69 19
1854.7 § 4	2003.1?	1.23	*2088.9 6		1.18 20
1857.1 4	2164.5	1.93 24	*2110.3 7		0.75 17
*1862.4 5		1.12 21	2124.9 6	2125.3	0.30 8
1862.4 § 5	1907.4?	1.12	*2155.0 6		0.69 17
1873.1 § 7	1918.5?	0.96	2165.9 9	2209.0	0.41 17
1878.7 4	2559.0	0.35	*2182.2 7		0.89 18
*1883.2 6		1.09 23	2209.0 5	2209.0	1.30 17
*1887.9 8		0.80 22	*2288.5 5		0.81 16
1890.7 11	1933.7	0.62 21	2317.3 9	2624.6	0.16 6
1907.2 § 4	1907.4?	0.87	*2322.1 3		1.16 18
*1911.1 4		1.13 21	*2326.0 6		0.73 17
*1919.1 5		0.92 19	*2359.1 11		0.38 11
*1923.6 10		1.04 21	*2379.2 8		0.88 13
*1926.4 6		0.73 20	2430.0 3	2578.5	0.39 7
1930.4 § 6	1975.7?	0.64	*2431.8 5		0.27 6
*1959.9 7		0.74 21	*2435.7 7		0.67 16
1976.7 6	2125.3	0.76 20	2476.2 6	2624.6	0.26 6
1983.7 § 9	2131.7?	0.67	2514.4 4	2559.0	0.34 7
*1992.2 4		1.25 20	2533.6 3	2578.5	0.40 6
1996.9 § 2	2145.3?	2.3	2578.5 4	2578.5	0.22 4
*1999.3 10		0.21 17	*2602.3 9		0.43 13
*2009.3 7		0.96 20	*2625.2 10		0.33 10
2015.8 2	2164.5	1.5			
*2041.0 9		0.66 19			
*2072.0 6		0.65 19			

† Weighted average of data from 1984BlZS, 1978De41, and 1972Mc19.

‡ From 1984BlZS relative to $I\gamma(635\gamma)=100$.

§ Placement of transition in the level scheme is uncertain.

Multiply placed.

* γ ray not placed in level scheme.

$^{238}\text{U}(\text{n},\text{n}'\gamma)$ 2014Go06 (continued)

Level Scheme

* Multiply placed
Intensities: relative I_γ

$^{238}\text{U}(\text{n},\text{n}'\gamma)$ 2014Go06 (continued)

Level Scheme (continued)

* Multiply placed

Intensities: relative I_γ $^{238}_{92}\text{U}_{146}$

$^{238}\text{U}(\text{n},\text{n}'\gamma)$ 2014Go06 (continued)

Level Scheme (continued)

* Multiply placed

Intensities: relative I_γ $^{238}_{92}\text{U}_{146}$

$^{238}\text{U}(\text{n},\text{n}'\gamma)$ 2014Go06 (continued)

Level Scheme (continued)

* Multiply placed

Intensities: relative I_{γ}

²³⁸U(d,d')

1972El08: E=16 MeV. σ , FWHM AP 8 keV. $\theta=90^\circ$, 125°

1974ThZG: 12.1, 13.1 MeV. σ . $\theta=90^\circ$, 125

1967Fe09: E=12 MeV. σ .

For a comparison of d'(θ) of inelastically and elastically scattered deuterons with coupled-channel calculations, see 1977Fe11.

All data are from 1972El08, except where noted otherwise.

2013Gu27: Nuclear structure in the quasi-continuum region.

2006Ha42: E=4-200 MeV, deduced σ .

2006Pr13: E=10-10000 MeV, deduced σ .

²³⁸U Levels

E(level)	J $\pi^\dagger$	Comments
0.0 ‡	0+	
45 ‡	2+	
149 ‡	4+	
308 ‡	6+	
520 ‡	8+	
679 §	1-	
731 §	3-	
825 §	5-	
930	1-	
967		
998	3-	B(E3)=0.22 3 normalized using B(E3)(731 level)=0.54 (1972El08).
1037 $^\#$	2+	
1061 $^\@$	2+	B(E2)=0.10 1 normalized using B(E2)(45 level)=11.7 (1972El08).
1103		
1126		
1169	3-	B(E3)=0.29 5 normalized using B(E3)(731 level)=0.54 (1972El08).
1231		
1288	5-	
1375		
1512		
1530		
1630		
1647		
1665		
1712		
1758		
1774		
1807		

† Assignments are based on intensity patterns, absolute cross sections and $\sigma(\theta=90^\circ)/\sigma(\theta=125^\circ)$ (1972El08).

‡ K π =0+ ground-state band.

§ K π =0- octupole-vibrational band.

$^\#$ K π =0+ β -vibrational band.

$^\@$ K π =2+ γ -vibrational band.

Coulomb Excitation

²³⁸ U(x, x' γ)	x= ²⁰⁷ Pb, E=1400 MeV	(2010Zh09)
²³⁸ U(x, x' γ)	x= α , E=19 MeV.	(2001Ga55)
¹⁸¹ Ta(x, x' γ)	x= ²³⁸ U, E=6 MeV/u	(1997Di05)
²³⁸ U(x, x' γ)	x= ¹⁸¹ Ta, ²⁰⁸ Pb, ²³² Th, E=5.8, 5.9, 5.95 MeV/u	(1997Ah04)
²³⁸ U(x, x' γ)	x= ²⁰⁹ Bi, E=1130, 1330 MeV	(1996Wa11)
¹⁸¹ Ta(x, x' γ)	x= ²³⁸ U, E=6 MeV/u	(1996Ho18)
²³⁸ U(x, x' γ)	x= α , E=18 MeV	(1994Mc03)
²³⁸ U(x, x' γ)	x= ²⁰⁸ Pb, E=4.7, 5.3 MeV/u	(1981Gr10)
²³⁸ U(x, x' γ)	x= α , E=16, 17 MeV: x= ¹⁶ O, E=51.2, 52 MeV	(1981A102)
²³⁸ U(x, x' γ)	x= α , E=16-18 MeV	(1973Be44, 1974Mc15)
²³⁸ U(x, x' γ)	x= ²⁰ Ne, ³² S, ⁴⁰ Ar	(1966St24, 1967Di07)

Other measurements: 2001Il01, 1975Gr23, 1973Ei02, 1971Mc21 (superseded by 1973Be44, priv. comm. from authors),

1971Fo17, 1966St24, 1963St10, 1963El06, 1961Sk01, 1961Re02, 1960Mc13, 1960Du10, 1959St40, 1957Ne07, 1956Da40.

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Coulomb Excitation (continued)

Ratios of experimental to theoretical Coul. ex. probabilities for the g.s. rotational band via ($^{40}\text{Ar}, ^{40}\text{Ar}'$) were calculated by 1973Ei02.

Multiple Coul. ex. probabilities for $^{238}\text{U}(^{84}\text{Kr}, ^{84}\text{Kr}')$ and $^{238}\text{U}(^{40}\text{Ar}, ^{40}\text{Ar}')$ were calculated by 1974Le24 and by 1975Ma16, respectively.

Coulomb nuclear interference for $^{238}\text{U}(^{40}\text{Ar}, ^{40}\text{Ar}'\gamma)$ see 1978Gu03.

Coul. ex. probability for K=0 octupole band was calculated for $^{238}\text{U}(^{40}\text{Ar}, ^{40}\text{Ar}')$ and $^{238}\text{U}(^{86}\text{Kr}, ^{86}\text{Kr}')$ by 1978Do11.

Polarization potential for $^{238}\text{U}(^{40}\text{Ar}, ^{40}\text{Ar}')$ was calculated by 1977Lo15.

Vacuum polarization corrections for $^{238}\text{U}(^{230}\text{Th}, ^{230}\text{Th}')$ were calculated by 1976Ra08.

Coul. ex. σ for pair production for $^{238}\text{U}(^{238}\text{U}, ^{238}\text{U}')$ was calculated by 1976Ob02.

B(E2) values to 2+ states of K=0+, 2+ vibrational bands, and B(E3) values to 3- states of octupole-vibrational bands (K=0-, 1-, 2-) were calculated by 1971Ko31. B(E3) values to octupole-vibrational band were also calculated by 1970Ne08. See 1972Ab10 for calculated B(E2) values to K=0+ bands.

 ^{238}U Levels

Assignment of rotational bands is that given in 1996Wa11, based on work of those authors and on earlier work referenced in 1996Wa11.

E(level) [†]	J π	T _{1/2} [‡]	Comments
0.0 ^{\$}	0+		
44.915 ^{\$} 13	2+	206 ps 3	B(E2) $\uparrow$ =12.30 15 (1973Be44). B(E2) $\uparrow$: from 1973Be44. This value supersedes that of 11.70 15 given in 1971Mc21 and 1971Fo17. Others: 13.2 20 (1961Re02), 12.7 7 (1961Sk01). T _{1/2} : from B(E2) with α =609. This value is the E2 theory value reduced by 2% (see 1987Ra01).
148.40 ^{\$} 4	4+		B(E4) $\uparrow$ =0.69 37 (1973Be44).
307.3 ^{\$} 3	6+		
517.9 ^{\$} 4	8+	23 ps 3	B(E2)(6+ to 8+)=4.7 6 (1981Gr10).
680.17 [#] 20	1-		B(E1) $\uparrow$ =0.00049 17 (1981Al02). B(E1) $\uparrow$: 1981Al02 give 0.00044 13 for a positive M3/M1 matrix element, and 0.00053 14 for a negative ratio.
732.06 [#] 18	3-		B(E3) $\uparrow$ =0.57 4 (1994Mc03). Other B(E3) values: 0.64 6 (1974Mc15), 0.59 5 (1981Al02).
775.7 ^{\$} 5	10+	9.0 ps 10	B(E2)(8+ to 10+)=5.2 6 (1981Gr10).
827.0 [#] 5	5-		
927.3 ^f 6	(0+)		
931.2 ^h 4	(1-)		
950.5 [@] 4	2-		
966.11 ^f 4	2+		B(E2)=5.76 $\times 10^{-3}$ 35 (1994Mc03), 0.017 7 (1974Mc15). J π : Coulomb excitation. $\gamma(0)(967\gamma, 818\gamma)$ give J=2.
966.4 [#] 4	7-		
997.23 ^g 24	0+		E(level): 1994Mc03 report E=992 based on a weak 947 γ assigned as the branch to the 45 level. 1967Di07 report E=993 based on E γ =948, and E=993 for an E0 transition to the g.s. Given E(level)=997.23 as determined by 2001Ga55, one gets E γ =952.3 for the transition to the 45 level. This transition would not be resolved from the 952 transition seen in β^- decay, Coulomb excitation, and (n,n' γ), but assigned to the 997.6 3- level. The 993 transition seen in the ce spectrum of 1967Di07 may correspond to the 992.3 E2+E0 transition from the 1037 2+ level.
997.6 ^h 3	3-		B(E3) $\uparrow$ =0.184 18 (1994Mc03). B(E3) $\uparrow$: other: 0.19 3 (1981Al02), 0.24 5 (1974Mc15).
1028 [@]	4-		
1037.24 ^g 7	2+		B(E2)=0.066 9 (1994Mc03), 0.063 9 (1974Mc15) B(E2) others: 0.037 15 (1981Al02); 0.048 11(1974ThZG). These authors do not include the E0 component in the 992 γ . B(E2)(888.9 γ)/B(E2)(1037.3 γ)=1.50 21 and B(E2)(992.3 γ)/B(E2)(1037.3 γ)<0.97 11 (1981Al02).
1056 ^f	4+		
1060.27 ^c 14	2+		B(E2) $\uparrow$ =0.133 8(1994Mc03). B(E2) $\uparrow$: others: 0.145 12 (1981Al02), 0.127 9 (1974Mc15).
1076.4 ^{\$} 5	12+	4.4 ps 4	B(E2)(10+ to 12+)=5.1 5 (1981Gr10). T _{1/2} : weighted average of 4.5 ps 5 from B(E2) and 4.2 ps 6 from DSA (1981Gr10).
1105 ^b	3+		
1128.8 ^d 3	(2-)		
1130.74 ^g 24	(4+)		
1150.4 [#] 5	9-		
1151 [@]	6-		
1163 ^c	(4+)		

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Coulomb Excitation (continued)
²³⁸U Levels (continued)

E(level) [†]	J π	T _{1/2} [‡]	Comments
1168	(4+)		Assigned by 1994Mc04 as the 4+ member of the K=2 γ -vibrational band; however, 1996Wal1 show that this band member has an energy of 1163.
1169.1 d 3	3-		B(E3) $\uparrow$ =0.166 23 (1994Mc03).
1223.93 25	2+		B(E3) $\uparrow$: others: 0.15 2 (1981Al02), 0.28 7 (1974Mc15). B(E2) $\uparrow$ =0.0123 12 (1994Mc03). B(E2) $\uparrow$: other: 0.022 13 (1974Mc15). J π : γ (0)(1224 γ) gives J=2. Coulomb excitation.
1232 b	5+		
1269 g	(6+)		
1278.3	2+		B(E2) $\uparrow$ =4.3 $\times$ 10 ⁻³ 4 (1994Mc03). J π : γ (0)(1278 γ , 1130 γ) give J=2. Coulomb excitation.
1311 c	6+		
1318.0 @	8-		
1378.6 # 5	11-		
1403 b	7+		
1414	2+		B(E2) $\uparrow$ =5.5 $\times$ 10 ⁻³ 6 (1994Mc03). J π : γ (0)(1414 γ) gives J=2. Coulomb excitation.
1415.2 \$ 6	14+	2.55 ps 20	B(E2)(12+ to 14+)=5.1 5 (1981Gr10). T _{1/2} : weighted average of 2.54 ps 23 from B(E2) and 2.56 ps 28 from DSA (1981Gr10).
1446 e	(7-)		
1504 c	8+		
1528 @	10-		
1530.1	2+		B(E2) $\uparrow$ =1.05 $\times$ 10 ⁻² 11 (1994Mc03). J π : γ (0)(1382 γ) gives J=2. Coulomb excitation.
1545.8 i j 14	8+		
1619 b	9+		
1643 e	(9-)		
1649.0 # 6	13-		
1741 c	10+		
1778 @	12-		
1782	2+		B(E2) $\uparrow$ =0.0179 18 (1994Mc03).
1786.7 i j 15	10+		
1788.2 \$ 7	16+	1.74 ps 13	B(E2)(14+ to 16+)=3.9 5 (1981Gr10). T _{1/2} : weighted average of 2.05 ps 27 from B(E2) and 1.66 ps 14 from DSA (1981Gr10).
1865 e	(11-)		
1875 b	11+		
1958.9 # 6	15-		
2018 c	12+		
2033 a	(12+)		
2048.7 i j 15	12+		
2066 @	14-		
2122 e	(13-)		
2170 b	13+		
2190.9 \$ 7	18+	1.18 ps 11	T _{1/2} : from DSA (1981Gr10).
2306.4 # 7	17-		
2333 c	14+		
2346.4 i j 16	14+		
2356 a	(14+)		
2389 @	16-		
2418 e	(15-)		
2502 b	15+		
2619.0 \$ 8	20+	0.91 ps 8	B(E2)(18+ to 20+)=4.4 7 from yield data (1981Gr10). T _{1/2} : weighted average of 0.94 ps 13 from B(E2) and 0.90 ps 10 from DSA (1981Gr10).
2645 &	(14+)		
2675.2 i j 17	16+		
2683 c	16+		
2689.0 # 8	19-		
2712 a	(16+)		
2744 @	18-		
2751 e	(17-)		
2867 b	17+		
2991 &	(16+)		
3031.2 i j 19	18+		

Continued on next page (footnotes at end of table)

Coulomb Excitation (continued) ^{238}U Levels (continued)

E(level) [†]	J π	T _{1/2} [‡]	Comments
3065 ^c	18+		
3068.1 [§] 9	22+	0.76 ps 10	B(E2)(20+ to 22+)=3.9 6 (1981Gr10). T _{1/2} : weighted average of 0.82 ps 13 from B(E2) and 0.69 ps 15 from DSA (1981Gr10).
3095 ^a	(18+)		
3104.0 [#] 8	21-		
3120 ^e	(19-)		
3128 [@]	20-		
3264 ^b	19+		
3368 ^{&}	(18+)		
3411.2 ^{ij} 22	20+		
3474 ^c	20+		
3502 ^a	(20+)		
3521 ^e	(21-)		
3535.1 [§] 9	24+	0.51 ps 8	B(E2)(22+ to 24+)=5.1 8 (1981Gr10).
3538 [@]	22-		
3547.5 [#] 9	23-		
3685 ^b	21+		
3773 ^{&}	(20+)		
3811.2 ^{ij} 24	22+		
3906 ^c	22+		
3947 ^e	(23-)		
3971 [@]	24-		
4016 [#]	25-		
4017.9 [§] 11	26+	0.40 ps 7	B(E2)(24+ to 26+)=5.6 10 (1981Gr10).
4127 ^b	23+		
4205 ^{&}	(22+)		
4232 ^{ij} 3	24+		
4358 ^c	24+		E(level): authors (1996Wa11) show 4356 on the level scheme, but the only transition from this level is a 452 γ to the 3906 level.
4393 ^e	(25-)		E(level): authors(1996Wa11) give E=4417; however, the deexciting transition to the 3947 level has E γ =446, giving E(level)=4393.
4424 [@]	26-		
4503 [#]	27-		
4517.2 [§] 14	28+	0.36 ps 9	B(E2)(26+ to 28+)=5.1 13 (1981Gr10).
4585 ^b	25+		
4677 ^{ij} 3	26+		
4825 ^c	26+		E(level): authors show 4823 on the level scheme, but see comment on the 4359 level.
4895 [@]	28-		
5002 [#]	29-		
5034.9 [§] 17	30+	<0.9 ps	B(E2)(28+ to 30+)>1.7 (1981Gr10).
5063 ^b	27+		
5144 ^{ij} 3	28+		
5512 [#]	31-		
5581 [§] 3	32+		E(level),J π : From 2010Zh09.
6037 [#] 3	33-		E(level),J π : From 2010Zh09.
6146 [§] 4	34+		E(level),J π : From 2010Zh09.

[†] 1997Ah04 and 1997Di05 both looked for evidence of internal pair production from levels with E=1800. Neither sees evidence of ipc. 1997Ah04 report E γ =1780 2 with σ between 27 mb 3 and 34 mb 3 with a dependence on impact parameter and a variation with beam and target characteristic of Coulomb excitation. The cross section is about 8 times larger than that expected from the B(E2) given by 1994Mc03 for excitation of a 1782 2+ level. 1997Di05 also see a γ peak at 1782; however, they report a σ of only 4.8 mb 8. 1997Ah04 suggest that their 1782 peak may be a composite of several transitions to the g.s. band from a band with the same moment of inertia built on the 1782 level.

[‡] From B(E2) data of 1981Gr10, except where noted otherwise.

[§] (A): K π =0+ ground state band.

[#] (B): K π =0- octupole-vibrational band.

[@] (C): K π =1-. α =0.

[&] (D): Unassigned, but possibly built on the 1414 or 1530 2+ levels.

^a (E): Possibly associated with the 1037 2+ level, assigned by 1994Mc03 as the second K=0 β -vibrational band.

^b (F): K π =2+ γ -vibrational band. α =1.

^c (G): K π =2+ γ -vibrational band. α =0.

^d (H): K π =2-.

^e (I): Probably associated with the octupole band built on the 1129 2- level, and thus probably K π =2- with α =1.

Footnotes continued on next page

Coulomb Excitation (continued)

 ^{238}U Levels (continued)

 f (J): $K\pi=0+$.

 g (K): $K\pi=0+$ second β -vibrational band.

 h (L): $K\pi=1-$. $\alpha=1$.

 i (M): Band based on $J\pi=8+$, interpreted as a 2-phonon octupole band (2010Zh09).

j From 2010Zh09.

 $\gamma(^{238}\text{U})$

$E\gamma^{\dagger}$	E(level)	$I\gamma^{\ddagger}$	Mult. [§]	δ	α	Comments
(41.4 [@])	1169.1		(E2)			Mult.: $\gamma(\theta)$ for the 1084 and 397 γ 's from the 1129 2- level are consistent with the 1-3 correlation if the unobserved 41.4 transition is pure quadrupole.
44.915 ^b 13	44.915					
(51.8 ^a)	732.06					
(67.1 ^a)	997.6					
69	1232					
78	1028					E γ : shown in level scheme of 1996Wa11 with no energy label.
79	1311					
92	1403					
102	1504					
103.50 ^b 4	148.40					
114	1619					
122	1741					
123	1151					
127	1232					
134	1875					
143	2018					
149	1311					
153	2170					
158.9 [#] 4	307.3	10.5 11				E γ : other: 1994Mc03 report 158.8 4.
162	2333					
163.9 ^f 5	1223.93	3.3 3				E γ , I γ : not shown in 1994Mc03 but given in earlier private communication from the lead author.
167	1318.0					
169	2502					
170	1958.9					
171	1403					
172&	1169.1	4.83				
179&	1128.8	5.14				
182	2683					
184 [#]	1150.4					
	2867					
193	1504					
197	1643					
	3065					
198	1128.8					I(γ +ce): masked by an impurity line. I γ (198 γ)/I γ (1084 γ)=0.18 in ^{238}Pa β^- decay.
202.6&	1169.1	1.83	E1			
210	1528					
210.6 [#] 4	517.9					
216	1619					
218.6& 10	950.5	2.53 26				
222	1865					
228.1 [#] 4	1378.6					
234	1649.0					
234.5& 10	966.11	3.0 3	(E1)			
237	1741					
241 ^e	1786.7					
250	1778					
251.1& 10	931.2	2.52 26				
256	1875					

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Coulomb Excitation (continued)
 $\gamma(^{238}\text{U})$ (continued)

$E\gamma^{\dagger}$	E(level)	$I\gamma^{\ddagger}$	Mult.§	δ	α	Comments
257	2122					
257.8# 4	775.7					
258&	1223.93	0.93	(E2)			
259e	1786.7					
262e	2048.7					
270.3& 10	950.5	2.3 4				
270.5# 4	1649.0					
271e	2048.7					
273&	1223.93	3.55	E1			
277	2018					
281e	2346.4					
286.3& 10	966.11	1.74 14	(E1)			
288	2066					
293&	1223.93	1.45	E1			
296	1028					
	1223.93	1.61	E2			
	2170					
	2418					
298e	2346.4					
300.6# 4	1076.4					
302.3# 4	1378.6					Ey: placement questioned by 1981Gr10 but confirmed by 1996Wall.
305.5& 6	1037.24	8.8 4	E1			
309.9# 4	1958.9					
315	2333					
318.0& 10	997.6	5.7 3	E2			
323	2356					
	2389					
324	1151					
329e	2675.2					
332	2502					
333	2751					
338.8# 4	1415.2					
346	2991					
347.5# 4	2306.4					
350	2683					
352	1318.0					
354&	1414	0.49	E2			
355	2744					
356	2712					
	3031.2					
357.5& 6	1037.24	7.1 3				
365	2867					
368e	2675.2					
369	3120					
372.9# 4	1788.2					
374.8# 4	1150.4					
377	1528					
	3368					
380e	3411.2					
382	3065					
382.7# 4	2689.0					
383	3095					
384	3128					
387e	2346.4					
397.0& 10	1128.8	3.75 19				
397	3264					
399	1778					
400e	2048.7					
	3811.2					
400.6&	1530.1	0.68				
401	3521					
402.6# 4	2190.9					

Continued on next page (footnotes at end of table)

Coulomb Excitation (continued)
 $\gamma(^{238}\text{U})$ (continued)

$E\gamma^{\dagger}$	E(level)	$I\gamma^{\ddagger}$	Mult.§	δ	α	Comments
405	3773					
408 ^e	1786.7					
	3502					
409	3474					
410	3538					
415.1 [#] 4	3104.0					
421	3685					
	4232					
426	3947					
427.9 [#] 4	2619.0					
432	3906					
	4205					
433	3971					
437.0 ^{&} 4	1169.1	10.9 5	M1+E2	+0.23 +12-9		δ : From 1994Mc03.
441	4127					
443.6 [#] 4	3547.5					
445 ^e	4677					
446	4393					
448.3 ^{&} 4	1128.8	14.4 6				
448.9 [#] 4	3068.1					
449	966.4					
452	4358					
453	4424					
459	4585					
467.0 [#] 4	3535.1					
467	4825					
	5144					
469	4016					
471	4895					
473	2122					
477	5063					
479	3547.5					
480	1446					
481	4016					
482.8 [#] 6	4017.9					
485	3104.0					
487	1865					
	4503					
489.0 ^{&} 10	1169.1	2.55 20	E2			
493	1643					
498.3 [#]	2689.0					E γ : placement questioned by 1981Gr10, but confirmed by 1996Wa11.
499	5002					
499.3 [#] 8	4517.2					
510	5512					
517.7 [#] 10	5034.9					
518.3 [#] 4	2306.4					
520.0 ^{&} 6	827.0	6.9 4	E1			
524 ^e	6037					
^x 530						
542 ^e	5581					
543.7 [#] 4	1958.9					
546.7 ^{&}	1278.3	1.90	E1			
564 ^{&}	1530.1	1.42	(E2)			
565 ^e	6146					
572.4 [#] 4	1649.0					
583.7 ^{&} 3	732.06	250 5	E1			$\alpha(K)_{\text{exp}}=0.0053$ 13 (2001Ga55). $I\gamma$: $I\gamma/I\gamma(687\gamma)=0.817$ 11 (1981A102).
599 ^{&}	1530.1	3.33	E1			
602.9 [#] 4	1378.6					
632.6 [#] 4	1150.4					
635.3 ^{&} 3	680.17	48.9 10	d			$\alpha(K)_{\text{exp}}=0.016$ 4 (2001Ga55).
636 ^e	1786.7					

Continued on next page (footnotes at end of table)

Coulomb Excitation (continued)

 $\gamma(^{238}\text{U})$ (continued)

$E\gamma^{\dagger}$	E(level)	$I\gamma^{\ddagger}$	Mult. [§]	δ	α	Comments
659.1 2	966.4					$E\gamma$: from (n,n' γ). E=659 in Coulomb excitation, but no uncertainties are available for transitions from the 7- level. Uncertainties are available for transitions from both lower and higher band members.
670 ^e	2048.7					
677	2867					
678.4& 6	827.0	13.7 8	E1			
680.2& 5	680.17	38.6 19	d			$\alpha(K)\text{exp}=0.016\ 5$ (2001Ga55).
687.3& 3	732.06	307 6	E1			
698 ^e	2346.4					
713	2502					
716 ^e	2675.2					
724 ^e	3031.2					
749&	1056	1.42	E2			
	3368					
755	2170					
793	1311					
798	1875					
798.4&	1530.1	1.91	E1			
800	2991					
818.1& 4	966.11	21.6 9	(E2)			$\alpha(K)\text{exp}=0.012\ 8$ (2001Ga55). Mult.: $\alpha(K)\text{exp}$ agrees with mult=E2, but does not exclude E1.
843	1151					
	1619					
849.1& 4	997.6	71.3 22	E1			$\alpha(K)\text{exp}=0.0046\ 27$ (2001Ga55). Mult.: from $\alpha(K)\text{exp}$.
855	1163					
857	2645					
861&	1168	1.22	E2			
880	1028					
882	3502					
882.3& 6	927.3	4.2 4	E2			
885	1403					
886.6& 6	931.2	19.1 8				
888.9& 3	1037.24	53.6 11	E2			$I\gamma$: $I\gamma(1037\gamma)/I\gamma(849\gamma)=0.69\ 10$ (1981A102).
904	3095					
905.8& 6	950.5	4.8 3	E1			
908&	1056	0.58				
911.9& 4	1060.27	15.8 9	E2			
921.19 ^c 3	966.11	13.0 6	E0+M1+E2		0.23 4	$\alpha(K)\text{exp}=0.191\ 30$ (2001Ga55). α : from $\alpha(K)\text{exp}$ and $\alpha/\alpha(K)=1.19$ (E0 theory). $\rho^2=0.0099\ 18$ (2001Ga55). δ : $\delta(E2/M1)=+4.1\ +6-5$ or -0.185 from $\gamma(\theta)$ (1994Mc03). Mult.: from $\alpha(K)\text{exp}$ and $\gamma(\theta)$.
924	2712					
925	1232					
931 ^e	2346.4					
931.5& 6	931.2	4.81 24				
941	2356					
952.6& 4	997.6	40.5 9	E1			$\alpha(K)\text{exp}=0.0045\ 60$. $\alpha(K)\text{exp}$: private communication from the lead author of 2001Ga55. $I\gamma$: $I\gamma(953\gamma)/I\gamma(849\gamma)=0.71\ 7$ (1981A102). Note that the B(E1) ratio given by the author is a misprint. The ratio should be inverted.
957	1105					
	2033					

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Coulomb Excitation (continued)

 $\gamma(^{238}\text{U})$ (continued)[illegible]

[†] From 1996Wai1, unless otherwise noted.

Coulomb Excitation (continued) $\gamma(^{238}\text{U})$ (continued)

- ‡ From 1994Mc03. Authors values of $I(\gamma+ce)$ in units of excitations per nanocurie have been converted by the evaluator to photon intensities. The $\Delta J=0,1$, $\Delta\pi=\text{no}$ transitions have been taken as E2, except where δ is known (priv comm from lead author). Uncertainties, where given, are from a 1987 priv. Comm. From the lead author. Other $I\gamma$ values, available as branching ratios from B(E2) ratios by 1981Al02, are included as comments. Additional branching ratios have been communicated to the evaluators by the lead author of 2001Ga55. These data are preliminary. For the 966 2+ level, $I\gamma(818\gamma):I\gamma(921\gamma):I\gamma(967\gamma)=(21.6\ 9):11.1\ 7:8.5\ 14$. For the 997 3- level, $I\gamma(953\gamma)/I\gamma(849\gamma)=0.642\ 32$. For the 1037 2+ level, $I\gamma(889\gamma):I\gamma(992\gamma):I\gamma(1037\gamma)=46.6\ 18:62.1\ 12:(74.8\ 19)$. For the 1060 level, $I\gamma(912\gamma):I\gamma(1015\gamma):I\gamma(1060\gamma)\leq 30:(443\ 17):267\ 9$.
- § From $\gamma(0)$ of 1994Mc03, unless otherwise noted. The $\alpha(K)\text{exp}$ data are from 2001Ga55 based on relative $I\gamma$ and ICE(k) data normalized to $\alpha(K)(687\gamma, E1)=0.0060\ 9$, $\alpha(K)(889\gamma, E2)=0.014\ 5$, and $\alpha(K)(1060\gamma, E2)=0.0063\ 7$.
- # From 1981Gr10.
- @ Not directly observed, but required to account for the yield of transitions from the J-1 member of this band (1994Mc03). $E\gamma$ is a rounded-off value based on adopted level energies.
- & From 1994Mc03. Uncertainties, where given, are from a 1987 priv comm from the lead author.
- a Not directly observed, but required to account for the yield of transitions from the J-2 member of this band (1994Mc03). $E\gamma$ is a rounded-off value based on adopted level energies 1987 private communication from the lead author.
- b From adopted gammas. 1981Gr10 report 44.9 4 and 103.5 4 for the 2+ to g.s. and 4+ to 2+ transitions, respectively. Adopted values are used so that advantage can be taken of the accurate $E\gamma$ values of 2001Ga55 for transitions to the 2+ and 4+ levels.
- c From 2001Ga55.
- d Anomalous E1 transition. $\alpha(K)\text{exp}$ is larger than E1 theory and agrees with E2 theory. Similar anomalous E1 transitions have been observed in ^{236}U . See 1983Fa15.
- e From 2010Zh09.
- f Placement of transition in the level scheme is uncertain.
- x γ ray not placed in level scheme.

Adopted Levels, Gammas

Q(β⁻)=1291.5 5; S(n)=5488.3 2; S(p)=5224.6 6; Q(α)=4691 4 2012Wa38.

Nilsson configurations are from 1990Ho02, unless otherwise noted.

For theoretical investigations see:

1987Be51 – Levels, bandhead energies.

1988Fr16 – Newby shift.

1988Qu03 – coupling effects.

1989Pl10 – level density in second potential well.

1992Gr16 – Half-life for SF.

additional list can be found in 1990Ho02.

Cluster decay.

²³⁸Np(³⁰Mg): 2012Sa31, 2011Sh13, 2005Bh02.

Theory:

2013Ni03, 2012Ro34, 2011Sa40, 2010Ni02, 2008Do12, 2006Sa35, 2004Sa55, 2002Sc36.

²³⁸Np Levels

Cross Reference (XREF) Flags

A ²³⁷Np(n,γ) E=th: Primary γ's

B ²⁴²Am α Decay (141 y)

C ²³⁷Np(n,γ) E=th: Secondary γ's

D ²³⁷Np(d,p)

E ²³⁷Np(n,γ) E=resonance

F ²³⁷Np(n,γ) E=res: Avg

E(level) ¹	Jπ ^m	XREF	T _{1/2}	Comments
0.0 [†] h	2+	ABCD	2.099 d 2	%β ⁻ =100. T _{1/2} : Weighted average of 2.1023 d 7, 2.1024 d 9, 2.1026 d 9 from (2006Re09), and 2.0980 d 3 (1990Ch35). Other values: 2.117 d 2 (1966Qa01), 2.10 d 1 (1950Fr53).
26.4266 [†] h 21	3+	BCDE		Jπ: M1+E2 to g.s. Member of band built on the g.s.
62.330 [†] h 4	4+	BCD		Jπ: member of g.s. band. M1+E2 to 3+.
86.6738 [‡] h 18	3+	BCD		
106.155 [†] h 15	5+	BCD		Jπ: member of g.s. band. M1+E2 to 4+.
121.645 [‡] h 9	4+	BCD		Jπ: band member. M1 γ's to 3+ and 4+.
136.0450 [§] h 23	3-	ABC EF	6.0 ns	T _{1/2} : from αγ(t) (1966As06).
161.685 [†] h 24	6+	B		Jπ: member of g.s. band.
165.532 [‡] h 15	5+	BCD		Jπ: band member. M1+E2 γ to 4+.
179.154 [§] h 7	4-	BC EF		
182.8775 [#] h 18	2-	ABC EF		Jπ: band head. E1 γ's to 2+ and 3+.
215.522 [#] h 4	3-	ABC EF		Jπ: band member. E1 γ's to 2+ and 3+.
217.949 ^{&i} 10	0-	C		Jπ: E2 to 2-, M2 to 2+. Not fed in (n,γ) from thermal, resonance, or average resonance capture; therefore, J not 1 to 4. Probable Kπ=0- bandhead.
218.7 ^{‡i} 6	(6+)	B D		Jπ: probable band member. γ from 7+. E(level): no deexciting transitions assigned by authors. Their energy of 218.7 6 comes from feeding via a 170.5γ from the 389 level. On the basis of an energy fit, the evaluators suggest possible placement of a 52.98γ feeding the 5+ member of the assigned band at 165.59. This would give E(level)=218.57 8. The (d,p) level at 221.2 8 is assigned by 1990Ho02 as being the same level.
232.828 [§] h 8	5-	BC		Jπ: probable band member. M1+E2 to 4-. Not seen in primary, average, or in resonance capture; therefore, Jπ not 1- to 4-.
243.959 ^{ai} 4	(1)+	C		Jπ: probable bandhead. M1+E2 to 2+.
246.4 14	1 to 4	A E		
250.33 ^{fj} 3	(1+)	B		Jπ: possible band member. γ to 2+.
250.39 ^{&j} 4	(2)-	A C EF		Jπ: possible band member. Jπ=1- to 3- from average resonance capture and feeding from a 2+ resonance in (n,γ). (E1) to 3+.
258.853 [#] h 8	4-	ABC EF		Jπ: band member. M1+E2 to 3-. E2 to 2-.
275.519 [@] h 9	5+	BCD		Jπ: band head. M1+E2 to 4+.
277.641 ^{aj} 18	(2)+	C		Jπ: possible band member. E2(+M1) to 3+. γ to 2+.
285.8? 10	1 to 4	A		
297.03 ^{§i} 5	(6-)	B	n	Jπ: probable band member. γ's to 5+.
298.368 ^{ai} 8	3+	C	n	Jπ: probable band member. M1 γ's to 2+ and 4+.
299.23 ^{fi} 6	(3+)	B	n	Jπ: probable band member. γ's to 2+ and 4+.
299.788 ^{ei} 20	(1)-	C F	n	Jπ: probable band head. Jπ=1- to 4- from population in average resonance capture. γ to 2-.
300.68 7	1-, 2, 3, 4-	B	n	Jπ: γ's to 3-.

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Adopted Levels, Gammas (continued) ^{238}Np Levels (continued)

E(level) ^l	$J\pi^m$	XREF	$T_{1/2}$	Comments
300.743 ^{d i} 16	(6-)	B		$J\pi$: probable band head. γ 's to 4-, 5-, and 5+. Not seen in thermal, average resonance, or resonance capture; therefore J not 1 to 4.
305.4 20	1- to 4-	F		E(level), $J\pi$: 1990Ho02 assign E=305.4 20 from their average resonance capture work, with $J\pi$ thus 1- to 4-. The evaluators note that a 218.56 γ -126.21 γ cascade from the 523.87 3+,4+ level to the 179.150 4- level would yield E=305.34 3 for the intermediate level; however, mult(218.56 γ) is M1+E2 so the resulting $J\pi$ (305) would be 3+ to 5+. The energy agreement may be fortuitous; however, one notes from fig. 3 of 1990Ho02 that the $I\gamma/E\gamma^5$ value for the 305 level overlaps the calculated range for $J\pi$ =1+ to 4+.
312.704 ^{# h} 19	5-	BC		$J\pi$: band member. M1+E2 to 4-.
315.063 8	4+, 5+	C		$J\pi$: E1+M2 to 5-. γ to 3-.
324.314 ^{& j} 8	(4)-	C F		$J\pi$: possible band member. γ to 3-. $J\pi$ =1- to 4- from arc.
325.210 ^{& j} 9	1-	A C EF		$J\pi$: M1 to 0-.
328.6 ^{@ h} 5	6+	B D		$J\pi$: band member. E(level): E=328.6 5 from (d,p). 1990Ho09 place the 163.25 γ from this level; however, this transition is doubly placed, and all of the intensity can be accounted for by placement from the 342 level. The authors' coincidence work does not seem to require a component from this level. If a component of the 163 γ does indeed deexcite this level, then E(level) can be established as 328.84 4.
334.0 6	1- to 3-	AB EF		E(level): weighted average of 334.7 8 from arc and 333.4 7 from primary γ 's in thermal and resonance capture. E=334.8 for a tentative level in α decay.
342.439 ^{g h} 8	5-	BC		$J\pi$: band head. E1 to 5+. γ to 3-. Not seen in arc.
348.8 9	1- to 3-	A EF		E(level): from primary γ 's in thermal and resonance capture. E=347.1 23 in arc.
352.46 ^{e j} 4	(3)-	C EF		$J\pi$: possible band member. Fed by primary γ 's in arc and from a 2+ resonance.
367.26 ^{e j} 3	(2)-	A C EF		$J\pi$: possible band member. Fed by primary γ in arc.
373.684 ^{b j} 14	(1)-	A C EF		$J\pi$: possible band head. (M1) to 1-. γ to 0-. Fed by primary γ in arc.
374.7 ^{f i} 10	(5+)	B D		E(level): from (d,p). $J\pi$: probable band member. $\sigma(\text{exp})$ in (d,p) agrees with $\sigma(\text{calc})$.
376.70 ^{# i} 7	(6-)	B		$J\pi$: probable band member. γ 's to 4- and 5+.
380.60 ^{& j} 4	(3)-	C F		$J\pi$: possible band member. E2(+M1) to 2-. Fed by primary γ in arc.
386.3 3	1 to 4	A E		E(level): weighted average of 386.3 3 from primary γ 's in thermal capture, and 386.2 5 in resonance capture.
389.4 ^{@ h} 5	7+	B D		E(level): weighted average of 389.9 9 in (d,p), and 389.2 6 in α decay.
395.198 ^{a k} 17	(5)+	C		$J\pi$: band member. $J\pi$: possible band member. Not populated in primary, average resonance, or in resonance capture; therefore J not 1 to 4. M1+E2 to 5+.
397.3 15		B		E(level): from E α .
407.59 ^{g h} 6	6-	B		$J\pi$: band member.
409.5 ^{d k} 5	(8-)	D		$J\pi$: possible band member. $\sigma(\text{exp})$ in (d,p) agrees with $\sigma(\text{calc})$.
417.641 12	2+, 3+, 4+	C		$J\pi$: M1+E2 to 3+.
431.3 ^{f i} 6	(4+)	D		$J\pi$: probable band member. $\sigma(\text{exp})$ in (d,p) agrees with $\sigma(\text{calc})$.
433.716 13	3+, 4+	C		$J\pi$: E1 γ 's to 3- and 4-.
442.23 ^{e j} 3	(4)-	A C EF		$J\pi$: possible band member. Fed by primary in arc.
456.3 ^{@ j} 7	(8+)	D		$J\pi$: possible band member.
457.65 19	1- to 3-	A EF		E(level): weighted average of 457.37 24 from primary γ 's in thermal and resonance capture, and 458.1 3 in arc.
459.6 ^{c i} 6	(6+)	B		$J\pi$: probable band head. HF in α decay.
469.1 12	1- to 4-	B F		
473.3 4	1- to 4-	F		
484 ^{g h} 3	7-	B		$J\pi$: band member. HF in α decay.
497.20 3	2-, 3-, 4-	C F		$J\pi$: M1+E2 to 3-. If the doubly placed 314 γ has most of its intensity here, then its M1+E2 character to 2- rules out 4-.
505.1 10	1- to 4-	F		
523.83 3	3+, 4+, 5+	C		$J\pi$: M1+E2 to 4+.
524.2 ^{f i} 6	(6+)	D		$J\pi$: probable band member. $\sigma(\text{exp})$ in (d,p) agrees with $\sigma(\text{calc})$.
525.3 ^{c j} 15	(7+)	B		$J\pi$: possible band member.

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Adopted Levels, Gammas (continued)
 ^{238}Np Levels (continued)

E(level) ¹	J π^m	XREF	T _{1/2}	Comments
529.857 10	3-	A C EF		J π : E2 to 5-. M1+E2 to 2-.
543.24 4	3-, 4-	C F		J π : fed by primary in arc. γ to 5-.
567.023 13	3-	A C EF		J π : E2 to 5-. M1+E2 to 2-.
578 3		B		
584.5 3	1- to 4-	A F		E(level): weighted average of 584.9 4 from average resonance capture, and 584.2 4 from primary γ in thermal capture.
601.2 3	1- to 3-	A EF		E(level): weighted average of 601.1 4 from primary γ 's in thermal and resonance capture, and 601.4 4 from arc.
603.7 6		D		
619.5 3	1 to 4	EF		E(level): from primary γ in thermal capture. E=623.6 15 from resonance capture.
630.6 13		D		
635.3 10	1- to 4-	EF		
646.76 4	2+, 3+, (4)+	C		J π : M1+E2 to 3+. E2(+M1) to 2+.
648.1 9	1- to 3-	A DEF		E(level): weighted average of 649.0 6 from average resonance capture, 645.9 7 from primary γ 's in thermal and resonance capture, and 648.7 5 from (d,p).
673.6 3	1- to 3-	A dEF		XREF: d(675.6). E(level): weighted average of 673.7 3 from primary γ 's in thermal and resonance capture, and 672.7 10 in arc.
676.9 18	1- to 4-	d F		XREF: d(675.6).
692.1 3	1- to 3-	A DEF		E(level): weighted average of 691.9 6 from (d,p), 692.1 3 from arc, and 692.2 3 from primary γ 's in thermal and resonance capture.
709.24 25		A		
722.4 7		A		
764.1 6		A		
782.4 6		A		
797.4 4		A		
800.4 8		A		
809.8 3		A		
813.9 7		A		
834.7 6		A		
869.0 5		A		
903.3 4		A		
916.6 8		A		
929.1? 6		A		
948.9? 6		A		
970.7? 6		A		
986.5? 4		A		
1026.6? 6		A		
1033.4? 7		A		
1046.5? 6		A		
1065.2? 5		A		
1081.0? 6		A		
1089.0? 6		A		
1107.8 7		A		
1119.6? 7		A		E(level): the authors' value of 1197.6 in table I is a misprint.
1143.0 6		A		
1163.1 4		A		E(level): the authors' value of 1153.1 is a misprint, or else E γ is incorrect.
1176.1 6		A		
1256.1 3		A		
1260.5 6		A		
1276.1 5		A		
1291.3 4		A		
1313.5 3		A		
1330.7 6		A		
1364.8 7		A		
1369.8 7		A		
1375.6 4		A		
1384.6 3		A		
1392.8 5		A		
1408.5 6		A		

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued)

²³⁸Np Levels (continued)

E(level) ¹	XREF	T _{1/2}	Comments
1445.7 6	A		
1484.1 8	A		
1492.8? 7	A		
1509.0 5	A		
1546.5 7	A		
1711.5 5	A		
1822.5 6	A		
2104.3 6	A		
2109.5 5	A		
2300		112 ns 39	%SF≤100. %SF: only SF activity was observed by 1970Vi05. γ branch from a shape isomer with T _{1/2} between 2 μs and 20 ms was searched for its decay by 1974Bo02 in ²³⁸ U(p,n) reaction, and no γ could be assigned definitely. Upper limit on the isomeric ratio was found by 1976Vo04 by γγ(t) in ²³⁷ Np(thermal n) reaction for an isomer with T _{1/2} =70–200 ns. T _{1/2} : measured by 1970Vi05 in ²³⁷ Np(d,p), ²³⁸ U(d,2n). No SF isomer was observed in ²³⁷ Np(d,p) with 10 ns≤T _{1/2} ≤1 μs (1969La14). No SF isomer was observed in ²³⁸ U(d,2n) with T _{1/2} >1 ns (1970Po01). T _{1/2} for fission was calculated as 52 s by 1972We09, and as 20000–2000 s by 1971Ba30. T _{1/2} (γ)=2.3 s was calculated also by 1972We09. E(level): E(level)=2100 calculated by 1971Ba30, E(level)=2300 calculated by 1972We09, E(level)=2200 calculated by 1969Ni13.

2857.4 6 A

- † (A): Kπ=2+ 5/2[642]–v 1/2[631].
‡ (B): Kπ=3+ 5/2[642]+v 1/2[631].
§ (C): Kπ=3– 5/2[523]+v 1/2[631].
(D): Kπ=2– 5/2[523]–v 1/2[631].
@ (E): Kπ=5+ 5/2[642]+v 5/2[622].
& (F): Kπ=0– 1/2[530]–v 1/2[631].
a (G): Kπ=0+ 1/2[400]–v 1/2[631].
b (H): Kπ=1– 1/2[530]+v 1/2[631].
c (I): Kπ=6+ 5/2[523]+v 7/2[743].
d (J): Kπ=6– 5/2[642]+v 7/2[743].
e (K): Kπ=0– 5/2[523]–v 5/2[622].
f (L): Kπ=0+ 5/2[642]–v 5/2[622].
g (M): Kπ=5– 5/2[523]+v 5/2[622].
h 1990Ho02 estimate confidence in the evidence for a level configuration as well established.
i 1990Ho02 estimate confidence in the evidence for a level configuration as probable.
j 1990Ho02 estimate confidence in the evidence for a level configuration as plausible.
k 1990Ho02 estimate confidence in the evidence for a level configuration as speculative.
l From a least-squares fit to the adopted Eγ's, except where noted otherwise.
m The Jπ assignments start with the following model-independent data: Jπ(342)=5– based on HF(α)=2.01 7 from 5–. J(g.s.)=2, a measured value (see 1976Fu06) with π(g.s.)=+ from an E1, M1+E2, M1, M1 cascade from the 342 level. Jπ(136)=3– can then be established based on an M1+E2, M1+E2 cascade from the 342 level, and an E1 to the 2+ g.s. Jπ(179)=4– follows from an M1+E2 from 342 and an M1+E2 to 136, and Jπ(86)=3+ based on an E1 from 179 and an M1+E2 to g.s. The g.s., 86 level, and 136 levels are bandheads of Kπ=2+, 3+, and 3– bands, respectively. The 342 level is a Kπ=5– bandhead. Other adopted Jπ's are based on band assignments of 1990Ho02, in addition to transition multipolarities as noted. In general, Jπ assignments of 1 to 4 are based on feeding by primary γ's in thermal (n,γ), Jπ=1– to 4– assignments are based on feeding by primary γ's in average resonance capture and Jπ=1– to 3– assignments are based on feeding by primary γ's in average resonance capture and from a 2+ resonance.
n T_{1/2}=50 ns for a level at E=300, from αγ(t) (1966As06).

γ(²³⁸Np)

E(level)	Eγ [†]	Iγ [‡]	Mult.	δ ^d	α	Comments
26.4266	26.43 2	100	M1+E2	0.097 6	333 12	
62.330	35.90 2	83 17	M1+E2	0.130 3	133.6 24	
	62.33 3	100	E2		136.0	
86.6738	24.37 2	0.28 4	M1(+E2)	≤0.03	326 8	
	60.243 4	29.6 22	M1+E2	0.089 23	23.5 7	
	86.676 2	100 17	M1+E2	0.10 3	7.95 18	

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued)
 $\gamma(^{238}\text{Np})$ (continued)

E(level)	E $\gamma^{\dagger}$	I $\gamma^{\ddagger}$	Mult.	δ^d	α	Comments
106.155	43.84 3	100	M1+E2	0.111 5	65.3 12	
	79.74 3	32 7	E2		42.0	
121.645	34.97 3	93 13	M1		110.8	
	59.31 4	9.3 15	M1		23.4	
	95.22 2	52 7	(M1)		5.90	
	121.69 4	100 15	E2		6.04	
136.0450	49.372 2	100.0 16	E1		0.820	B(E1)(W.u.)=1.1×10 ⁻⁴ .
	73.715 4	5.7 18	E1		0.285	B(E1)(W.u.)=2.0×10 ⁻⁶ .
	109.614 ^{a e} 4	10 ^{a e} 4	E1+M2 ^a	0.026 6	0.138 19	B(E1)(W.u.)=1.0×10 ⁻⁶ .
	136.045 10	7.9 13	E1		0.247	B(E1)(W.u.)=4.3×10 ⁻⁷ .
165.532	43.98 4		M1+E2	0.13 4	68 8	
	139.05 2		[E2]		3.41	
179.154	43.11 3	23 4	M1+E2	0.08 2	65 3	
	92.486 7	100 21	E1		0.1574	
	152.69 ^{c f}	≤174 ^f	(E1) ^c		0.189	
182.8775	46.84 3	0.80 12	M1+E2	0.14 4	56 6	
	95.7 6					
	156.452 2	30.4 16	E1		0.1784	
	182.876 2	100 12	E1		0.1239	
215.522	32.67 3	3.2 5	M1(+E2)	≤0.025	136.4 22	
	79.483 17	21 4	E2(+M1)	≥4	41.7 12	
	153.192 12	53 6	(E1)		0.187	
	189.099 6	54 5	E1		0.1146	I γ : I γ /I γ (216 γ)=0.46 11 in α decay.
	215.517 5	100 5	E1		0.0847	
217.949	35.07 3	3.6 8	E2		2210	
	217.966 20	100	M2		10.57	
218.7	52.98 ^g		M1+E2	0.17 2	40.1 19	
232.828	53.70 7	20 3	M1+E2	0.271 4	48.3 9	
	96.82 5	17 3	E2		16.87	
	111.197 15	100 21	[E1]		0.0974	
243.959	243.959 4	100	M1+E2	0.10 1	1.93	
250.33	250.33 [#] 3	100 [#]				
250.39	223.89 10	100	(E1)		0.0776	
	250.40 [#] 4	≤148 [#]				
258.853	43.32 3	1.59 24	M1+E2	0.391 20	156 9	
	75.97 7	2.2 4	E2		52.9	
	122.76 7	6.6 3	[M1]		13.43	
	152.69 ^{c f} 3	≤114 ^f	^c			
	196.46 [§] 10	17 [§] 9				
	232.433 8	100 17	E1		0.0712	
275.519	153.870 9	100	M1+E2		4.7 25	
277.641	251.25 4	61 15	E2+(M1)	≥4.6	0.39 4	
	277.633 19	100				
297.03	131.49 8	100				
	190.88 5	39 22				
298.368	54.40 4	0.66 10	E2		262	
	236.025 11	100 8	M1		2.13	
	271.953 11	72 5	M1		1.437	
	298.38 4	9.2 10	M1		1.111	
299.23	237.02 10	100 5				
	272.75 7	81 18				
	299.20 14	60 30				
299.788	116.90 2	100				
300.68	84.9 2					
	117.2 ^h 6					
	164.67 7					
300.743	67.93 3	59 5				
	121.3 6					
	135.19 2	100 6				
	139.05 2	≤2.1				
	194.61 2	21.0 7				
312.704	53.88 4	10.0 18	M1+E2	0.22 4	42 5	
	97.22 5	32 4	E2		16.54	

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued)
 $\gamma(^{238}\text{Np})$ (continued)

E(level)	E $\gamma^{\dagger}$	I $\gamma^{\ddagger}$	Mult.	δ^d	α	Comments
312.704	151.07 5	=300			16.7	E γ , I γ : seen only in α decay and placed by the authors from the 313 level. The placement is perhaps questionable since I γ /I γ (176 γ)=3.0 16 in α decay, and this ratio for (n, γ) would give I γ (151 γ)=0.5 3 per 100 neutron captures, an intensity large enough for the γ line to have been seen.
	176.62 5	100 18				
	250.36# 3	$\leq 241^{\#}$				
315.063	82.232 4	100 14	E1+M2	0.024 +6-7	0.32 6	
	135.918 7	35 5				
	179.00 3	33 7				
324.314	108.792 7	100				
325.210	107.263 6	100	M1		4.18	
	142.328 10	68 20				
328.6	163.25 ^b g 2	b	b			
342.439	66.919 5	97 3	E1		0.368	
	109.614 ^{ae} 4	$\leq 120^{\text{ae}}$	a			
	163.26 ^b 2	100 ^b 6	M1+E2 ^b	6.26 7	1.86	
	206.37 ^s 2	10.2 ^s 12				
352.46	52.60 5	1.8 5				Mult.: 1990Ho02 assign mult=E2 in (n, γ), and the placement requires $\Delta J=2$, $\Delta\pi=\text{no}$; however, the ce ratios suggest an M1 component. One gets $\delta=1.44$ 8, 0.27 3, and 0.93 7 from L1/L2, L3/L2, and M1/M2, respectively. M3/M2 gives $\delta>0.25$.
	93.67 5	100				
367.26	184.38 3	100				
373.684	48.50 3	5.0 10	(M1)		42.3	
	155.731 11	100				
376.70	117.8 6					
	270.55 6					
380.60	130.215 12		E2 (+M1)	≥ 7.9	4.56 9	
389.4	113.7 6					
	170.50 1					
395.198	289.04 8	67 15	M1+E2	0.9 3	0.77 19	
	332.868 16	100	E2 (+M1)	≥ 5.9	0.155 10	
407.59	132.6 6					
	174.76 6					
417.641	295.984 15	100 8	E2		0.208	
	330.966 19	46 13				
	391.27 3	59 5	M1+E2	1.34 +26-19	0.25 4	
	417.60 ^{&f} 6	$\leq 4.9^{\text{f}}$	&			
433.716	174.88 3	23 17	E1		0.1375	
	218.17 3	42 8				
	297.672 15	100 12	E1		0.0410	
442.23	74.975 2					
459.6	117.2 ^h 6					
497.20	281.79 10	100	M1+E2	1.0 +5-3	0.77 21	
	314.31 ^{@f} 3	$\leq 176^{\text{f}}$	@			
523.83	358.25 4	79 7				
	417.60 ^{&f} 6	$\leq 7.2^{\text{f}}$	&			
	461.59 9	84 14	M1+E2	0.93 +25-20	0.21 4	
	497.49 5	100 9				
529.857	217.26 7	100 10	E2		0.589	
	314.31 ^{@f} 3	$\leq 70^{\text{f}}$	@			
	346.98 1	37 10	M1+E2	0.7 4	0.53 15	
543.24	310.40 8	9 5				
	364.09 4	100				
567.023	334.205 13	42 12	E2		0.1441	
	351.37 8	52 8	E2		0.1247	

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued) $\gamma(^{238}\text{Np})$ (continued)

E(level)	$E_{\gamma}^{\dagger}$	$I_{\gamma}^{\ddagger}$	Mult.	δ^d	α
567.023	384.12 4	29 3	M1+E2	0.93 16	0.34 5
	430.96 3	100 12	M1+E2	0.87 22	0.26 5
646.76	584.47 5	63 16			
	620.28 6	100 13	M1+E2	0.97 21	0.093 15
	646.75 7	87 8	E2 (+M1)	≥ 1.9	0.040 12

[†] From (n, γ) and α decay. No details are available as to the γ energy involved in the measurement.

[‡] Branching ratios are from (n, γ), except where from α decay as noted, or where the level is populated only in α decay.

[§] From α decay. Not seen in (n, γ).

[#] From (n, γ) one has $E_{\gamma}=250.40$ 4 with mult=E1 or E2, doubly placed from the 250.39 and 313 levels, and from α decay one has $E_{\gamma}=250.33$ 3 doubly placed from the 250.32 and 313 levels. All placements involve $\Delta\pi=\text{yes}$, except for the 250.39 level. The evaluators adopt a weighted average of 250.36 3 for placement from the 313 level, and the branchings for all placements are upper limits.

[@] From (n, γ) one has $E_{\gamma}=314.31$ 3 with mult=M1+E2 doubly placed from the 497 and 530 levels. Both placements involve $\Delta\pi=\text{no}$.

[&] In (n, γ) one has $E_{\gamma}=417.60$ 6 with mult=M1 doubly placed from the 418 and 524 levels. Both placements involve $\Delta\pi=\text{no}$.

^a In (n, γ) one has $E_{\gamma}=109.614$ 4 with mult mainly E1 doubly placed from the 136 and 342 levels. The transition is also seen in α decay. From a comparison of the branchings in (n, γ) and α decay the intensity can be divided between the two placements. Most of the intensity belongs with the 136 level, and mult=E1 can be assigned to this placement. Placement from the 342 level involves $\Delta\pi=\text{no}$.

^b In α decay one has $E_{\gamma}=163.25$ 2 doubly placed from the 329 and 342 levels. $E_{\gamma}=163.29$ 5 is reported in (n, γ) with mult=M1+E2, and placed from the 342 level only. From a comparison of branchings from the two sources, all the intensity of the 163 γ in α decay can be accounted for by placement from the 342 level.

^c In (n, γ) one has $E_{\gamma}=152.69$ 3 with tentative mult=E1 doubly placed from the 179 and 259 levels. The same transition is also seen in α decay with the same placements. Both placements involve $\Delta\pi=\text{yes}$.

^d From $^{237}\text{Np}(n,\gamma)$ E=th.

^e Multiply placed; intensity suitably divided.

^f Multiply placed; undivided intensity given.

^g Placement of transition in the level scheme is uncertain.

^h Multiply placed.

Adopted Levels, Gammas (continued)

Adopted Levels, Gammas (continued)

Adopted Levels, Gammas (continued)

$$^{238}_{93}\text{Np}_{145}$$

²⁴²Am α Decay (141 y) 1990Ho02,1979Ba67

Parent ²⁴²Am: E=48.63 5; Jπ=5-; T_{1/2}=141 y 2; Q(g.s.)=5588.50 25; %α decay=4.59×10⁻¹ 12.

²⁴²Am-Q(α): From 2012Wa38.

²⁴²Am-%α decay: %α=0.459 12.

The α decay branching of ^{242m}Am is 0.459% 12; 98.54% decays by an isomeric transition (IT).

²³⁸Np Levels

E(level) [†]	Jπ [#]	T _{1/2}	Comments
0.0	2+		
26.450 [§] 16	3+		
62.344 [§] 22	4+		
86.651 [§] 15	3+		
106.13 [§] 3	5+		
121.659 [§] 23	4+		
136.021 14	3-	6.0 ns	T _{1/2} : from αγ(t) of 1966As06.
161.68 4	6+		
165.518 23	5+		
179.145 18	4-		
182.885 16	2-		
215.503 16	3-		
218.7 6	(6+)		
232.82 3	5-		
250.33 3	(1+)		
258.83 3	4-		
275.505 23	5+		
297.01 5	(6-)		
299.25 6	(3+)		
300.726 25	(6-)		
300.79 5	1-, 2, 3, 4-		
312.75 5	5-		
328.77? 3	6+		
334.8? [‡]	1- to 3-		
342.390 18	5-		
374.7? 10	(5+)		E(level): from (d,p).
376.68 7	(6-)		
389.2 6	7+		
397.3 [‡] 15			
407.58 7	6-		
459.6 [‡] 6	(6+)		
470 [‡] 2	1- to 4-		
484 [‡] 3	7-		
525.3 [‡] 15	(7+)		
578.7 [‡]			

[†] From a least-squares fit to the Eγ data, except where noted otherwise.

[‡] From Eα and Q(α).

[§] Rounded-off values from adopted levels.

[#] From adopted levels.

α radiations

Eα [@]	E(level)	Iα ^{±a}	HF [†]	Comments
4974.7 [§]	578.7	=0.002 [§]	≈2400	Eα: from 1979Ba67. Not reported in 1990Ho02. HF: HF=2.4×10 ³ 3.
5027.2 15	525.3	0.02 1	≈700	Eα: weighted average of 5026.9 keV 15 from 1979Ba67, and 5031 keV 5 from 1990Ho02.
5068 3	484	0.25 7	88 30	HF: symmetrized uncertainty. HF=540 +509-210. Eα: unweighted average of 5064.0 keV 15 from 1979Ba67, and 5072 keV 3 from 1990Ho02.
5082 [§] 2	470	0.03 [§]	830 110	Eα: from 1979Ba67. Not reported in 1990Ho02.
5091.8 6	459.6	0.21 7	158 60	Eα: weighted average of 5088.2 keV 15 from 1979Ba67 and 5093 keV 4 from 1990Ho02.
5143.0 13	407.58	5.6 2	11.1 16	Eα: 5141.4 keV 5 (1979Ba67), 5144.4 keV 9 (1990Ho02).
5153.1 [§] 15	397.3	0.02 [§]	3600 500	Eα: from 1979Ba67. Not reported in 1990Ho02.

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²⁴²Am α Decay (141 y) 1990Ho02,1979Ba67 (continued)

α radiations (continued)

Eα [@]	E(level)	Iα ^{‡a}	HF [†]	Comments
5173.31 [#] 26	376.68	≤0.04 [#]	≥2000	
5175.3 [#] 10	374.7?	≤0.04 [#]	≥2100	
5207.06 25	342.390	89.0 7	1.79 24	Eα: 5206.6 keV 5 (1979Ba67), 5208.4 keV 8 (1990Ho02).
5214.5 ^{§b}	334.8?	0.03 [§]	5900 800	Eα: reported only in 1979Ba67 as a questionable line.
5248.01 ^{&} 25	300.726	≤1.1 ^{&}	≥220	
5248.12 ^{&} 26	300.79	≤1.1 ^{&}	≥220	
5249.50 ^{&} 26	299.25	≤0.04 ^{&}	≥6100	
5251.67 ^{&} 26	297.01	≤0.04 ^{&}	≥6300	Eα: 4251.67 corrected to 5251.67.
5272.85 25	275.505	1.1 1	420 41	Eα: =5273 keV (1979Ba67), 5271 keV 3 (1990Ho02).
5314.83 25	232.82	0.6 1	376 70	Eα: 5313.3 keV 10 (1979Ba67), 5313.6 keV 10 (1990Ho02).
5331.85 25	215.503	0.15 10	=11000	Eα: 5331 keV 5 (1990Ho02). Not reported in 1979Ba67. HF: symmetrized uncertainties. HF=6×10 ³ +14-3.
5367.61 25	179.145	1.1 2	1500 400	Eα: 5367.0 keV 10 (1979Ba67), 5369.1 keV 18 (1990Ho02).
5410.03 25	136.021	1.0 2	2900 800	Eα: 5409.1 keV 10 (1979Ba67), 5412.4 keV 21 (1990Ho02).
5458.58 [§] 25	86.651	0.14 [§]	3.9×10 ⁴ 5	Eα: 1979Ba67 report 5458.1 keV 15. Not reported in 1990Ho02. HF: uncertainty in HF does not include the contribution from Iα.
5517.79 [§]	26.450	≤0.006 [§]	≥1.7×10 ⁶	Eα,Iα: 1979Ba67 report 5517.1 keV but this α peak may include a contribution from ²⁴² Cm α decay not reported in 1990Ho02. Eα: uncertainty of 0.25 keV omitted in view of general footnote for Iα.

[†] r₀=1.508 5.

[‡] From 1990Ho02, except where noted otherwise. Uncertainties are not given in 1979Ba67; however, their values agree well with those given in 1990Ho02, except for the branch to the 300-keV level (or doublet).

[§] From 1979Ba67, not reported in 1990Ho02.

[#] 1979Ba67 report a doublet with E=5173 and 5173.5 15 with Iα=0.04. One of these lines corresponds to the 376.71 6 level. The other may correspond to a 374.7 keV 10 level reported in (d,p).

[@] From Q(α) and E(level), except where noted otherwise. Experimental values have been measured in 1990Ho02 and 1979Ba67 and are given in comments. Note that for 1979Ba67, the authors' original values have been decreased by 0.2 keV, as recommended in 1991Ry01, to account for changes in calibration energies. The authors assign Δ(Eα)=0.5 keV to the two most intense lines, and state that uncertainties do not exceed 1.0- to 1.5 keV for most of the other lines. Based on this statement, the evaluators have assigned uncertainties of 1.0 keV for lines with Iα between 0.6- and 1.2%, and 1.5 keV for lines with Iα between 0.02 and 0.2. No uncertainties have been assigned to the two lines with Iα<0.01%.

[&] Eα=5249.8 keV 15 (with %Iα=0.04) in 1979Ba67 gives E(level)=298.9 keV 15. Based just on energy, this α branch could correspond to those to the 299.24 keV and possibly to the 297.04- or 300.65 keV levels. The branch with E=5248.1 keV 12, is a weighted average of 5248.0 keV 15, from 1979Ba67, and 5248.4 keV 22 from 1990Ho02, gives E(level)=300.7 keV 12 which could correspond to the the 299.24 level. 1979Ba67 give Iα=0.11% and 1990Ho02 give 1.0% 1 for this branch. 1990Ho02 assign the first branch to the 297.04 level, and the second to the 299.24 and 300.65 levels. Evaluators suggest that the 300.755-keV level also may be fed.

^a For α intensity per 100 decays, multiply by 4.59×10⁻³ 12.

^b Existence of this branch is questionable.

γ(²³⁸Np)

Eγ [‡]	E(level)	Iγ ^{‡d}	Mult. [†]	δ [†]	α	Comments
(24.31 ^b)	86.651					
*26.32 3		1.36 10	E1 (+M2)			Iγ: It probably contains contribution from contamination with ²⁴¹ Am alpha decay. Mult.: the multipolarity is mainly E1 since I(γ+ce) should be <100. This limit gives δ(M2/E1)<0.05.
(26.44 ^b)	26.450					
(32.62 ^b)	215.503					
(35.01 ^b)	121.659					
(35.89 ^b)	62.344					
(43.12 ^b)	179.145					
(43.33 ^b)	258.83					
(43.79 ^b)	106.13					
(43.86 ^b)	165.518					
(46.87 ^b)	182.885					
49.35 2	136.021	29.1 9	E1		0.828	
(53.2 ^b)	218.7					

Continued on next page (footnotes at end of table)

²⁴²Am α Decay (141 y) ¹⁹⁹⁰Ho02,1979Ba67 (continued)

 $\gamma(^{238}\text{Np})$ (continued)

$E\gamma^{\ddagger}$	E(level)	$I\gamma^{\ddagger d}$	Mult. [†]	$\delta^{\ddagger}$	α	Comments
53.69 3	232.82	0.45 6	M1+E2	0.271 4	50.1 4	
(53.92 ^b)	312.75					
57.54 ^c 6	179.145	0.21 5				
(59.32 ^b)	121.659					
60.13 6	86.651	1.19 11	M1+E2	0.08 2	24.5 3	
(62.34 ^b)	62.344					
66.89 2	342.390	3.25 10	E1		0.369	
67.93 3	300.726	0.87 7				E γ : duplicated γ ray, the unplaced one has been omitted.
73.66 2	136.021	1.71 12	E1		0.290	
(75.95 ^b)	258.83					
(79.48 ^b)	215.503					
(79.68 ^b)	106.13					
84.9 2	300.79	0.21 7				
86.65 2	86.651	4.97 15	M1+E2	0.112 3	8.56 1	
^x 89.60 5		0.29 7				
92.52 3	179.145	0.61 7				
93.82 3	215.503	0.79 9				
(95.21 ^b)	121.659					
95.7 6	182.885					
(96.80 ^b)	232.82					
98.0 6	312.75					
109.59 ^e 2	136.021	$\leq 4.3^{\S e}$	E1+M2	0.026 7	0.142 20	
109.59 ^e	342.390	$\leq 4.3^{\S e}$				
111.16 5	232.82	0.55 9	(E1)		0.099	
113.7 6	389.2					
^x 114.3 6						
117.2 ^g 6	300.79					
	459.6					
117.8 6	376.68					
121.3 6	300.726					
(121.66 ^b)	121.659					
122.5 6	258.83					
126.83 ^c 5	342.390	0.028 14				
131.49 8	297.01	0.059 31				
132.6 6	407.58					
135.19 2	300.726	1.47 8				
136.03 2	136.021	2.05 6	E1		0.251	
139.05 ^e 2	165.518	$\leq 0.031^{\textcircled{e}}$				
	300.726	$\leq 0.031^{\textcircled{e}}$				
151.07 4	312.75	0.018 4				
152.69 ^e 2	179.145	$\leq 0.158^{\#e}$				
	258.83	$\leq 0.158^{\#e}$				
(153.16 ^b)	215.503					
153.85 2	275.505	0.721 22				
156.46 2	182.885	0.059 10	E1		0.181	
^x 160.61 2		0.09 4				
163.25 ^{fh} 2	328.77?	$\leq 0.33^{\&f}$				
	342.390	3.34 ^{&f} 19	M1+E2	6.6 +24-12	1.90 5	
164.67 7	300.79					
^x 165.97 15		0.010 5				
170.50 1	389.2	0.136 10				
174.76 6	407.58	0.038 10				
176.68 15	312.75	0.006 3				
182.86 2	182.885	0.199 7	E1		0.125	
189.01 3	215.503	0.059 10	E1		0.116	
190.88 5	297.01	0.023 5				
194.61 2	300.726	0.308 10				
196.46 10	258.83	0.021 10				E γ : not seen in (n, γ), but assigned to this level in 1990Ho02.
206.37 2	342.390	0.34 4				
213.20 ^c 14	275.505	0.012 4				
215.52 2	215.503	0.129 21	E1		0.085	

Continued on next page (footnotes at end of table)

^{242}Am α Decay (141 y) 1990Ho02,1979Ba67 (continued) $\gamma(^{238}\text{Np})$ (continued)

$E\gamma^{\ddagger}$	E(level)	$I\gamma^{\ddagger d}$	Mult. [†]	α
232.40 3	258.83	0.122 7	E1	0.0719
^x 233.69 10		0.028 7		
237.02 10	299.25	0.010 5		
238.53 ^c 5	300.79	0.0035 18		
250.33 ^{a f} 3	250.33	0.110 ^{a f} 6		
250.33 ^{a f}	312.75	≤ 0.024 ^{a f}		
270.55 6	376.68	0.0063 18		
272.75 7	299.25	0.0081 18		
280.04 ^c 5	342.390	0.0130 14		
299.20 14	299.25	0.006 3		

[†] From adopted gammas.

[‡] From 1990Ho02, except where noted otherwise. The $I\gamma$ are per 100 α decays, obtained by measuring the intensity ratio at saturation for the 984.45-keV γ in ^{238}Np β^- decay and the 163.25-keV γ in ^{242}Am (141y) α decay. The uncertainties given are relative values. For absolute uncertainties add 14.3% in quadrature.

[§] 1990Ho02 report $I\gamma=4.0$ 3 for a 109.59 keV 2 transition doubly placed from the 136- and 342-keV levels.

[#] 1990Ho02 report $I\gamma=0.150$ 8 for a 152.79-keV 2 transition doubly placed from the 179- and 259-keV levels. The energy is probably a misprint. The authors report $E=152.69$ keV 3 for the same transition in (n, γ). From E(level) differences, excluding this transition, one obtains $E\gamma=152.733$ keV 9 for placement from the 179-keV level, and 152.67 keV 4 for placement from the 259-keV level.

[@] 1990Ho02 report $I\gamma=0.024$ 7 for a 139.05 keV 2 transition doubly placed from the 166- and 300.755 keV levels.

[&] 1990Ho02 report $I\gamma=3.50$ 10 for a 163.25 keV 2 transition doubly placed from the 329- and 342-keV levels. From $I\gamma/I\gamma(66.9\gamma)$ in (n, γ), one expects $I\gamma(163\gamma)=4.0$ 8 for placement from the 342-keV level. This leaves $I\gamma\leq 0.32$ for placement from the 329-keV level. Evaluators adopt $I\gamma(163.25\gamma)=3.34$ 19 and ≤ 0.32 for each placement, respectively.

^a 1990Ho02 report $I\gamma=0.122$ 10 for a 250.33 keV 3 transition doubly placed from the 250.3- and 313-keV levels. From $I\gamma/I\gamma(176\gamma)\leq 2.6$ from the 313-keV level in (n, γ), one obtains $I\gamma(250\gamma \text{ from } 313)\leq 0.024$, and thus $I\gamma(250\gamma \text{ from } 250)=0.110$ 16.

^b γ transition included on the basis of (n, γ) results in 1990Ho02. $E\gamma$ is from level-energy difference.

^c This γ unplaced in 1990Ho02.

^d For absolute intensity per 100 decays, multiply by 4.59×10^{-3} 12.

^e Multiply placed; undivided intensity given.

^f Multiply placed; intensity suitably divided.

^g Multiply placed.

^h Placement of transition in the level scheme is uncertain.

^x γ ray not placed in level scheme.

²⁴²Am α Decay (141 y) 1990Ho02,1979Ba67 (continued)

Decay Scheme

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

²⁴²Am α Decay (141 y) 1990Ho02,1979Ba67 (continued)

Decay Scheme (continued)

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

5- 48.63 141 y
²⁴²Am₁₄₇ %α=4.59×10⁻¹ 12
Q_α(g.s.)=5588.50²⁵

$^{237}\text{Np}(\text{n},\gamma)$ E=th: Secondary γ 's 1990Ho02

Secondary γ -rays following thermal neutron capture in ^{237}Np were measured with the curved-crystal spectrometers **GAMS1** and **GAMS2/3** at the **ILL**. The conversion electrons following thermal neutron capture in ^{237}Np have been studied with the **BILL** β -spectrometer at the **ILL**.
E(n)=thermal.

 ^{238}Np Levels

E(level) [†]	J π [‡]	T _{1/2}	Comments
0.0	2+	2.117 d 2	T _{1/2} : from adopted levels.
26.427 2	3+		
62.330 3	4+		
86.674 3	3+		
106.164 14	5+		
121.645 16	4+		
136.044 5	3-		
165.59 3	5+		
179.156 6	4-		
182.878 3	2-		
215.521 4	3-		
217.949 10	0-		
218.57? 8	6+		
232.823 13	5-		
243.959 4	1+		
250.385 14	2-		
258.855 8	4-		
275.515 11	5+		
277.642 17	2+		
298.368 8	3+		
299.789 19	1-		
312.707 19	5-		
315.068 7	(4)+		
324.314 8	4-		
325.210 9	1-		
342.396 19	5-		
352.46 4	3-		
367.26 3	2-		
373.684 14	1-		
380.600 9	3-		
395.198 16	5+		
417.639 13	2+, 3+		
433.719 12	3+, 4+		
442.24 3	4-		
473.3 4	(3-, 4-)		
497.20 3	2-, 3-		
523.87 3	5+, 4+		
529.857 9	3-		
543.23 3	4-		
567.021 15	3-		
646.76 3	2+, 3+		

[†] From 1990Ho02.

[‡] From adopted levels.

²³⁷Np(n,γ) E=th: Secondary γ's 1990Ho02 (continued)

γ(²³⁸Np)

In analyzing their ce data, 1990Ho02 used theoretical values directly from 1968Ha53. The ce(L2) subshell binding energy used by 1968Ha53 is incorrect, and consequently the values of α(L2) for Z=93 in that tabulation are also incorrect. The internal conversion program BRICC used by the NSDD network, and available from BNL, contains corrected values. Using this program, the evaluators have reanalyzed the ce data of 1990Ho02. None of the multipolarity assignments are changed as a result of this reanalysis, but several of the mixing ratios are revised from values given in 1990Ho02 multipolarity assignments is changed as a result of this reanalysis..

Eγ [§]	E(level)	Iγ ^{§h}	Mult.#	δg	α [‡]	Comments
24.37 ^d 2	86.674	0.0064 ^d 10	M1 (+E2)	≤0.03 [†]	326 8	δ: From M2/M1=0.13 2.
^x 25.93 ^d 2		2.50 ^d 25	E1		4.41	M1:M2:M3=100:126 11:233 20.
26.43 ^d 2	26.427	0.104 ^d 15	M1+E2	0.097 [†] 6	333 12	δ: From M1:M2:M3=100:34 2:20 1.
^x 27.58 ^d 4		0.038 ^d 6	M1+E2	0.096 [†] 4	286 7	δ: From M2/M1=0.31 1.
32.67 ^d 3	215.521	0.026 ^d 4	M1 (+E2)	≤0.025 [†]	136.4 22	δ: From M2/M1=0.13 1.
34.97 ^d 3	121.645	0.082 ^d 11	M1+E2	0.097 [†] 3	130.7 23	δ: From M2/M1=0.25 1.
35.07 ^d 3	217.949	0.0071 ^d 10	E2		2210	M3/M2=1.10 3.
35.90 ^d 2	62.330	0.0109 ^d 15	M1+E2	0.130 [†] 3	133.6 24	δ: From M1:M2:M3=100:35 1:19 1.
^x 37.371 ^d 2		0.26 ^d 3	M1+E2	0.094 [†] 4	104.5 19	α(M1)exp=5.9 7 Evaluators believe emcl=15.9 7 (typographical error). δ: From M1:M2:M3=100:28 1:6.1 4. δ: From L2/L1=0.17 2; M1/L1=0.25 1. L1:L2:L3=100:123 17:91 11; M1/L1=0.59 7; M1:M2:M3=37 11:100:19 3. Mult.: from L-subshell ratios. The M-subshell values give inconsistent results. M1/M2 yields δ=0.60, M3/M2 yields δ=0.056, and M1/L1 requires an E4 component.
43.11 ^d 3	179.156	0.044 ^d 7	M1+E2	0.08 [†] 2	65 3	δ: From L1:L2:L3=100:21 1:9.0 5; M1/L1=0.31 2; M1:M2:M3=100:23.6 12:8 1.
43.32 ^d 3	258.855	0.0046 ^d 7	M1+E2	0.391 20	156 9	Mult.: authors' entry of I(α(M1))=236 12 relative to I(α(M1))=100 in table ii is a misprint. The evaluators assume this should be 23.6 12.
43.84 ^d 3	106.164	0.075 ^d 11	M1+E2	0.111 [†] 5	65.3 12	δ: From L1:L2:L3=100:20 1:11 1; M1/L1=0.35 2; M1:M2:M3=100:64 16:13 2. δ: M2/M1 yields an inconsistent value of 0.26 5 and is not used in arriving at the adopted value.
43.98 ^d 4	165.59	0.058 ^d 8	M1+E2	0.13 [†] 4	68 8	δ: From L2/L1=0.17 1; M1/L1=0.20 1; M1:M2:M3=100:17 1:18 1. L3/L2=0.37 4; M2/L2=0.44 6; M3/M2=0.49 5. Mult.: authors' entry of I(ce(M1))=100 in table ii is probably a misprint. This entry should be blank.
^x 45.197 4		0.13 3				
46.84 ^d 3	182.878	0.111 ^d 17	M1+E2	0.14 [†] 4	56 6	δ: From L2/L1=0.17 1; M1/L1=0.20 1; M1:M2:M3=100:17 1:18 1. L3/L2=0.37 4; M2/L2=0.44 6; M3/M2=0.49 5.
^x 46.97 ^d 3		0.0016 ^{d f} 2	E2		533	Mult.: authors' entry of I(ce(M1))=100 in table ii is probably a misprint. This entry should be blank.
48.50 [@] 3	373.684	0.0111 [@] 17	[M1]		42.3	α(L1)exp=0.19 1.
49.372 2	136.044	8.57 14	E1		0.820	L1:L2:L3=13 1:100:64 3; M2/L2=0.32 2; M1:M2:M3=24 3:100:76 11.
52.60 ^d 5	352.46	0.0035 ^{d f} 6				Mult.: the authors assign mult=E2 and place the transition from a 3- to a 1- level; however, the data are not consistent with pure E2. All the ce ratios except M3/M2 require an M1 admixture; however, the deduced δ values are not self consistent. One gets δ>0.25 from M3/M2, and 1.44 8, 0.27 3, and 0.93 7 from L1/L2, L3/L2, and M1/M2, respectively.

Continued on next page (footnotes at end of table)

$^{237}\text{Np}(n,\gamma)$ E=th: Secondary γ 's 1990Ho02 (continued) $\gamma(^{238}\text{Np})$ (continued)

$E\gamma^{\S}$	E(level)	$I\gamma^{\S h}$	Mult.#	δg	$\alpha^{\ddagger}$	Comments
52.98 ^{d k} 7	218.57?	0.029 ^d 4	M1+E2	0.17 [†] 2	40.1 19	δ : From L2/L1=0.18 2; M1/L1=0.20 1; M2/M1=1.17 7. E γ : unplaced by authors. Added by evaluators on the basis of E(level)=218.7 6 for the 6+ member of the band whose 5+ member is at 165.59.
^x 53.562 9		0.15 5	E1+M2	0.022 [†] 7	1.27 45	δ : From α (L1)exp=0.46 16. Mult.: 1990Ho02 assign (E1).
53.70 ^d 7	232.823	0.038 ^d 6	M1+E2	0.271 4	48.3 9	L1:L2:L3=100:50 2:29 1; M1/L1=0.30 2; M2/M1=0.56 6.
						δ : from α (M)exp=9.20 17 and α (N+...)exp=3.22 6.
53.88 ^d 4	312.707	0.017 ^d 3	M1+E2	0.22 [†] 4	42 5	Mult.: From L1:L2:L3=100:37 4:7 2; M1/L1=0.28 4; M2/M1=0.71 15.
						δ : weighted average of 0.23 2, 0.13 2, and 0.33 5 from L2/L1, L3/L1, and M2/M1, respectively.
^x 54.13 ^d 4		0.075 ^d 11	M1+E2	0.06 [†] 1	31.5 6	δ : From L1:L2:L3=100:19 1:1.8 2; M1/L1=0.27 1; M2/M1=0.051 14.
54.40 ^d 4	298.368	0.0040 ^{d f} 6	E2		262	L3/L2=0.96 3; M2/L2=0.20 2; M3/M2=0.89 11.
^x 59.211 25		0.147 21	M1+E2	$\leq 0.10^{\ddagger}$	24.3 9	δ : From M3/L3=0.31 5; M3/M2=0.49 10; α (M2)exp=0.62 11.
59.31 [@] 4	121.645	0.0082 [@] 13	[M1]		23.4	
60.243 4	86.674	0.68 5	M1+E2	0.089 [†] 23	23.5 7	δ : From L1:L2:L3=100:17 1:2.5 1; M1/L1=0.25 2; M1:M2:M3=100:14 1:3.7 4; α (L1)exp=11.8 8.
^x 62.18 [@] 5		0.07 [@] 3	[M1]		20.4	
62.33 ^d 3	62.330	0.0132 ^{d f} 20	E2		136.0	L1:L2:L3=3.1 4:100:86 10; M2/L2=0.31 2; M3/M2=0.80 6.
^x 65.10 ^d 4		0.017 ^d 3	M1+E2	0.28 [†] 1	24.6 6	δ : From L1:L2:L3=100:37 4:23 2.
66.919 5	342.396	0.23 3	E1		0.368	α (L2)exp<1.2. Mult.: the authors show mult=(E1,E2); however, α (L2)exp is consistent only with E1(+M2) with δ <0.24.
^x 67.17 [@] 4		0.028 [@] 14	[M1]		16.28	
^x 70.15 ^d 2		0.0027 ^{d f} 4	E2		77.3	L3/L2=0.76 10.
^x 72.873 10		0.66 7	E1		0.294	α (L1)exp=0.09 2.

Continued on next page (footnotes at end of table)

$^{237}\text{Np}(n,\gamma)$ E=th: Secondary γ 's 1990Ho02 (continued) $\gamma(^{238}\text{Np})$ (continued)

$E\gamma^{\S}$	E(level)	$I\gamma^{\S h}$	Mult. #	δ^g	$\alpha^{\ddagger}$	Comments
$^{*}73.01\ 8$						L1:L2:L3=100:84 8:78 7; M1/L1=0.25 2; M1:M2:M3=100:43 10:40 9. Mult.,I γ : there is an inconsistency in the authors' I γ , ce, and mult. In the authors' table I, I γ is given as 0.019 7 based on mult=M1 and $\alpha(L1)(M1)=9.1$, implying I(ce(L1))=0.172. In table ii, however, the mult is given as E1+M2 with $\delta=0.022$, based on L- and M-subshell ratios, and thus $\alpha(L1)(E1/M2)$ would be 0.172. If the above deduced I(ce(L1)) is correct, then for mult=E1+M2 one would get I γ =1.0, a value large enough that it would have been seen in the photon spectrum. Note that the ce data are reasonably consistent with M1+E2. The L2/L1, L3/L1, M2/M1, and M3/M1 values giving $\delta=0.51\ 3$, $0.61\ 3$, $0.31\ 6$, and $0.40\ 5$, respectively. With mult=M1+E2 and $\delta=0.4$, I(ce(L1))=0.172 gives I γ =0.021. In view of these discrepancies, the evaluators have not given I γ or mult for this unplaced transition.
73.715 4	136.044	0.49 15	E1		0.285	L1:L2:L3=100:86 10:61 8. $\alpha(L1)\text{exp}=0.08\ 2$. Mult.: 1990Ho02 assign mult=E1+M2 with $\delta=0.022$; however, the evaluators' reanalysis indicates that no M2 admixture is required.
$^{*}74.679\ 2$		0.38 11	E1		0.276	$\alpha(L1)\text{exp}<0.18$.
74.975 2	442.24	0.27 7				
$75.97^d\ 7$	258.855	$0.0064^d\ f\ 10$	E2		52.9	L3/L2=0.61 7. Mult.: the experimental L3/L2 value of 0.61 7 is slightly smaller than the E2 theory value of 0.73, suggesting E2+M1 with $\delta=0.45\ +27-11$; however, the placement of this transition requires $\Delta L=2$.
$^{*}76.646\ 10$		0.46 10	E1		0.258	L2/L1=0.72 22; $\alpha(L1)\text{exp}=0.09\ 3$.
79.483 17	215.521	0.17 3	E2 (+M1)	5.8 2	41.7	δ : From $\alpha(L1)\text{exp}=0.91\ 20$.
$79.74^d\ 3$	106.164	$0.024^d\ f\ 4$	E2		42.0	L3/L2=0.61 3. Mult.: the experimental L3/L2 value of 0.61 3 is slightly smaller than the E2 theory value of 0.72, suggesting E2+M1 with $\delta=0.49\ +10-7$; however, the placement of this transition requires $\Delta L=2$.
82.232 4	315.068	0.57 8	E1+M2	0.025 +6-7	0.33 7	$\alpha(L1)\text{exp}=0.13\ 3$.
$^{*}86.219\ 4$		0.34 11	M1+E2	$0.22^{\dagger}\ 12$	8.8 13	δ : From L1:L2:L3=100:18 5:1.5 7; M1/L1=0.39 19; M1:M2:M3=100:45 22:8 4; $\alpha(L1)\text{exp}=6.7\ 24$. Mult.: the subshell ratios do not give a unique solution for δ , one gets $\delta=0.08\ +3-4$, $0.16\ +7-11$, $0.06\ +3-6$, $0.20\ +5-6$ from L3/L1, L2/L1, M3/M2, and M2/M1, respectively. Elc gives $\delta\leq 5.9$. The authors assign mult=M1(+E2).

Continued on next page (footnotes at end of table)

$^{237}\text{Np}(n,\gamma)$ E=th: Secondary γ 's 1990Ho02 (continued) $\gamma(^{238}\text{Np})$ (continued)

$E\gamma^{\S}$	E(level)	$I\gamma^{\S h}$	Mult.#	δg	$\alpha^{\ddagger}$	Comments
86.676 2	86.674	2.3 4	M1+E2	0.10 [†] 3	7.95 18	δ : From L1:L2:L3=100:16 4:1.9 5; M1/L1=0.28 7; M1:M2:M3=100:22 5:2.5 6; $\alpha(L1)\text{exp}=6.2$ 13.
92.486 7	179.156	0.19 4	E1		0.1574	$\alpha(L2)\text{exp}<0.07$. Mult.: $\delta<0.075$.
93.67 5	352.46	0.19 4				
95.22 [@] 2	121.645	0.046 [@] 6	[M1]		5.90	
96.82 ^d 5	232.823	0.033 ^{df} 5	E2		16.87	L3/L2=0.77 12. Mult.: the L3/L2 ratio gives mult=E2(+M1) with $\delta>1.4$. Placement in the level scheme requires $\Delta L=2$.
97.22 ^d 5	312.707	0.055 ^{df} 7	E2		16.54	M2/L2=0.25 4; M3/M2=0.80 18. Mult.: the M3/M2 ratio gives mult=E2(+M1) with $\delta>0.66$. Placement in the level scheme requires $\Delta L=2$.
^x 97.798 10		0.31 8				
^x 106.137 6		0.135 24	M1(+E2)	≤ 0.23	4.48 18	δ : From $\alpha(L1)\text{exp}=3.5$ 6.
107.263 6	325.210	0.65 12	M1		4.18	L2/L1=0.12 4; M1/L1=0.28 1; M1:M2:M3=100:15 1:5.7 7. $\alpha(L1)\text{exp}=3.0$ 5. Mult., δ : $\delta=0.09$ +3-4 from M2/M1. $\alpha(L1)\text{exp}$ gives $\delta<0.46$, L2/L1 gives $\delta<0.16$, and M3/M1 gives an anomalously high value of 0.210 15.
108.792 7	324.314	0.45 22				
109.614 ^{&i}	136.044	0.9 ^{&i} 3	E1+M2	0.028 6	0.144 21	$\alpha(L1)\text{exp}=0.06$ 1.
	342.396	$\leq 0.32^{\&i}$				
^x 111.104 11		0.25 4				
111.197 15	232.823	0.19 4				
116.90 [@] 2	299.789	0.095 [@] 14	[M1]		3.26	Mult.: 1990Ho02 show mult=M1+E2 in table I; however, $I\gamma$ was deduced from $I(\text{ce}(L1))$ using the $\alpha(L1)$ value for mult=M1.
^x 117.359 5		0.62 13	E1		0.0847	$\alpha(L1)\text{exp}=0.041$ 7.
^x 118.532 21		0.41 6	M1+E2	0.72 8	4.32 19	δ : From L2/L1=0.72 8; M1/L1=0.38 5; M1:M2:M3=100:60 12:22 5; $\alpha(L1)\text{exp}=0.92$ 12.
121.69 ^d 4	121.645	0.088 ^{df} 13	E2		6.04	Mult.: L3/L2(E2 theory)=0.60, slightly inconsistent with the experimental value of 0.53 4. The placement requires $\Delta L=2$.
122.76 7	258.855	0.019 8	[M1]		13.43	Mult.: 1990Ho02 show mult=M1+E2 in table I; however, $I\gamma$ was deduced from $I(\text{ce}(L1))$ using the $\alpha(L1)$ value for mult=M1.
^x 124.29 5		0.054 21	M1+E2	1.2 4	8.6 15	δ : $\text{elc1}=0.82$ 31.
^x 125.241 9		0.26 4				
^x 126.21 3		0.191 17				
^x 126.355 3		0.48 8				
130.215 12	380.600	0.25 4	E2(+M1)	5.7×10^3 1	4.50	δ : $\text{elc1}=0.13$ 3.
^x 133.662 15		0.21 3	M1+E2	2.8 1	4.77 9	δ : $\text{elc1}=0.28$ 4.
135.918 7	315.068	0.20 3				$E\gamma$: authors' value of 135.198 in table I is a misprint.
136.045 10	136.044	0.68 11	E1		0.247	$\alpha(K)\text{exp}=0.20$ 3.
^x 138.47 3		0.21 6				
142.328 10	325.210	0.44 10				
^x 144.260 21		0.14 3	M1(+E2)	<0.7	7.6 10	δ : $\alpha(K)\text{exp}=7.0$ 22.
152.69 ^{bj}	179.156	$\leq 0.33^{\text{bj}}$				
	258.855	$\leq 0.33^{\text{bj}}$				
153.192 12	215.521	0.43 5	(E1)		0.187	Mult.: $\alpha(K)\text{exp}$ is consistent with E1 or E2(+M1). Placement in the level scheme requires $\Delta\pi=\text{yes}$.
^x 153.731 11		0.46 4	M1+E2	2.8 3	2.80 13	

Continued on next page (footnotes at end of table)

$^{237}\text{Np}(n,\gamma)$ E=th: Secondary γ 's 1990Ho02 (continued) $\gamma(^{238}\text{Np})$ (continued)

$E\gamma^{\text{§}}$	E(level)	$I\gamma^{\text{§h}}$	Mult.#	δ^{g}	$\alpha^{\ddagger}$	Comments
153.870 9	275.515	0.45 10				L1/K=0.054 2; L1:L2:L3=100:15 1:8.9 15; M1/L1=0.25 1. $\alpha(\text{K})_{\text{exp}}=1.8$ 4. Mult.: 1990Ho02 assign mult=M1+E2; however, the conversion data are not consistent. $\alpha(\text{K})_{\text{exp}}$ gives $\delta=1.7$ 3, L2/L1 gives $\delta=0.18$ 4, L3/L1 gives $\delta=0.42$ 4, and L1/K is not consistent with any multipolarity. Placement in the decay scheme involves $\Delta J=1$, $\Delta\pi=\text{no}$.
155.731 11	373.684	0.22 3				
156.452 2	182.878	4.23 22	E1		0.1784	$\alpha(\text{K})_{\text{exp}}=0.14$ 1.
$^x159.585$ 21		0.28 5	M1+E2	5.6 +24-11	2.07 8	
$^x160.642$ 14		0.37 5				
$^x161.521$ 4		0.37 5				
163.29 5	342.396	0.28 4	M1+E2	6.26 [†] 7	1.86	δ : From $\alpha(\text{K})_{\text{exp}}=0.31$ 5.
174.88 3	433.719	0.15 11	E1		0.1375	
176.62 5	312.707	0.17 3				
179.00 3	315.068	0.19 4				
182.876 2	182.878	13.9 16	E1		0.1239	M1/L1=0.17 2; $\alpha(\text{K})_{\text{exp}}=0.097$ 13.
184.38 3	367.26	0.24 4				
$^x185.24$ 3		0.23 5				
$^x188.05$ 9		0.34 4				
189.099 6	215.521	0.44 4	E1		0.1146	
$^x197.315$ 14		0.40 15	E1		0.1038	Mult.: $\alpha(\text{K})_{\text{exp}}=0.09$ 3.
$^x198.52$ 3		0.29 4				
215.517 5	215.521	0.81 4	E1		0.0847	Mult.: $\alpha(\text{K})_{\text{exp}}=0.067$ 7.
217.26 7	529.857	0.30 3	E2		0.589	Mult.: $\alpha(\text{K})_{\text{exp}}=0.12$ 3.
217.966 ^d 20	217.949	0.20 ^d 3	M2		10.57	Mult.: L1/L2/L3 (exp)=100/15 1/13 1; L1/K(exp)=0.31 3.
218.17 3	433.719	0.28 5				
$^x218.56$ 6		0.29 5	M1+E2	1.41 14	1.27 10	δ : $\alpha(\text{K})_{\text{exp}}=0.79$ 13.
223.89 10	250.385	0.29 4	(E1)		0.0776	Mult.: $\alpha(\text{K})_{\text{exp}}=0.10$ 3. Mult.: $\alpha(\text{K})_{\text{exp}}$ is consistent with mult=E1 or E2. Placement in the level scheme requires $\Delta\pi=\text{yes}$.
232.433 8	258.855	0.29 5	E1		0.0712	$\alpha(\text{K})_{\text{exp}}=0.05$ 2.
$^x233.650$ 6		0.243 22	M1+E2	1.50 25	0.99 15	δ : $\alpha(\text{K})_{\text{exp}}=0.67$ 11.
236.025 11	298.368	0.61 5	M1		2.13	
243.959 4	243.959	3.6 4	M1+E2	0.2 9	1.88 79	$\alpha(\text{K})_{\text{exp}}=1.5$ 2.
250.40 ^{a,j} 4	250.385	$\leq 0.41^{\text{a,j}}$	(E1) ^a		0.0602	Mult.: $\alpha(\text{K})_{\text{exp}}$ is consistent with mult=E1 or E2. Placement in the level scheme requires $\Delta\pi=\text{yes}$.
250.40 ^{a,j}	312.707	$\leq 0.41^{\text{a,j}}$	a			
251.25 4	277.642	0.152 21	E2		0.354	Mult.: $\alpha(\text{K})_{\text{exp}}=0.14$ 3. $\alpha(\text{K})_{\text{exp}}=0.076$ 8.
$^x262.80$ 8		0.49 4				Mult.: 1990Ho02 assign mult=E2; however, $\alpha(\text{K})=0.098$ for E2 theory. The $\alpha(\text{K})_{\text{exp}}$ value is consistent with E1+M2 with $\delta=0.091$ 12.
$^x264.68$ 3		0.13 3	M1+E2	1.0 2	0.92 14	δ : $\alpha(\text{K})_{\text{exp}}=0.65$ 13.
271.953 11	298.368	0.44 3	M1		1.437	Mult.: $\alpha(\text{K})_{\text{exp}}=1.3$ 2.
277.633 19	277.642	0.25 5				
281.79 10	497.20	0.15 4	M1+E2	1.0 +5-3	0.77 21	δ : $\alpha(\text{K})_{\text{exp}}=0.57$ 18.
289.04 8	395.198	0.16 3	M1+E2	0.9 3	0.77 19	δ : $\alpha(\text{K})_{\text{exp}}=0.64$ 16.
294.178 ^k 20	473.3	0.21 3	M1		1.156	Mult.: $\alpha(\text{K})_{\text{exp}}=1.1$ 2. Transition is unplaced by 1990Ho02. Placement is suggested by the evaluators as deexcitation of the 473.3 level reported by these authors in their arc work.

Continued on next page (footnotes at end of table)

²³⁷Np(n,γ) E=th: Secondary γ's 1990Ho02 (continued)

γ(²³⁸Np) (continued)

Eγ ^s	E(level)	Iγ ^{sh}	Mult. [#]	δg	α [‡]	Comments
295.984 15	417.639	0.63 5	E2		0.208	Mult.: α(K)exp=0.07 1s. Mult.: the authors assign mult=E1,E2, but α(K)exp is consistent only with E2, unless one invokes an M2 admixture with δ=0.114 17.
297.672 15	433.719	0.66 8	E1		0.0410	Mult.: α(K)exp=0.03 1.
298.38 4	298.368	0.056 6	M1		1.111	Mult.: α(K)exp=1.0 3.
^x 302.65 7		0.19 3	E2+M1	4.4 16	0.24 6	δ: α(K)exp=0.13 3.
310.40@ 8	543.23	0.008@ 3	[M1]		0.997	
^x 314.168 14		0.23 4				
314.31e j 3	497.20	≤0.209e j	e			
	529.857	≤0.209e j	e			
^x 328.89 3		0.13 3				
^x 329.24 10		0.024 6	[M1]		0.847	Iγ: 1990Ho02 show mult=M1+E2 in table I; however, the α(K) value used to get Iγ is that corresponding to mult=M1.
330.966 19	417.639	0.29 8				
^x 332.257 13		0.75 5	M1+E2	0.38 [†] 10	0.74 5	δ: From α(K)exp=0.58 3.
332.868 16	395.198	0.24 3	E2(+M1)	9.0 2	0.1540	δ: α(K)exp=0.07 1.
334.205 13	567.021	0.27 8	E2		0.1441	α(K)exp=0.05 1.
^x 341.760 12		0.36 4				
346.98 1	529.857	0.11 3	M1+E2	0.7 [†] 4	0.53 15	δ: α(K)exp=0.4 1. δ: From α(K)exp=0.4 1.
351.37 8	567.021	0.34 5	E2		0.1247	α(K)exp=0.06 1.
358.25 4	523.87	0.34 3				Mult.: 1990Ho02 show mult=E2 for this transition; however, no ce data are available. The basis for this assignment is not given.
364.09 4	543.23	0.09 3				
^x 368.41 5		0.32 3	M1+E2	0.97 14	0.37 4	δ: α(K)exp=0.28 3.
^x 369.875 15		0.271 24				
^x 373.03 5		0.85 3				
^x 374.59@ 7		0.031@ 6	[M1]		0.595	
^x 380.302 25		0.014 4	[M1]		0.571	
^x 381.995 19		0.241 25				
384.12 4	567.021	0.191 19	M1+E2	0.93 [†] 16	0.34 5	δ: 0.26 3. δ: From α(K)exp=0.26 3.
391.27 3	417.639	0.37 3	M1+E2	1.3 2	0.25 4	δ: α(K)exp=0.19 3. Mult.: the authors assign mult=M1; however, α(K)exp requires an E2 admixture.
^x 405.213 11		0.27 3	M1		0.480	Mult.: α(K)exp=0.26 3.
^x 409.96 3		0.188 22				
417.60e j	417.639	≤0.031e j				
417.60e j 6	523.87	≤0.031e j				
430.96 3	567.021	0.65 8	M1+E2	0.87 [†] 22	0.26 5	δ: 0.20 3. δ: From α(K)exp=0.20 3.
^x 432.05 1		0.021 6	[M1]		0.403	
^x 442.74 3		0.026 6	[M1]		0.377	
^x 456.040 13		0.51 3				
461.59 9	523.87	0.36 6	M1+E2	0.93 +25-20	0.21 4	δ: α(K)exp=0.17 3.
^x 469.17 4		0.15 3				
^x 476.99 3		0.13 4	M1+E2	0.7 5	0.225 74	δ: α(K)exp=0.17 5.
^x 478.79 4		0.38 4	M1+E2	0.4 3	0.27 5	δ: α(K)exp=0.21 2.
^x 481.605 19		0.50 4	M1+E2	0.56 25	0.24 4	δ: α(K)exp=0.19 2.
^x 482.60 4		0.45 7	M1+E2	0.5 4	0.25 6	δ: α(K)exp=0.19 3.
^x 483.75 5		0.44 8				
^x 496.53 4		0.55 9	M1+E2	1.2 2	0.143 21	δ: α(K)exp=0.11 2.
497.49 5	523.87	0.43 4				
^x 530.61 10		0.34 7				
^x 538.39 5		0.32 3	M1(+E2)	≤0.5	0.204 19	δ: α(K)exp=0.17 2.
^x 541.28 4		0.37 7	M1+E2	0.9 3	0.14 4	δ: α(K)exp=0.11 2.

Continued on next page (footnotes at end of table)

²³⁷Np(n,γ) E=th: Secondary γ's 1990Ho02 (continued)

γ(²³⁸Np) (continued)

Eγ [§]	E(level)	Iγ ^{§h}	Mult. [#]	δg	α [‡]	Comments
^x 551.64 5		0.29 3				
^x 554.62 7		0.33 4				
^x 555.16 6		0.39 8	M1+E2	0.9 3	0.13 3	δ: α(K)exp=0.10 2.
^x 555.50 6		0.394 25				
^x 557.45 7		0.37 3	M1+E2	1.7 2	0.081 9	δ: α(K)exp=0.06 1.
^x 565.31 5		0.40 4	M1+E2	0.7 2	0.143 21	α(K)exp=0.11 1.
^x 571.25 3		0.36 5				
^x 582.53 6		0.20 3				
584.47 5	646.76	0.4 1				
^x 588.92 5		0.95 15				
^x 592.92 6		0.19 4				
^x 602.50 3		0.61 7				
^x 603.23 5		0.41 4	M1+E2	1.7 2	0.066 7	α(K)exp=0.05 1.
^x 606.73 4		0.44 5				
^x 609.07 8		0.15 4				
^x 612.86 5		0.32 5	M1+E2	1.06 [†] 20	0.091 14	δ: From α(K)exp=0.07 1.
^x 614.09 6		0.16 3				
620.28 6	646.76	0.63 8	M1+E2	0.97 21	0.093 15	
^x 625.73 5		0.184 22				
^x 630.54 7		0.20 3				
^x 633.56 9		0.14 3				
646.75 7	646.76	0.55 5	E2(+M1)	≥1.9	0.040 12	α(K)exp=0.03 1.
^x 648.27 8		0.50 7				

[†] Deduced by evaluators using conversion-electron in 1990Ho02 data and a minimization procedure (Program BRICCMixing), except as noted.

[‡] Theoretical values listed here are from 2002Ba85, and have been interpolated using the computer code bricc (Band Raman Internal Conversion Coefficients) (2005KiZT).

[§] From 1990Ho02. The Iγ are in units of photons per 100 neutron captures.

[#] From experimental conversion coefficient and subshell ratio data of 1990Ho02.

[@] No photon is observed, and only an L1 subshell or K ce peak is seen. 1990Ho02 assume mult=M1 to deduce Eγ and Iγ. In such cases mult=E0, E3 or higher or M2 or higher would be possible but much less likely.

[&] 1990Ho02 report E=109.614 4 with Iγ=1.09 24 and α(L1)exp=0.06 1 for this doubly placed transition. Placement from the 136 level requires mult=E1(+M2), and placement from the 342 level requires mult=M1 or E2. Comparison of α(L1)exp with the theory values of 0.038 (E1), 0.233 (E2), and 2.80 (M1) suggests that most of the intensity of this transition belongs with the 136 level. From Iγ(109γ)/Iγ(67γ)≤1.23 10 from the 342 level in α decay, one obtains Iγ(109γ)≤0.32 for placement from the 342 level in (n,γ), leaving Iγ(109γ)=0.9 3 for placement from the 136 level in (n,γ).

^a 1990Ho02 report E=250.40 4 with Iγ=0.35 6 and α(K)exp=0.13 3 for this doubly placed transition. Both placements require mult=E1(+M2); however, the α(K)exp gives δ=0.13 +2-3, an unusually large value. The authors observe a 250.33 transition in α decay, with a placement requiring mult=M1 or E2. A 5% contribution to the 250.44 peak from the 250.33 transition would yield the observed K-shell conversion coefficient.

^b 1990Ho02 report E=152.69 3 with Iγ=0.29 4 for this doubly placed transition. The authors assign a tentative mult of E1, probably based on the absence of any ce lines. Both placements of this transition involve ΔJ=1, Δπ=yes.

^c 1990Ho02 report E=417.60 6 with Iγ=0.025 6 for this doubly placed transition. No photon has been seen, and this intensity has been deduced by the authors from I(ce(K)) with the assumption of mult=M1. Both placements involve ΔL=0,1 and Δπ=no.

^d No photon has been detected. Eγ and Iγ are obtained from the ce data and the deduced multipolarity.

^e 1990Ho02 report E=314.31 3 with Iγ=0.185 24 and α(K)exp=0.46 7 for this doubly placed transition. α(K)exp is consistent with mult=M1,E2 required for both placements.

^f Authors' value, deduced from I(ce(L2)) and α(L2), is reevaluated by the evaluators to correspond to the corrected theoretical α(L2). See the general comment at the head of the γ listing.

^g If no value given it was assumed δ=1.00 for E2/M1, δ=1.00 for E3/M2 and δ=0.10 for the other multiplicities.

^h Absolute intensity per 100 neutron captures.

ⁱ Multiply placed; intensity suitably divided.

^j Multiply placed; undivided intensity given.

^k Placement of transition in the level scheme is uncertain.

^x γ ray not placed in level scheme.

$^{237}\text{Np}(n,\gamma) \text{E=th: Secondary } \gamma\text{'s}$ 1990Ho02 (continued)

Level Scheme

@ Multiply placed; intensity suitably divided
 & Multiply placed; undivided intensity given
 Intensities: I(γ +ce) per 100 n captures

$^{237}\text{Np}(n,\gamma) \text{E=th: Secondary } \gamma\text{'s}$ 1990Ho02 (continued)

Level Scheme (continued)

@ Multiply placed; intensity suitably divided
 & Multiply placed; undivided intensity given
 Intensities: I(γ +ce) per 100 n captures

$^{237}\text{Np}(\text{n},\gamma)$ E=th: Primary γ 's 1979Io01 $J\pi(^{237}\text{Np})=5/2+$ so the capturing state has $J\pi=2+$ or $3+$, and decays to levels with $J=1$ to 4 . ^{238}Np Levels

E(level) [†]	$J\pi^{\ddagger}$	Comments
0.0	2+	
136.03 25	3-	
182.4 6	2-	
216.5 10	3-	
249.98 25	(2)-	
258.7 6	4-	
285.8 10		
325.2 §		
334.3 8	1- to 3-	
347.5 4	1- to 3-	
368.0 5	(2)-	
372.8 6	(1)-	
386.4 4		
441.7 3	(4)-	
457.5 3	1- to 3-	
528.0 6	3-	
567.6 6	3-	
584.2 4	1- to 4-	
601.5 7	1- to 3-	
619.5 3		
647.0 7	1- to 3-	
673.6 3	1- to 3-	
692.5 6	1- to 3-	
709.24 25		
722.4 7		
764.1 6		
782.4 6		
797.4 4		
800.4 8		
809.8 3		
813.9 7		
834.7 6		
869.0 5		
903.3 4		
916.6 8		
929.1? 6		
948.9? 6		
970.7? 6		
986.5? 4		
1026.6? 6		
1033.4? 7		
1046.5? 6		
1065.2? 5		
1081.0? 6		
1089.0? 6		
1107.8 7		
1119.6?# 7		
1143.0 6		
1163.1@ 4		
1176.1 6		
1256.1 3		
1260.5 6		
1276.1 5		
1291.3 4		
1313.5 3		
1330.7 6		
1364.8 7		
1369.8 7		
1375.6 4		
1384.6 3		
1392.8 5		

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²³⁷Np(n,γ) E=th: Primary γ's 1979Io01 (continued)

²³⁸Np Levels (continued)

E(level) [†]	Comments
1408.5 6	
1445.7 6	
1484.1 8	
1492.8? 7	
1509.0 5	
1546.5 7	
1711.5 5	
1822.5 6	
2104.3 6	
2109.5 5	
2857.4 6	
5488.32 20	S(n)=5488.32 keV 20 (2012Wa38).

[†] From E_γ with S(n)=5488.09 20. Recoil corrections have been applied.

[‡] From adopted levels. J=1 to 4 for levels with no J_π given.

[§] Rounded-off value from adopted levels. Primary γ present in spectrum, but peak is weak.

[#] The authors' value of 1197.6 in table I is a misprint.

[@] The authors' value of 1153.1 is a misprint, or else E_γ is incorrect.

γ(²³⁸Np)

E _γ [‡]	E(level)	I _γ ^{‡‡}	Comments
2630.7 6	5488.32	22 7	
3378.6 4	5488.32	19 5	
3383.8 5	5488.32	16 4	
3665.6 5	5488.32	13 4	
3776.6 4	5488.32	20 4	
3941.6 7	5488.32	14 3	
3979.1 4	5488.32	13 3	
3995.3 7	5488.32	8 3	
4004.0@ 8	5488.32	13@ 3	
4042.4 6	5488.32	12 3	
4079.6 5	5488.32	17 3	
4095.3 4	5488.32	13 3	
4103.5 2	5488.32	30 4	
4112.5 3	5488.32	20 4	
4118.3 7	5488.32	13 4	
4123.3 7	5488.32	15 4	
4157.4 5	5488.32	28 3	
4174.6 2	5488.32	24 3	
4196.8 3	5488.32	17 3	
4212.0 4	5488.32	16 3	
4227.6 6	5488.32	13 3	
4232.0 2	5488.32	48 3	
4312.0 5	5488.32	10.4 24	
4325.0 4	5488.32	27 3	
4345.1 5	5488.32	11 3	
4368.5& 7	5488.32	10 3	
4380.3@ 7	5488.32	17@ 3	
4399.1& 6	5488.32	8 2	
4407.1& 6	5488.32	6 2	
4422.9& 4	5488.32	11 2	
4441.6& 6	5488.32	6.9 20	
4454.7& 7	5488.32	7 2	
4461.5& 6	5488.32	8 2	
4501.6& 3	5488.32	20.3 24	
4517.4& 6	5488.32	7 2	
4539.2& 5	5488.32	12 3	
4559.0& 6	5488.32	8 2	
4571.5 8	5488.32	9 2	
4584.8 3	5488.32	21 2	

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²³⁷Np(n,γ) E=th: Primary γ's 1979Io01 (continued)

γ(²³⁸Np) (continued)

Eγ [†]	E(level)	Iγ ^{†‡}	Comments
4619.1@ 4	5488.32	19@ 2	
4653.4 5	5488.32	22 2	
4674.2 7	5488.32	11 3	
4678.3 2	5488.32	42 4	
4687.7 8	5488.32	15 6	
4690.7 3	5488.32	16# 6	
4705.6 5	5488.32	9 2	
4723.9 6	5488.32	7.4 19	
4765.6 7	5488.32	10 2	
4778.80 15	5488.32	54 3	
4795.5 5	5488.32	5.0 15	
4814.4 2	5488.32	33.5 23	
4841.0§ 7	5488.32	7§ 2	
4868.5 2	5488.32	32.4 25	
4886.5 7	5488.32	9 2	
4903.8 3	5488.32	18.5# 30	
4920.4@ 5	5488.32	8@ 2	
4960.0 6	5488.32	9 2	
5030.55 15	5488.32	57 3	
5046.3 2	5488.32	39 3	
5101.6 3	5488.32	16 2	
5115.2 6	5488.32	14 3	
5120.0 5	5488.32	21 3	
5140.5 4	5488.32	11.5 19	
5153.7§ 8	5488.32	4.2§ 15	
5162.8	5488.32		Eγ: from E(level) and S(n). Peak seen but is weak.
5202.2 10	5488.32		Eγ: reported only in the authors' BNL experiment.
5229.3§ 5	5488.32	7.5§ 15	
5238.05 15	5488.32	35.6 23	
5271.5 10	5488.32	6 2	Eγ,Iγ: doublet. One component is an impurity line from ¹⁵ N.
5305.7 6	5488.32	8.0 16	
5352.00 15	5488.32	100 4	
5488.32 20	5488.32	5.7 9	

[†] For intensity per 100 neutron captures, multiply by ≈0.01.

[‡] From authors' table 1. These are data taken at Fribourg with a pair spectrometer. FWHM=2.7 keV at 2200 increasing linearly to 4.6 keV at 5500. Data are also given in table 3 from an experiment at BNL using a Ge(Li) detector with FWHM=7 keV at 5000.

§ Questioned by authors; however the transition defines a level with energy corresponding to a level seen in arc and/or in resonance neutron capture.

An Al background contribution has been subtracted.

@ Possible background contribution.

& Placement of transition in the level scheme is uncertain.

²³⁷Np(n,γ) E=resonance 1990Ho02,1979Io01

E(n)=0.489 eV, 1.33 eV, 5.3 eV (1979Io01).

E(n)=1.48 eV (1990Ho02,1979Io01).

Jπ(1.48 eV resonance)=2+, Jπ(5.8 eV resonance)=3+ (1973Mu14).

Others: 2012Ha16, 2012Pr13, 2011Ch57, 2011Gu21, 2011Iw04, 2011Ma59, 2011Mu13, 2010Pr07, 2010No02, 2010Co02, 2009Ha10, 2008Br06, 2008Es01, 2008Pa14, 2007Ko28, 2006Ad16, 2006Vl01, 2005Na45, 2005Re25, 2005Sh15, 2004Sh01, 2003Ka47, 2002Ko18, 2001Wa28.

2012GU07: Neutron beam at E=0.7–500 eV from neutron time-of-flight facility n_TOF at CERN. Target=49.1 mg NpO₂ (99.2% purity). Measured total absorption γ spectra, E(n), σ(E), transmission spectra using 4π BaF₂ Total Absorption Calorimeter (40 BaF₂ crystals). Deduced neutron resonances, levels, level spacing distribution, average capture cross sections, neutron widths.

S(n)(²³⁸Np)=5488.32 keV 20 (2012Wa38).

Jπ(²³⁷Np g.s.)=5/2+.

²³⁷Np(n,γ) E=resonance 1990Ho02,1979Io01 (continued)

²³⁸Np Levels

 $\Gamma_\gamma=40.9$ meV 18 for all resonances.

E(level) [†] d	Jπ [‡]	Γ _n (eV)	Comments
26.4 ^a	3+		
136.0 [§]	3-		
179.2 [#] @c	4-		
182.9 [§] #@c	2-		
215.5 [§] #@&	3-		
246.8 ^b 16			
250.4 [§] @c	(2)-		
258.9@c	4-		
325.2 [§]	1-		
334.0 [§]	1- to 3-		
347.7@	1- to 3-		
352.5 [§]	(3)-		
367.3 [§]	(2)-		
373.7@&a	(1)-		
386.2& 5			
442.2&	(4)-		
457.5@a	1- to 3-		
529.9 [§] &	2-, 3-		
567.0 [§] @&	3-		
601.4@&a	1- to 3-		
623.6& 15			E(level): E=619.5 3 for this level in thermal capture.
648.4 [§] @&	1- to 3-		
674.5 [§] @&	1- to 3-		
692.3 [§] @	1- to 3-		
S(n)+0.00132 1	3	3.17×10 ⁻⁵ eV 12	S(n)=5488.32 keV 20 (2012Wa38). E(n)=0.001321 eV 1.
S(n)+0.00197 1	3	1.40×10 ⁻⁵ eV 5	E(n)=0.001969 eV 1.
S(n)+0.00387 1	3	2.07×10 ⁻⁴ eV 8	E(n)=0.003865 eV 2.
S(n)+0.00426 1	2	3.23×10 ⁻⁵ eV 12	E(n)=0.004264 eV 3.
S(n)+0.00486 1	2	3.96×10 ⁻⁵ eV 15	E(n)=0.004863 eV 3.
S(n)+0.00578 1	3	5.24×10 ⁻⁴ eV 19	E(n)=0.005777 eV 4.
S(n)+0.00638 1	3	7.8×10 ⁻⁵ eV 3	E(n)=0.006378 eV 4.
S(n)+0.00148 1	2	1.81×10 ⁻⁴ eV 7	E(n)=0.001478 eV 1.
S(n)+0.00668 1	2	1.36×10 ⁻⁵ eV 5	E(n)=0.006677 eV 4.
S(n)+0.00719 1	2	8.2×10 ⁻⁶ eV 3	E(n)=0.007189 eV 5.
S(n)+0.00768 1	2	1.76×10 ⁻⁶ eV 12	E(n)=0.007678 eV 7.
S(n)+0.00831 1	3	8.8×10 ⁻⁵ eV 3	E(n)=0.008307 eV 6.
S(n)+0.00898 1	3	1.01×10 ⁻⁴ eV 4	E(n)=0.008978 eV 6.
S(n)+0.00930 1	2	5.85×10 ⁻⁴ eV 22	E(n)=0.009299 eV 6.
S(n)+0.01023 1	2	2.75×10 ⁻⁵ eV 10	E(n)=0.010231 eV 7.
S(n)+0.01068 1	3	4.22×10 ⁻⁴ eV 16	E(n)=0.010682 eV 7.
S(n)+0.01110 1	2	1.00×10 ⁻³ eV 4	E(n)=0.011097 eV 8.
S(n)+0.00742 1	3	1.19×10 ⁻⁴ eV 4	E(n)=0.007423 eV 5.
S(n)+0.01220 1	3	4.87×10 ⁻⁵ eV 18	E(n)=0.012202 eV 9.
S(n)+0.01262 1	2	8.9×10 ⁻⁴ eV 3	E(n)=0.012618 eV 9.
S(n)+0.01314 1	3	1.78×10 ⁻⁵ eV 7	E(n)=0.013139 eV 9.
S(n)+0.01428 3	2	9.6×10 ⁻⁷ eV 10	
S(n)+0.01580 1	3	6.71×10 ⁻⁵ eV 25	
S(n)+0.01085 1	3	6.83×10 ⁻⁴ eV 25	E(n)=0.010845 eV 8.
S(n)+0.01595 1	3	3.74×10 ⁻⁵ eV 18	
S(n)+0.01686 1	2	2.90×10 ⁻⁴ eV 11	
S(n)+0.01760 1	3	1.51×10 ⁻⁴ eV 6	
S(n)+0.01791 1	2	1.55×10 ⁻⁵ eV 7	
S(n)+0.01889 1	2	4.18×10 ⁻⁵ eV 15	
S(n)+0.01993 2	3	6.22×10 ⁻⁵ eV 23	
S(n)+0.02040 2	2	1.30×10 ⁻³ eV 5	
S(n)+0.01609 1	2	1.01×10 ⁻³ eV 4	
S(n)+0.02110 2	3	4.29×10 ⁻⁴ eV 16	
S(n)+0.02135 2	2	2.54×10 ⁻⁵ eV 11	
S(n)+0.02202 2	2	1.46×10 ⁻³ eV 5	
S(n)+0.01794 4	3	3.0×10 ⁻⁶ eV 3	
S(n)+0.02287 2	3	3.75×10 ⁻⁴ eV 14	

Continued on next page (footnotes at end of table)

²³⁷Np(n,γ) E=resonance 1990Ho02,1979Io01 (continued)

²³⁸Np Levels (continued)

E(level) ^{†d}	Jπ [‡]	Γ _n (eV)	E(level) ^{†d}	Jπ [‡]	Γ _n (eV)
S(n)+0.02368 2	3	1.39×10 ⁻³ eV 5	S(n)+0.03391 3	2	4.37×10 ⁻⁴ eV 16
S(n)+0.01913 1	3	8.4×10 ⁻⁵ eV 3	S(n)+0.03469 3	3	1.45×10 ⁻⁴ eV 5
S(n)+0.02399 2	2	1.79×10 ⁻⁴ eV 7	S(n)+0.03521 3	2	3.67×10 ⁻⁴ eV 14
S(n)+0.02476 2	3	5.03×10 ⁻⁵ eV 22	S(n)+0.03639 3	3	1.12×10 ⁻⁴ eV 4
S(n)+0.02499 2	3	3.56×10 ⁻³ eV 13	S(n)+0.03685 3	2	8.4×10 ⁻⁵ eV 3
S(n)+0.02620 2	3	2.11×10 ⁻⁴ eV 8	S(n)+0.03716 3	3	1.07×10 ⁻³ eV 4
S(n)+0.02657 2	3	2.31×10 ⁻³ eV 9	S(n)+0.03790 3	2	4.0×10 ⁻⁵ eV 4
S(n)+0.02709 2	2	4.33×10 ⁻⁵ eV 16	S(n)+0.03807 3	2	2.33×10 ⁻⁴ eV 19
S(n)+0.02845 2	2	9.3×10 ⁻⁵ eV 3	S(n)+0.03892 3	3	7.3×10 ⁻⁴ eV 3
S(n)+0.02894 2	2	1.40×10 ⁻⁴ eV 5	S(n)+0.03406 3	3	3.8×10 ⁻⁵ eV 3
S(n)+0.02948 2	2	8.5×10 ⁻⁵ eV 3	S(n)+0.03901 3	2	4.1×10 ⁻⁴ eV 4
S(n)+0.03042 2	3	3.10×10 ⁻³ eV 11	S(n)+0.03984 3	2	9.1×10 ⁻⁵ eV 9
S(n)+0.03076 2	2	3.44×10 ⁻⁴ eV 13	S(n)+0.04137 3	3	1.82×10 ⁻³ eV 7
S(n)+0.03131 3	3	2.43×10 ⁻⁴ eV 9	S(n)+0.04241 4	3	5.90×10 ⁻⁵ eV 22
S(n)+0.03167 3	3	4.52×10 ⁻⁵ eV 17	S(n)+0.04284 4	3	7.3×10 ⁻⁵ eV 3
S(n)+0.03248 3	2	1.31×10 ⁻⁵ eV 9	S(n)+0.03820 3	3	1.10×10 ⁻³ eV 4
S(n)+0.02862 2	3	3.59×10 ⁻⁵ eV 18	S(n)+0.03924 3	3	5.14×10 ⁻⁴ eV 19
S(n)+0.03343 3	3	3.87×10 ⁻⁴ eV 14	S(n)+0.03994 3	3	4.18×10 ⁻⁴ eV 15

[†] Rounded-off values from adopted levels. The primary γ data are given in 1990Ho02 and 1979Io01, along with the level energies deduced from these transitions.

[‡] From adopted levels. Levels strongly fed from the 1.48-eV 2+ resonance are expected to have J=1, 2, or 3, and those fed from the 3+ 5.8-eV resonance are expected to have J=2, 3, or 4.

§ Fed from the 1.48-eV resonance and reported by both 1979Io01 and 1990Ho02.

Fed from the 5.8-eV resonance.

@ Fed from the 1.33-eV resonance.

& Fed from the 0.489-eV resonance.

a Fed from the 1.48-eV resonance but reported only by 1990Ho02.

b Fed from the 1.48-eV resonance but reported only by 1979Io01.

c Primary transition from 0.489-eV resonance could feed one or both of the close-lying levels at this energy.

d Neutron resonance energies are from 2012Gu07.

²³⁷Np(n,γ) E=res 1990Ho02

E(n)=2 keV. Primary γ rays from average resonance capture.

²³⁸Np Levels

E(level)	Jπ [†]	Comments
136.3 3	3-	
181.5 5	4- and 2-	E(level),Jπ: assigned by the authors as including the 179.2 4- and the 182.9 2- adopted levels.
216.7 3	3-	
250.0 11	(2)-	
258 3	4-	
300 2	(1)-	
305.4 20	1- to 4-	
324.5 4	(4)- and 1-	E(level),Jπ: assigned by the authors as including the 324.3 (4)- and the 325.2 1- adopted levels.
334.7 8	1- to 4-	
347.1 23	1- to 3-	
352.3 10	(3)-	
367.0 9	(2)-	
373.8 7	(1)-	
381.1 10	(3)-	
443.8 10	(4)-	
458.1 3	1- to 3-	
468.6 15	1- to 4-	
473.3 4	1- to 4-	
497.1 6	2-, 3-, 4-	
505.1 10	1- to 4-	

Continued on next page (footnotes at end of table)

$^{237}\text{Np}(\text{n},\gamma)$ E=res 1990Ho02 (continued) **^{238}Np Levels (continued)**

E(level)	$J\pi^\dagger$
529.5 7	3-
545.1 21	3-, 4-
567.0 3	3-
584.9 4	1- to 4-
601.4 4	1- to 3-
635.3 10	1- to 4-
649.0 6	1- to 3-
672.7 10	1- to 3-
676.9 18	1- to 4-
692.1 3	1- to 3-

† From adopted levels. Levels strongly populated in average resonance neutron capture are expected to have $J=1$ to 4 with $\pi=-$.

 $^{237}\text{Np}(\text{d},\text{p})$ 1979Io01

E=12 MeV. FWHM=14 keV estimated by evaluators.

 ^{238}Np Levels

E(level)	$J\pi^@$	$T_{1/2}$	E(level)	$J\pi^@$	E(level)	$J\pi^@$
0.0 †	2+	2.117 d 2	221.2 ‡ 8	(6+)	456.3 § 7	(8+)&
26.5 † 8	(3+)		278.1 § 10	(5+)	524.2 $^\#$ 6	(6+)&
62.0 † 7	(4+)		328.6 § 5	(6+)	603.7 6	
86.9 ‡ 5	(3+)		374.7 $^\#$ 10	(5+)&	630.6 13	
107.3 † 12	(5+)		389.9 § 9	(7+)	648.7 5	
123.0 ‡ 5	(4+)		409.5 5		675.6 5	
165.1 ‡ 12	(5+)		431.3 $^\#$ 6	(4+)&	691.9 6	

† (A): π 5/2[642]-v 1/2[631]:K=2.

‡ (B): π 5/2[642]+v 1/2[631]:K=3.

§ (C): π 5/2[642]+v 5/2[622]:K=5.

$^\#$ (D): π 5/2[642]-v 5/2[622]:K=0.

$^@$ From authors, based on information about L values deduced from the ratios of cross section at 85° and 135°, comparison of measured cross sections with the calculated ones, systematics of proton and neutron orbitals, and rotational band parameters.

& Based on their (n, γ) and α decay work, 1990Ho02 reinterpret the members of the π 5/2[642]-v 5/2[622] K=0 band. They reassign the 374.7 level as the 5+ member of this band, with levels at 250 and at 299, not seen in (d,p), as the 1+ and 3+ members, respectively. The 4+ and 6+ members are the same in the two works. The 456.3 level is reassigned as the 8+ member of the K=5 band, and the 332.5 level, seen in the (n, γ) work of 1979Io01, is left unassigned. 1979Io01 assigned the 374 level as an unresolved doublet, the 2+ and 3+ members of the K=0 band, and the 456.3 level as the 5+ band member.

Adopted Levels, Gammas

$Q(\beta^-) = -2258.3$ 51; $S(n) = 6999.8$ 13; $S(p) = 5997.5$ 4; $Q(\alpha) = 5593.20$ 19 2012Wa38.

Energies of vibrational states ($K=0+$, $2+$, $0-$, $1-$, $2-$, $3-$), and $B(E2)$, $B(E3)$ values for the excitation of $2+$, $3-$ levels have been calculated by 1965So04, 1970Ne08, 1971Ko31, 1975LeZR, 1975IvZZ. See also 1969Bl13, 1992Ra14, 1993Sa15, 1994Mi14 see 1964So02 for calculated energies of two-quasiparticle states in ^{238}Pu and also for structure of some collective states.

Discovery of ^{238}Pu : 2013Fr02.

Alpha Decay: 2014Ba07, 2013De12, 2013Fe03, 2013Is13, 2013Se17, 2012Is08, 2011Ni11, 2011Qi06, 2011Zh36, 2010Le01, 2010Ni02, 2010Wa23, 2010Wa31, 2009De32, 2009Dr05, 2009Ni06, 2009Wa01, 2009Zh28, 2006Ch34, 2006De05, 2006Ha20, 2006Ha53, 2006Xu08, 2006Xu15, 2005Sh42, 2004Ca24, 2004ChZY, 2004Le07, 2003Ba64, 2003Jo04.

Nuclear reactions: 2013Bo29, 2010Wa07, 2002Be08, 2002Lo18.

$^{239}\text{Pu}(n,2n)$: 2002Be08.

$^{238}\text{U} \beta-\beta^-$ Decay: 2012Zu07, 2010Ba07, 2006Ba35, 2005Tr01, 2004Ra13, 2003Cr04, 2002Hi09.

Cluster Decay.

$^{238}\text{Pu}(^{32}\text{Si})$: 2014Ba09, 2013Qi04, 2013Zd01, 2013Zd02, 2012Ku23, 2012Ba35, 2012Mi17, 2012Sa31, 2012So15, 2012Ta10, 2010Si12, 2010Zh51, 2009Ar11, 2009Qi07, 2009Ro16, 2008Bh05, 2005Bh02, 2005Ku04, 2005Ku32, 2004Ba64, 2004Re22, 2002Ba80.

$^{238}\text{Pu}(^{28}\text{Mg})$: 2013Na25, 2012Sa31, 2012So15, 2011Sh13, 2010Sa29, 2010Zh51, 2009Ar11, 2009Qi07, 2009Ro16, 2008Bh05, 2002Ba80, 2002Du16.

$^{238}\text{Pu}(^{30}\text{Mg})$: 2013Qi04, 2013Zd01, 2013Zd02, 2012Ba35, 2012Ku29, 2012Ku16, 2012Qi01, 2012Sa31 2012Si01 2012So15 2011Si13, 2010Sa29, 2010Si12. 2009Ar05, 2009Ar11, 2009Ro16 2008Bh05 2005Ku32, 2004Ba64, 2004He16, 2002Du16, 2002Ba80.

$^{238}\text{Pu}(^{34}\text{Si})$: 2009Qi07.

Nuclear Structure: 2014Lu01, 2013Af01, 2013Bo24, 2013Li30, 2013Ni02, 2013To12, 2012Ib02, 2012Ko06, 2012Lu02, 2012Mi06, 2012Pr09, 2012Ro29, 2012Ro34, 2011Af04, 2011Bo12, 2011In03, 2011Li44, 2011Ri05, 2011Wa30, 2010Bu02, 2010Is01, 2010Ko36, 2010Ra10, 2010Vr01, 2009So02, 2008Bu11, 2007Ba18, 2007Bo46, 2007Sh17, 2006De23, 2006Ra21, 2006Sa35, 2005Al40, 2005Bu38, 2005Du18, 2005La04, 2005Za02, 2004Go33, 2004Sa55, 2003Bu11, 2003Bu27, 2003Mi18, 2003Ra17, 2003Za01, 2002Do15, 2002Ma85, 2002Ra25, 2002Re31.

Isomer energy calculations – 1992Bh03. Other: 2011He12.

Fission Isomers and Super Deformed Bands: 2002Si26.

Quadrupole moments calculations – 1992Bh04.

^{238}Pu Levels

Cross Reference (XREF) Flags

A ^{238}Am ε Decay	F $^{240}\text{Pu}(p,t)$
B ^{238}Np β^- Decay	G $^{238}\text{U}(\alpha,4n\gamma)$
C ^{242}Cm α Decay	H $^{239}\text{Pu}(^{207}\text{Pb},^{208}\text{Pb}\gamma)$
D Coulomb Excitation	I $^{239}\text{Pu}(^{117}\text{Sn},^{118}\text{Sn}\gamma)$
E $^{239}\text{Pu}(d,t)$	

E(level)	$J\pi^d$	XREF	$T_{1/2}$	Comments
0.0 [†]	0+	ABCDEFGH	87.7 y 1	% α =100; %SF=1.9 $\times 10^{-7}$ 1. $T_{1/2}$, %SF: recommended by 1986LoZT. $T_{1/2}$: 86.41 y 30 specific activity $^{238}\text{Pu}/^{242}\text{Cm}$ (1957Ho71), 87.77 y 2 by calorimetry (1973JoYT), 86.98 y 39 by specific activity (1976Po08), 87.71 y 3 specific activity $^{238}\text{Pu}/^{242}\text{Cm}$ (1977Di04), 87.98 y 51 relative activity using $T_{1/2}(^{239}\text{Pu})=24110$ y (1981Ag06). $T_{1/2}(\text{SF})=4.77\times 10^{10}$ y 14 (1972Ha11), 4.63 $\times 10^{10}$ y 12 (1975GaZX), 5.1 $\times 10^{10}$ y 6 (1961Dr04).
44.065 [†] 15	2+	ABCDEFGH	175 ps 3	$J\pi$: E2 to g.s. $T_{1/2}$: weighted average of 177 ps 5 from aga9ta0 in ^{242}Cm α decay, and 174 ps 3 from B(E2) in Coulomb excitation.
145.936 [†] 21	4+	ABCDEFGH		B(E4) $\uparrow$ =1.9 7. $J\pi$: E2 to 2+. Coul. ex. B(E4) $\uparrow$: from Coul. ex.
303.36 [†] 6	6+	BC FGHI		$J\pi$: E2 γ to 303 level.
512.55 [†] 15	8+	C GHI		$J\pi$: E1 to g.s.. The intensity ratio for the transitions to 0+ and 2+ agree with theory for $K=0$, not with $K=1$.
605.18 [‡] 3	1-	ABC		B(E3) $\uparrow$ =0.71 12. $J\pi$: E1+M2 γ 's to 2+ and 4+.
661.44 [‡] 4	3-	ABCD		B(E3) $\uparrow$: from Coul. ex. $J\pi$: M1+E2 γ from (4)- determines $\pi=-$. γ 's to 4+ and 6+ then give J=5. Member of $K=0$ octupole band.
763.24 [‡] 11	5-	BC		

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Adopted Levels, Gammas (continued)

²³⁸Pu Levels (continued)

E(level)	J π^d	XREF	T _{1/2}	Comments
771.9 [†] 5	10+	GHI		
911.6 [‡] 8	7-	H		
941.47 [§] 8	0+	ABC EF		J π : E0 to g.s.
962.783 [#] 23	1-	ABC		J π : E1 to g.s.. The configuration was proposed by 1972Ah04 on the basis of log ft ratios in ϵ decay and energy calculations of 1964So02.
968.2? 4	(2-)	B	<8.5 ns	J π : 114.4 γ from (4)- is probably E2. γ to 2+. 1972Wi22 propose K=2, J π =2-.
983.09 [§] 7	2+	ABCDEF	0.55 ps +15-11	T _{1/2} : from delayed ce γ coincidence. J π : E0+E2 to 2+.
985.45 [#] 5	2-	AB		T _{1/2} : from B(E2) in Coulomb excitation. J π : M1 to 3-. log ft=7.5 (log f ^{lut} =8.2) from 1+ rules out 3- and 4- M1. The log ft for the ϵ feeding rules out J π =3-,4-.
1018.6? 3		C		
1028.537 [@] 16	2+	ABC F		J π : E2 to g.s.
1069.929 [@] 22	3+	B		J π : M1+E2 γ 's to 2+ and 4+ log ft for the β^- feeding, photon intensity ratios, and band parameter suggest K=2, J π =3+.
1077.7 ^{†e} 5	12+	GHI		
1082.55 ^b 6	(4)-	B	8.5 ns 5	J π : E1+M2 to 4+. Configuration proposed by 1972Wi22. T _{1/2} : from $\beta\gamma(t)$ in ²³⁸ Np decay (1970Be57).
1102.4 ^{‡e} 5	9-	H		
1125.75 [@] 17	(4+)	C		J π : γ 's to 2+ and 4+. Possible member of K=2 band.
1134 4	(0+)	F		J π : L(p,t)=(0).
1174.4 4	(2+)	A		J π : from γ transitions to 0+, 2+ states J π =1 $\pm$,2+. Intensity ratio is not in good agreement with Alaga rule for J=1, but it agrees well for J=2.
1202.45 ^c 8	(3)-	B		J π : M1(+E2) to (4)-. γ to 2+.
1228.65 ^{&} 18	0+	A C E		J π : E0 to g.s.
1252 2		F		
1264.20 ^{&} 15	2+	A C E		J π : E0+E2+M1 to 2+.
1310.3? 3	1+, 2+	A		J π : M1 to 2+. log ft=7.4 from 1+ rules out 3+.
1340.4 ^{‡e} 6	11-	H		
1426.4 [†] 6	14+	GHI		
1426.61 ^{ae} 24	0+	A		J π : E0 to g.s.
1447.24 19	1-	A		J π : E0 to 1- intensity ratio of gammas to g.s. band suggests K=0.
1458.29 ^a 22	2+	A		J π : E0+E2+M1 to 2+ energy spacing of the 1426 and 1458 levels and the ratio of ft's for the ϵ feedings to these levels suggest that they are members of a band.
1559.82 14	1-	A		J π : M1+E2 to 2-. γ to g.s. gammas to 0+, 1-, 2+ levels.
1596.3 3	(2+)	A		J π : gammas to 0+, 2+, and possibly 4+. J=1 is not ruled out if the placement of 1450 γ to 4+ is not correct.
1621.29 12	1-	A		J π : E1 to 0+ E0+M1+E2 transitions with about equal intensity to K,J π =0,1- and 1,1- states imply that the configuration of the 1621 state is probably a mixture of K=0 and K=1.
1621.8 ^{‡e} 6	13-	H		
1636.40 13	1-	A		J π : E1 to 0+ E0 transitions with about same intensity to K,J π =0,1- and 1,1- states imply that the configuration of the 1636.6 state is a mixture of K=0 and K=1.
1651.2 4	1, 2+	A		J π : γ 's to 0+ and 2+.
1726.34 22	1, 2+	A		J π : γ 's to 0+ and 2+.
1783.5 3	1, 2+	A		J π : γ 's to 0+ and 2+.
1815.5 ^{†e} 5	16+	GHI		
1898.42 22	2-	A		J π : M1 γ 's to 1- and 3-.
1944.6 ^{‡e} 4	15-	H		
2241.7 ^{†e} 6	18+	GHI		
2308.2 ^{‡e} 5	17-	H		

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued)

²³⁸Pu Levels (continued)

E(level)	Jπ ^d	XREF	T _{1/2}	Comments
≈2400			0.6 ns 2	%SF≤100. %SF: only SF decay observed. T _{1/2} : 0.5 ns 2 ²³⁶ U(α,2n) (1973Li01), 0.7 ns 2 ²³⁸ Pu(d,pn) (1974MeYP). 1972We09 calculated T _{1/2} (SF)=0.95 ns, T _{1/2} (γ)=7.0 μs. E=2400 200 from thresholds (1973Li01). Calculated energies are: E=2250 (1972We09), E=2000 (1971Pa33), E=1800 (1972Ma11). Assignment: ²³⁶ U(α,2n) excit (1973Li01).
2702.3 [†] e 8	20+	HI		
2708.7 [‡] e 6	19-	H		
3143.8 [‡] e 8	21-	H		
3195.4 [†] e 8	22+	HI		
≈3500	(0+)		6.0 ns 15	%SF≤100. %SF: only SF decay observed. T _{1/2} : 6.5 ns 15 ²³⁶ U(α,2n) (1970Bu02,1971Br39), 5.0 ns 20 ²³⁶ U(α,2n) (1973Li01). Other measurements: 1973Na35, 1969Me11. E=3700 200 from ²³⁶ U(α,2n) thresholds (1973Li01), E=3400 400 estimated from excitation functions (1973Br38). Angular distribution of fission fragments following ²³² Th(α,F) and ²³⁶ U(a,2nf) reactions were measured, and possible spin assignments were proposed from measured anisotropy by 1974SpZS. See also 1975Kh06 for a discussion on spin of this isomeric state. Assignment: ²³⁶ U(α,2n) excit (1971Br39,1973Li01).
3610.6 [‡] e 10	23-	H		
3717.1 [†] e 10	24+	HI		
4105.2 [‡] e 11	25-	H		
4263.7 [†] e 11	26+	HI		
4623.2 [‡] e 13	27-	H		
4833.3 [†] e 13	28+	H		
5161.3 [‡] e	(29-)	H		
5426.5 [?] †e 9	(30+)	H		

[†] (A): Kπ=0+ g.s. band.

[‡] (B): Kπ=0- octupole-vibrational band.

[§] (C): Kπ=0+ β-vibrational band.

[#] (D): Kπ=1- v 7/2[743]-v 5/2[622] band.

[@] (E): Kπ=2+.

[&] (F): Kπ=0+.

^a (G): Kπ=0+.

^b (H): Kπ=4- v 7/2[743]+v 1/2[631] state.

^c (I): Kπ=3- v 7/2[743]-v 1/2[631] state.

^d From an energy fit to the g.s. band in addition to other arguments as given.

^e From ²³⁹Pu(²⁰⁷Pb,²⁰⁸Pbγ).

γ(²³⁸Pu)

E(level)	Eγ [†]	Iγ [#]	Mult. [@]	δ [@]	α	I(γ+ce)	Comments
	x565.8 3						
	x665.2 2		(E0) §				
	x749.2		(E0) §				
	x884.3 3						
	x908.8 2		(M1)				
	x1097.3 3		(E2)				
	x1226.4 3						
	x1231.3 3						
	x1368.8 5						
	x1501.7 5		(E0) §				
	x1551.0		(E0) §				
	x1761.5 4						
	x1789.0 5						

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Adopted Levels, Gammas (continued)
 $\gamma(^{238}\text{Pu})$ (continued)

E(level)	E $\gamma^{\dagger}$	I $\gamma^{\#}$	Mult. @	$\delta^{\oplus}$	α	I($\gamma+\text{ce}$)	Comments
44.065	^x 1835.1 5 44.06 2	100	E2		775		B(E2)(W.u.)=285 5. $\alpha, \alpha(\text{L}), \alpha(\text{M})$: values given are the E2 theory values lowered by 3% (see 1987Ra01).
145.936	101.88 3	100	E2		14.8		
303.36	157.42 5	100	E2		2.24		
512.55	209.20 14	100	E2		0.73		E γ : From ²⁴⁸ Cm α decay. Mult.: from ce(L2)/ce(L3) in ($\alpha, 4n\gamma$).
605.18	561.17 5	100	E1		0.0116		
	605.18 5	73 2	E1		0.0101		
661.44	515.53 7	55 1	E1+M2	0.114 17	0.023 3		I γ : from ϵ decay. Values of ≈ 0.64 from β^- decay and 0.67 from α decay depend on splitting the intensity of the doubly placed 713 γ on the basis of model-dependent arguments.
763.24	617.41& 5 459.80 20	100& ≈ 3.4	E1+M2	0.077 17	0.0122 13		I γ : from ϵ and α decay, see comment on 515 γ from the 661 level.
771.9	617.36& 259.4 $\frac{7}{2}$ 5	100& 100	E2				
911.6	608.7 ^a 5	100					
941.47	336.38 15	2.8 16	[E1]				I γ : from ²⁴² Cm α decay, if I(897.33 γ)=100.
	897.33 10	100 7	(E2)		0.0154		
	941.5 2		E0			59 7	I($\gamma+\text{ce}$): from ²³⁸ Am ϵ decay, I($\gamma+\text{ce}$)/I γ (897 γ)=0.62 from 1960As10 in α decay. The value of 1.4 2 in β^- decay appears to be discrepant.
962.783	301.5 1	1.68 9	E2		0.213		
	357.62 7	7.80 16	M1+E2	2.43 20	0.224 15		
	918.69 4	82.0 8	E1		0.00471		
	962.77 3	100.0 8	E1		0.00434		
968.2?	924 ^a	100	[E1]				B(E1)(W.u.)>2.0 $\times 10^{-8}$.
	968.9 ^a 4	12 6	[M2]		0.122		B(M1)(W.u.)>0.016.
983.09	321.75 20	1.8 7	[E1]		0.036		B(E1)(W.u.)=4.7 $\times 10^{-5}$ 24.
	378.05 13	4.4 7	[E1]		0.0255		B(E1)(W.u.)=6.8 $\times 10^{-5}$ 22.
	837.11 15	35 2	[E2]		0.0176		B(E2)(W.u.)=3.1 10.
	938.95 10	43 3	E0+E2		4.4 4		
	983.0 3	100 30	[E2]		0.0129		B(E2)(W.u.)=3.9 12.
985.45	323.98 9	2.8 1	M1+E2	2.8 8	0.29 6		
	380.29 13	2.2 2	[M1]		0.665		Mult.: From 1981Le15.
	941.38 5	100.0 10	[E1+M2]	-0.17 +1-2	0.0083 6		
1018.6?	974.5 ^a 3						
1028.537	882.63 3	3.19 2	E2		0.0159		
	984.45 2	100 1	M1+E2	>+23	0.00129		
	1028.54 2	72.6 3	E2		0.0119		Mult.: from 1981Le15.
1069.929	923.98 2	30.0 2	M1+E2	+44 +72-8	0.00145		
	1025.87 2	100	M1+E2	>+31	0.00119		
1077.7	305.9 $\frac{3}{2}$ 5	100					
1082.55	114.4 4	1.51 27	(E2)		8.67		B(E2)(W.u.)=0.46 6.
	319.29 11	2.3 3	M1+E2	1.0 5	0.66 23		
	421.14 11	6.0 2	[M1]		0.29		
	936.61 6	100.0 14	E1+M2	-0.24 4	0.009 5		B(E1)(W.u.)=2.01 $\times 10^{-8}$ 12.
1102.4	190.8 $\frac{3}{2}$ 6	60 19					
	330.5 $\frac{3}{2}$ ^a 6	35 11					
	589.9 $\frac{3}{2}$ 5	100 24	E1				A ₂ =-0.4 2; A ₄ =0.1 2.

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Adopted Levels, Gammas (continued)
 $\gamma(^{238}\text{Pu})$ (continued)

E(level)	E $\gamma^{\dagger}$	I $\gamma^{\#}$	Mult. @	$\delta^{\oplus}$	α	I(γ +ce)	Comments
1125.75	979.80 20	100					
	1081.7 3	19 7					
1174.4	1130.2 5	100					
	1174.5 5	83 22					
1202.45	119.9 1	100 4	M1 (+E2)	<0.38	3.81 21		
	132.49 11	2.4 2	[E1]		0.271		
	174.0 2	22.0 5	[E1]		0.143		
1228.65	1184.55 21	100	E2		0.0091		
	1228.7 3		E0			9.2 12	
1264.20	1118.25 21	100	[E2]		0.0102		
	1220.15 21	81 15	E0+E2+M1		0.26 3		
1310.3?	1266.2 3	100	M1		0.0268		
1340.4	238.0 6	74 25	E2				A ₂ =0.21 2; A ₄ =-0.09 2.
	262.6 ^a						E γ : From authors' figure, not in their table.
	568.5 6	100 29	E1				A ₂ =-0.20 14; A ₄ =0.05 17.
1426.4	348.8 [‡] 5	100					
1426.61	821.5 4	100	E1		0.00574		
	1426.6 3		E0			8.5 12	
1447.24	841.9 4		E0			4.4 5	
	1403.2 3	100 9	E1		0.00229		
	1447.3 3	62 4	E1		0.00217		
1458.29	1414.0 3	$\approx$ 23	E0+E2+M1				
	1458.5 3	100					
1559.82	574.0 3	77 19	M1+E2	3.2 5	0.055 6		
	597.0 3	100 12	[M1+E2]		0.12 8		
	954.7 3	$\approx$ 58	[M1+E2]		0.035 22		
	1515.9 3	79 10					
	1560.0 3	65 10					
1596.3	633.0 ^a 5	$\approx$ 77					
	1450.4 ^a 5	$\approx$ 77					
	1552.2 3	100 16					
	1596.5 5	$\approx$ 31					
1621.29	658.4 2	6.2 7	E0+E2+M1		1.39 14		
	679.5 4	8.8 9	E1		0.00809		
	1016.2 2	9.7 10	E0+E2+M1		0.66 7		
	1577.3 3	100 8	E1				
	1621.4 4	$\approx$ 0.6					
1621.8	281.5 6	100 39					A ₂ =0.25 5; A ₄ =-0.13 9.
	544.1 6	73 33	E1				A ₂ =-0.26 16; A ₄ =-0.02 22.
1636.40	653.3 5	$\approx$ 4.4					
	673.4 2		E0			3.3 4	
	1031.3 3		E0			4.2 4	
	1592.5 3	38 4					
	1636.6 3	100 9	E1				
1651.2	1607.0 4	100					
	1651.4 5	18 7					
1726.34	1682.2 3	100	E1, E2				
	1726.4 3	59 9					
1783.5	1739.4 4	48 15					
	1783.6 4	100					
1815.5	389.0 [‡] 5	100	E2				
1898.42	935.2 ^a 3	$\approx$ 27					
	1237.0 3	81 7	M1		0.0285		
	1293.2 3	100 9	M1		0.0254		
1944.6	323.1 5	100 44					
	518.3 5	57 29					
2241.7	426.2 [‡] 5	100	E2				
2308.2	363.5 5	100 48	E2				A ₂ =0.4 3; A ₄ =-0.05 45.
	492.8 5	46 46					
2702.3	460.6 5	100					
2708.7	400.5 5	100	E2				A ₂ =0.31 16; A ₄ =-0.1 2.
	467.1 5	$\approx$ 38					

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Adopted Levels, Gammas (continued) $\gamma(^{238}\text{Pu})$ (continued)

E(level)	$E\gamma^\dagger$	$I\gamma^\#$	Mult. @	Comments
3143.8	435.1 5	100 49	E2	$A_2=0.14$ 18; $A_4=-0.09$ 24.
	441.6 ^a 5	38 20		
3195.4	493.10 $\ddagger$ 17	100		
3610.6	415.7 ^a 5	40		
	466.8 5	100		$A_2=0.4$ 2; $A_4=-0.2$ 3.
3717.1	521.7 $\ddagger$ 5	100		
4105.2	494.6 6	100	E2	
4263.7	546.6 $\ddagger$ 5	100		
4623.2	518.0 $\ddagger$ 7	100		
4833.3	569.6 $\ddagger$ 6	100		
5161.3	538.5 $\ddagger$ ^a 7	100		
5426.5?	592.2 $\ddagger$ ^a 6	100		

[†] From β^- decay, α decay, and ϵ decay, except where from in-beam studies as noted.[‡] From $^{239}\text{Pu}(^{207}\text{Pb}, ^{208}\text{Pb}\gamma)$.[§] No photon was observed. ce(K) line seen.[#] Branching ratios are from β^- decay, α decay, and ϵ decay.[@] From ce data in β^- , ϵ decay, and $\gamma(0)$ in $^{239}\text{Pu}(^{207}\text{Pb}, ^{208}\text{Pb}\gamma)$.[&] Multiply placed; intensity suitably divided.^a Placement of transition in the level scheme is uncertain.^x γ ray not placed in level scheme.

Adopted Levels, Gammas (continued)

²³⁸Np β⁻ Decay

Parent ²³⁸Np: E=0.0; Jπ=2+; T_{1/2}=2.117 d 2; Q(g.s.)=1292.0 7; %β⁻ decay=100.

²³⁸Pu Levels

E(level)	Jπ [†]	T _{1/2}	Comments
0.0	0+ [‡]	87.74 y 4	
44.051 16	2+ [‡]		
145.934 21	4+ [‡]		
303.36 6	6+		
605.16 4	1-§		
661.43 4	3-§		
763.21 15	5-§		
941.54 13	0+@		
962.765 18	1-#		
968.2 3	(2-)	<8.5 ns	T _{1/2} : from delayed cey coincidence.
983.02 6	2+@		
985.47 4	2-#		
1028.542 18	2+&		
1069.924 22	3+&		
1082.53 4	(4)- ^a	8.5 ns 5	T _{1/2} : from βγ(t) (50-300β)(936.6γ)(t) (1970Be57).
1202.62 4	(3)- ^b		

[†] From adopted levels.

[‡] K=0 g.s. band.

§ K=0 octupole-vibrational band.

K=1 band.

@ K=0 β-vibrational band.

& K=2 band.

^a K=4 v 7/2[743]+v 1/2[631] proposed by 1972Wi22.

^b K=3 v 7/2[743]-v 1/2[631] proposed by 1972Wi22.

β⁻ radiations

β measurements: β feeding to each level has been deduced from γ-transition intensities. The measured β energies and intensities are compared below with the values deduced from level scheme.

1950Fr53	1955Ra28	1956Ba95	1962Bo03	from level scheme		
-----	-----	-----	-----	-----		
Eβ	Iβ	Iβ	Eβ	Iβ	Eβ	Iβ
		= 200? 8%			222 2	11.3% 6
		250 10 31%				
258 53%	55%		= 260 58% 4		263 2	45.% 4
		280 10 20%				
					329 2	1.3% 1
		1133 2.8%				
1272 47%	45%	1236 5 38%	= 1240 42% 4	1248 2	40.5% 10	

Eβ ⁻	E(level)	Iβ ^{-†}	Log ft	Comments
(89.4 7)	1202.62	0.54 5	6.6 1	
222 2	1069.924	11.51 11	6.5 1	
263 2	1028.542	44.8 5	6.1 1	δ(ΔL=1/ΔL=2)=10 +∞-3 (1990Si11), so the transition is mainly gamov-Teller.
(306.5 7)	985.47	0.521 7	8.2 1	
(309.0 7)	983.02	0.26 3	8.6 1	
(329.2 7)	962.765	1.254 13	7.9 1	
(630.6 7)	661.43	0.0384 21	10.4 1	
(686.8 7)	605.16	0.102 3	10.1 1	
1248 2	44.051	41.1 6	8.4 1	Iβ ⁻ : see comment on I(γ+ce)(44.08γ).

[†] Absolute intensity per 100 decays.

²³⁸Np β⁻ Decay (continued)

γ(²³⁸Pu)

I_γ normalization, I(γ+ce) normalization: From weighted average of the following absolute γ-ray intensities: 24.99% 34 (2012Le03), 25.6% 4 (2010Le01), 25.17% 13 (2006Re09), 25.19% 21 (1990Ch35), and 23.8% 6 (1967Sc34) for the 984.5-keV gamma ray.

γγ: 1971Wi03.

x-rays: measurements of 1981Le15 for Kα x ray and of 1972Wi22 for K_β x ray

E _γ	I _γ	
99.6	0.769 8	Kα ₂ x ray
average RI from 2006Re09 and 1981Le15.		
103.7	1.16 8	Kα ₁ x ray
average RI from 2006Re09 and 1981Le15.		
117.3	0.295	Kβ ₁ ' x ray
from 2006Re09.		
120.5	0.119	Kβ ₂ ' x ray
From RI(120.5) + RI(121.7) = 0.119 (2006Re09).		

1981Le15 normalized experimental α to α(K)(1028.54γ)=0.0088 (E2 theory).

E _γ [†]	E(level)	I _γ ^{†§}	Mult.&	δ ^a	α	I(γ+ce) [†]	Comments
44.06 2	44.051	0.395 6	E2		775	320.6 10	Mult.: from α(M)exp=175 20 (1981Le15). I(γ+ce): from ΣI(γ+ce)[(γ+ce) to g.s. excluding the 44.08γ]=76.4 7, the normalization factor 0.2519 21, and the requirement of 100% feeding of the g.s. by γ+ce, one gets I(γ+ce)(44γ)=320.6 10 and Iβ(to 44 level)=41.0% 5. From α, one then gets Iγ=0.413 5, including a 1% uncertainty assigned to the theoretical α value. 1990Ch35 report Iγ=0.35 4, and 1981Le15, based on ce data, report 0.32 4. Iγ: From I(ce) and theoretical α value. α: value given is the E2 theory value lowered by 3% (see 1987Ra01).
101.88 3	145.934	0.97 4	E2		14.8		Mult.: α(L)exp=11.2 6; (L1+L2):L3=1.61 5 (1981Le15).
114.4 4	1082.53	0.020 4	(E2)		8.67		Eγ, Iγ: from 1972Wi22. Mult.: from an intensity balance at the 968 level, α≤16; therefore, mult could be E1, M1 or E2. An intensity balance at the 1083 level gives α=11 6 which rules out E1 and pure M1. The proposed level structure requires ΔJ=2.
120.09 3	1202.62	0.42 [#] 3	M1(+E2)	<0.38	3.81 21		Mult.: from α(L)exp=2.8 6, α(M)exp=0.69 6, α(N)exp=0.23 3 (1981Le15).
132.77 50	1202.62	0.0095 8	[E1]		0.271		
157.42 5	303.36	=0.004	[E2]		2.243		Eγ, Iγ: from ²⁴² Cm α decay (1981Le15).

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²³⁸Np β⁻ Decay (continued)

γ(²³⁸Pu) (continued)

E _γ [†]	E(level)	I _γ ^{†§}	Mult.&	δ ^a	α	I(γ+ce) [†]	Comments
174.08 5 x220.87 11	1202.62	0.091 2 0.0122 14	[E1] (M2)		0.143 11.45		α(K)exp=6.7 15, α(L)exp=4.0 10 (1981Le15). E _γ ,I _γ : from 1972Wi22. 1981Le15 report I _γ <0.14. Other: 2006Re09.
301.37 7 319.26 20	962.765 1082.53	0.043 3 0.033 3	E2 M1+E2	1.0 5	0.213 0.66 23		Mult.: from ε decay. Mult.,δ: from α(K)exp=0.49 20 (1981Le15).
321.8 1	983.02	0.0048 20					I _γ : From 1981Le15. Other value: I _γ =0.0048 8 (2006Re09).
324.07 15 336.38 15	985.47 941.54	0.058 2 0.0009 5	M1+E2	2.8 8	0.29 6		Mult.: from α(K)exp=0.17 5 (1981Le15). E _γ : from ²⁴² Cm α decay (1981Le15). I _γ : from the intensity of the 897γ and the branching ratio I(336γ)/I(897γ)=0.031 15 in ²⁴² Cm α decay. (1981Le15).
357.68 9	962.765	0.200 4	M1+E2	2.43 20	0.224 15		Mult.: from α(K)exp=0.13 2 (1981Le15) and data in ε decay.
378.1 1	983.02	0.012 2					I _γ : From 1981Le15. Other value: I _γ =0.008 8 (2006Re09).
380.33 10 421.05 10 459.80 20	985.47 1082.53 763.21	0.043 3 0.086 3 0.012 1	[M1] [M1]		0.67 0.29		Mult.: see ε decay.
515.53 7	661.43	0.147 3	E1+M2 ^b	0.114 17	0.023 3		E _γ : from ²⁴² Cm α decay (1981Le15). δ: from α(K)exp in ε decay. 1990Si11 report δ=-0.2 +2-5.
561.17 5	605.16	0.419 5	E1 ^b		0.0116		δ: 1990Si11 report δ=0.3 +∞-4. δ <0.05 from α(K)exp in ε decay.
605.18 5 617.41 ^c 5	605.16 661.43	0.308 6 0.269 ^{#c} 6	E1 ^b E1+M2 ^b	0.077 17	0.0101 0.0122 13		δ: from α(K)exp in ε decay. 1990Si11 report δ=-0.2 +1-2.
617.41 ^c 836.88 7 882.63 3	763.21 983.02 1028.542	=0.03 ^{#c} 0.095 5 3.19 2	[E2] E2		0.0176 0.0159		Mult.: from α(K)exp=0.0115 8 (1981Le15).
x885.00 15 897.55 30 918.70 4	941.54 962.765	0.16 2 0.032 3 2.10 2	(E2) E1		0.0154 0.00471		E _γ ,I _γ : from 2006Re09. Mult.: from ε decay. Mult.: from α(K)exp=0.0036 8 (1981Le15). δ: 1990Si11 report δ=-0.02 +11-3. δ <0.05 from α(K)exp in ε decay.
923.99 2	1069.924	10.33 5	M1+E2	+44 +72-8	0.0145		Mult.: from α(K)exp=0.0099 4 (1981Le15) δ; from 1990Si11.
924	968.2	0.26					E _γ and I _γ measured by 1970Be57 in delayed cey coincidence.
936.60 5	1082.53	1.43 [#] 1	[E1+M2]	-0.24 4	0.009 5		δ: From 1990Si11.

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^{238}Np β^- Decay (continued) $\gamma(^{238}\text{Pu})$ (continued)

$E\gamma^\ddagger$	E(level)	$I\gamma^\ddagger$	Mult.&	δ^a	α	$I(\gamma+ce)^\ddagger$	Comments
938.85 30	983.02	0.117 7	E0+E2		4.4 4		Mult.: from $\alpha(K)\text{exp}=3.5$ 4, K/L=5.2 2 (1981Le15); K:L12:M12=72:21:7.5 (1960Al29). I γ : Other from I γ /I γ (837 γ)=0.94 22 in α decay.
941.41 4	985.47	1.98 2	[E1+M2]	-0.17 +1-2	0.0079 6		δ : from 1990Si11.
941.5 3	941.54		E0			0.042 3	Mult.: no photons were observed, Ice(K)=0.0338 25 (1981Le15).
962.76 2	962.765	2.56 2	E1		0.0043		Mult.: from $\alpha(K)\text{exp}=0.0021$ 10 (1981Le15).
968.2 4	968.2	0.032 14	[M2]		0.122		
983.0 3	983.02	0.27 8	[E2]		0.0129		E γ ,I γ : from α decay. I γ /I γ (837 γ)=2.7 8.
984.45	1028.542	100 1	M1+E2	>+23	0.0129		Mult.: from $\alpha(K)\text{exp}=0.0096$ 3; K/ L=4.4 2; (L1+L2)/L3=19 2; L/M=3.4 2 (1981Le15) $\alpha(K)\text{exp}=0.0100$ from absolute Ice measurements of 1962Bo03, and absolute I(γ)=23.8 6 measurements of 1967Sc34.
1025.87 2	1069.924	34.8 2	M1+E2	>+31	0.0119		δ : From 1990Si11. Mult.: from $\alpha(K)\text{exp}=0.0091$ 4, K/ L=4.3 3 (1981Le15).
1028.53 2	1028.542	72.5 3	E2		0.0119		δ : from 1990Si11. Mult.: from K/L=4.2 2 (1981Le15).

‡ For absolute intensity per 100 decays, multiply by 0.2515 13.

‡ From 2006Re09, unless otherwise noted. Others: 1981Le15, 1972Wi22. include their $E\gamma$ values from α decay in these weighted averages See also 1970Be57 (semi), 1970Pa22 (semi), 1962Bo03 (s ce), 1960Al29 (s ce), 1956Ba95 (s ce), 1967Sc34 and 1969GuZW (semi) see also γ and ce's observed in ^{238}Am ϵ decay, ^{242}Am α decay. Other measurements: 1950Fr53 (s ce), 1955Ra27 (s ce), 1959Ga13 (s ce).

§ Weighted average from 2006Re09, 2010Le01, 1990Ch35, 1981Le15, and 1971We22, unless otherwise noted. The I γ are normalized to I γ (984 γ)=100 others: 2009So02, 1970Pa22, 1970Be57, 1969GuZW, 1967Sc34.

$^\#$ I γ =0.269 6 for the doubly placed 617 transition. 1981Le15 divide the intensity based on band structure considerations whereby one expects I γ /I γ (459.8 γ) from the 763 5- level to be =3. The evaluators assign an uncertainty of 50% to this estimate in order to deduce I γ for placement from the 661 3- level.

$^\&$ From ce data of 1956Ba95, 1960Al29, 1962Bo03, 1981Le15. See also ϵ decay.

a Values of 1990Si11 are from low temperature nuclear orientation of $^{238}\text{Np}(\text{Gd})$.

b From ce data in ^{242}Cm α decay.

c Multiply placed; intensity suitably divided.

x γ ray not placed in level scheme.

²³⁸Np β⁻ Decay (continued)

Decay Scheme

²³⁸Am ε Decay

Parent ²³⁸Am: E=0.0; Jπ=1+; T_{1/2}=98 min 2; Q(g.s.)=2260 50; %ε+%β⁺ decay=100.

²³⁸Pu Levels

E(level)	Jπ [†]	T _{1/2}	Comments
0.0	0+ [‡]	87.74 y 4	
44.11 6	2+ [‡]		
145.99 10	4+ [‡]		
605.13 7	1- [§]		
661.38 10	3- [§]		
941.50 14	0+ [#]		
962.85 7	1-a		
983.09 14	2+ [#]		
985.53 10	2-a		
1028.57 13	2+b		
1174.4 4	(2+)		
1228.66 22	0+@		
1264.21 23	2+@		
1310.3? 3	1+, 2+		
1426.61 25	0+&		
1447.25 19	1-		
1458.31 22	2+		
1559.85 15	1-		
1596.4 3	(2+)		
1621.29 13	1-		
1636.42 14	1-		
1651.2 4	1, 2+		
1726.36 22	1, 2+		
1783.6 3	1, 2+		
1898.26? 19	2-		

E(level): proposed by the evaluators based on energy fit of three transitions.

²³⁸Am ϵ Decay (continued)

²³⁸Pu Levels (continued)

† From adopted levels.

‡ Band 1 K=0.

§ Band 2 K=0.

Band 3 K=0.

@ Band 4 K=0.

& Band 5 K=0.

^a K=1: ν 7/2[743]- ν 5/2[622].

^b K=2.

β^+, ϵ Data

I β normalization: ϵ intensities have been deduced from γ -transition intensities requiring an intensity balance at each level. ϵ intensity to the ground state has been calculated by comparing x-ray intensities expected from ϵ captures and internal conversion with the measured x-ray intensities.

E ϵ	E(level)	I β^+	I ϵ	Log <i>ft</i>	E ϵ	E(level)	I β^+	I ϵ	Log <i>ft</i>
(360 50)	1898.26?		0.66 8	6.75 19	(1000 50)	1264.21		0.35 5	8.09 8
(480 50)	1783.6		0.087 18	7.94 16	(1030 50)	1228.66		0.59 8	7.89 8
(530 50)	1726.36		0.76 10	7.12 12	(1090 50)	1174.4		0.092 16	8.75 9
(610 50)	1651.2		0.112 20	8.09 12	(1230 50)	1028.57		0.24 4	8.45 9
(620 50)	1636.42		1.89 24	6.89 11	(1270 50)	985.53		2.3 3	7.50 7
(640 50)	1621.29		4.1 5	6.58 10	(1280 50)	983.09		0.26 6	8.45 11
(660 50)	1596.4		0.151 20	8.05 10	(1300 50)	962.85		54 6	6.15 7
(700 50)	1559.85		0.58 8	7.52 10	(1320 50)	941.50		0.64 10	8.09 8
(800 50)	1458.31		0.160 23	8.21 9	(1600 50)	661.38		0.19 10	9.71 ^u 3
(810 50)	1447.25		1.12 14	7.38 9	(1650 50)	605.13	0.010 4	14.8 18	6.94 6
(830 50)	1426.61		0.34 5	7.92 9	(2220 50)	44.11	0.04 4	6 6	≥ 7.2
(950 [†] 50)	1310.3?		1.73 22	7.35 8	(2260 50)	0.0	0.08 8	11 11	≥ 7.0

[†] Existence of this branch is questionable.

$\gamma(^{238}\text{Pu})$

I γ normalization: Normalization obtained from K x ray/ γ .

$\gamma\gamma$, γce : 1972Ah04.

x-ray:

E γ	I γ (relative to I(962.8 γ)=100)		
99.5 1	82 5	K α_2 x ray	1972Ah04
103.8 1	124 8	K α_1 x ray	1972Ah04
117.1 2	46 3	K β_1 ' x ray	1972Ah04
120.6 2	16 1	K β_2 ' x ray	1972Ah04

ce intensities were normalized such that $\alpha(\text{K})(962.8\gamma)=0.0035$ (E1 theory).

E $\gamma^{\dagger}$	E(level)	I $\gamma^{\dagger}$ #	Mult.@	δ	α	I($\gamma+\text{ce}$) [†]	Comments
44.1 1	44.11	0.23 3	E2		775		Mult.: $\alpha(\text{L12})_{\text{exp}}=296\ 30$; L12:L3:M:N=68 7; 57 6; 43 5; 14.6 15. α : value given is the E2 theory value lowered by 3% (see 1987Ra01).
101.9 1	145.99	0.24 2	E2		14.8		Mult.: from L3/L12=0.62 9. I γ : photon obscured by K x rays. Value is from (I ϵ (L))=2.6 3 and $\alpha(\text{L})$. From an intensity balance at the 146 level one deduces I γ =0.137 13, suggesting additional feeding to the 146 level.

Continued on next page (footnotes at end of table)

^{238}Am ϵ Decay (continued) $\gamma(^{238}\text{Pu})$ (continued)

$E\gamma^{\dagger}$	E(level)	$I\gamma^{\dagger}\#$	Mult.@	δ	α	$I(\gamma+ce)^{\dagger}$	Comments
301.5 1	962.85	1.80 15	E2		0.213		Mult.: from $\alpha(K)\text{exp}=0.089$ 9 and $K:L12:L3:M:N=0.16$ 2:0.15 2:0.055 6:0.075 8: ≈ 0.034 .
324.2 3	985.53	0.22 3	M1+E2	2.8 8	0.29 6		α : δ gives $\alpha=0.27$ +7-4. Mult.: $\alpha(L12)\text{exp}=0.15$ and $M/L12=0.37$ agree with $\text{mult}=M1$; however, $\alpha(K)\text{exp}$ in β^- decay gives $\text{mult}=M1+E2$ with $\delta=2.8$ 8. If mult were M1, the ce(K) line would have had an intensity of 0.18, a value large enough to have been seen. Note that the ce(K) line of the 301.5 γ , with $\text{Ice}(K)=0.16$ is reported. The evaluators adopt the assignment from β^- decay.
357.7 1	962.85	7.5 5	M1+E2	2.43 20	0.224 15		Mult., δ : from $\alpha(K)\text{exp}=0.16$ 2, $L12/K=0.41$ 4, and also $\alpha(K)\text{exp}=0.13$ 2 from β^- decay.
380.3 2	985.53	0.159 13	[M1]		0.665		$E\gamma, I\gamma$: transition not observed. $I\gamma$ is from $I\gamma/I\gamma(941\gamma)=0.0199$ 10 in β^- decay and $E\gamma$ is a rounded-off value from β^- decay. Mult.: from $\text{Ice}(L12)=0.035$ and deduced $I\gamma$, one gets $\alpha(L12)\text{exp}=0.22$ compared with theory values of 0.034 for E2 and 0.10 for M1. The placement requires $\Delta J=1$ and $\Delta\pi=\text{no}$.
515.4 2	661.38	1.40 13	E1+M2	0.114 17	0.023 3		Mult., δ : from $\alpha(K)\text{exp}=0.018$ 2. 1990Si11 report $\delta=-0.2$ +2-5 in β^- decay.
561.0 1	605.13	39.0 23	E1		0.0116		Mult.: from $\alpha(K)\text{exp}=0.0092$ 10. $M/L=0.087$.
^x 565.8 3		0.55 7					
574.0 3	1559.85	0.4 1	M1+E2	3.2 5	0.055 6		Mult.: from $\alpha(K)\text{exp}=0.038$ 4.
597.0 3	1559.85	0.52 6	[M1+E2]		0.12 8		
605.1 1	605.13	27.0 16	E1		0.0101		Mult.: from $\alpha(K)\text{exp}=0.0078$ 8. $K:L12:M=0.21$ 2:0.035 4:0.024 3. $\delta(M2/E1)<0.05$.
617.4 2	661.38	2.6 2	E1+M2	0.077 17	0.0122 13		Mult., δ : from $\alpha(K)\text{exp}=0.0096$ 10. 1990Si11 report $\delta=-0.2$ +1-2 in β^- decay.
633.0 $\& 5$	1596.4	≈ 0.2					
653.3 $\& 5$	1636.42	≈ 0.2					
658.4 2	1621.29	0.64 7	E0+E2+M1		1.39 14		Mult.: from $\alpha(K)\text{exp}=1.08$ 11. $K:L12:M=0.69$ 7:0.147 15:0.04.
^x 665.2 2			E0				Mult.: no photon was observed. $\text{Ice}(K)=0.052$ 6.

Continued on next page (footnotes at end of table)

²³⁸Am ε Decay (continued)

γ(²³⁸Pu) (continued)

Eγ [†]	E(level)	Iγ [†] #	Mult.@	δ	α	I(γ+ce) [†]	Comments
673.4 2	1636.42		E0			0.15 2	Mult.: no photons were observed. I(γ+ce): Ice(K)=0.12, Ice(L12)=0.026.
679.5 4 x749.2	1621.29	0.91 9	E1 E0				Mult.: from α(K)exp<0.009. Mult.: no photon was observed. Ice(K)=0.024 3.
821.5 4 (837.1 2)	1426.61 983.09	1.1 1 0.13 3	E1 [E2]		0.0176		Mult.: from α(K)exp<0.008. Eγ,Iγ: transition was not observed in ε decay. Iγ is deduced from Iγ(837γ)/Iγ(939γ)=1.06 25 in α decay and Eγ is a rounded-off value from β ⁻ decay and α decay.
841.9 4	1447.25		E0			0.106 11	Mult.: no photons were observed. I(γ+ce): Ice(K)=0.084 9 and assumptions that L/K=0.22 and M+/L=0.3.
(882.6 1)	1028.57	0.0153 15	E2		0.0159		Eγ,Iγ: not observed in ε decay. E is a rounded-off value from β ⁻ decay, and Iγ is from Iγ/Iγ(984γ+1028γ)=0.01866 19 in β ⁻ decay. Mult.: from β ⁻ decay.
x884.3 3 897.3 2	941.50	0.47 6 2.0 2	(E2)		0.0154		Mult.: from α(K)exp=0.008 mult=E1 or E2. The placement requires Δπ=no.
x908.8 2 918.7 1	962.85	0.78 7 82 5	M1 E1		0.0646		Mult.: α(K)exp=0.055 6. Mult.: from α(K)exp=0.0037 4.
935.2 §& 3 939.0 2	1898.26? 983.09	≈0.3 0.121 13	E0+E2		4.4 4		δ(M2/E1)<0.05. Iγ: no photons were observed in ε decay. Iγ is deduced from Ice(K)=0.42 4 and (Ice(L)=0.082 8 (with M+/L taken as 0.3) and α=4.4 4 from β ⁻ decay.
941.4 1 941.5 2	985.53 941.50	8.0 5	[E1+M2] E0	-0.17 +I-2		1.18 11	Mult.: from β ⁻ decay. Mult.,δ: from β ⁻ decay. Mult.: no photons observed. Ice(K)=0.93 10, Ice(L12)=0.19 2.
954.7 3 962.8 1	1559.85 962.85	≈0.3 100	[M1+E2] E1		0.035 22 0.0043		Mult.: from β ⁻ decay. Ice(K) normalized to 0.35. K:L12:L3:M=(0.35):0.066 7:≈0.005:0.013 2.
(983.0 3)	983.09	0.34 9	[E2]		0.0129		Eγ,Iγ: transition was not observed in ε decay. Iγ is deduced from Iγ/Iγ(939γ)=2.8 8 in α decay and Eγ is from α decay.
984.0 5	1028.57	0.41 5	M1+E2	>+23	0.0129		Mult.: from β ⁻ decay. α(K)exp=0.012 in ε decay.

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²³⁸Am ε Decay (continued)

^γ(²³⁸Pu) (continued)

E ^γ [†]	E(level)	I ^γ [†] #	Mult. @	α	I(γ+ce) [†]	Comments
1016.2 2	1621.29	1.0 1	E0+E2+M1	0.66 7		Mult.: from α(K)exp=0.51 5. K:L12:M=0.51 5:0.103 11:0.025 3.
1028.5 4	1028.57	0.41 6	E2	0.0119		Mult.: from β ⁻ decay.
1031.3 3	1636.42		E0		0.188 19	Mult.: no photons were observed. I(γ+ce): Ice(K)=0.143, Ice(L12)=0.034.
^x 1097.3 3		1.1 1	(E2)	0.0105		Mult.: α(K)exp=0.006.
1118.2 3	1264.21	0.63 7	[E2]	0.0102		
1130.2 5	1174.4	0.18 3				
1174.5 5	1174.4	0.15 3				
1184.5 3	1228.66	1.90 16	E2			Mult.: from α(K)exp=0.0074 8. L12/K=0.31 0.0091.
1220.1 3	1264.21	0.50 6	E0+E2+M1	0.26 3		Mult.: from α(K)exp=0.21 2, L12/K=0.17 3.
^x 1226.4 3		0.16 3				
1228.7 3	1228.66		E0		0.175 16	Mult.: no photons were observed. I(γ+ce): Ice(K)=0.143 15, Ice(L12)=0.024 3.
^x 1231.3 3		0.15 3				
1237.0 §& 3	1898.26?	0.89 8	M1	0.0285		Mult.: from α(K)exp=0.022.
1266.2 3	1310.3?	6.0 4	M1	0.0268		Mult.: from α(K)exp=0.021 2. K:L12:M=0.123:0.02: =0.0054.
1293.2 §& 3	1898.26?	1.1 1	M1	0.0254		Mult.: from α(K)exp=0.020 2. L12/K=0.14.
^x 1368.8 5		≈0.2				
1403.2 3	1447.25	2.4 2	E1			Mult.: from α(K)exp=0.0013.
1414.0 3	1458.31	≈0.1	E0+E2+M1	≈0.27		Mult.: from α(K)exp=0.22. L12/K=0.18. Ice(K)=0.022 3.
1426.6 3	1426.61		E0		0.093 10	Mult.: no photons were observed. I(γ+ce): Ice(K)=0.075 8, Ice(L12)=0.0133 14.
1447.3 3	1447.25	1.5 1	E1			Mult.: from α(K)exp<0.002.
1450.4 §& 5	1596.4	≈0.2				
1458.5 3	1458.31	0.44 5		0.0062		
^x 1501.7 5			E0			Mult.: no photon was observed. Ice(K)=0.053 6.
1515.9 3	1559.85	0.41 5				
^x 1551.0 5			E0			Mult.: no photon was observed. Ice(K)=0.008.
1552.2 3	1596.4	0.26 4				
1560.0 3	1559.85	0.34 5				
1577.3 3	1621.29	10.3 8	E1			Mult.: from α(K)exp=0.001.
1592.5 3	1636.42	1.70 17				
1596.5 5	1596.4	≈0.08				
1607.0 4	1651.2	0.34 5				
1621.4 4	1621.29	≈0.06				
1636.6 3	1636.42	4.5 4	E1			Mult.: from α(K)exp=0.0013.
1651.4 5	1651.2	0.06 2				
1682.2 3	1726.36	1.70 17	E1, E2			Mult.: from α(K)exp=0.0029.
1726.4 3	1726.36	1.0 1				
1739.4 4	1783.6	0.10 2				
^x 1761.5 4		0.32 4				
1783.6 4	1783.6	0.21 5				
^x 1789.0 5		≈0.04				
^x 1835.1 5		0.12 3				

[†] For absolute intensity per 100 decays, multiply by 0.28 3.

[‡] Measurements of 1972Ah04 (semi) are given here. E_γ's measured by 1972PoZS agree with those of 1972Ah04.

[§] Unplaced by authors. Placement suggested by the evaluators on the basis of energy fit (2002Ch52).

[#] From 1972Ah04. Measurements of 1972PoZS are in agreement with those of 1972Ah04.

[@] From ce measurements of 1972Ah04 (semi) in ²³⁸Am ε decay, and from ²⁴²Cm α decay, ²³⁸Np β decay data.

[&] Placement of transition in the level scheme is uncertain.

^x γ ray not placed in level scheme.

²³⁸Am ε Decay (continued)

Decay Scheme

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

1+ 0.0 98 min
²³⁸Am₁₄₃
 %ε+%β⁺=100
 Q⁺=2260⁵⁰

²³⁸Am ε Decay (continued)

Decay Scheme (continued)

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

1+ 0.0 98 min
²³⁸Am₁₄₃
 %ε+%β⁺=100
 Q⁺=2260⁵⁰

²⁴²Cm α Decay

Parent ²⁴²Cm: E=0.0; Jπ=0+; T_{1/2}=162.86 d 8; Q(g.s.)=6215.56 8; %α decay=100.

²⁴²Cm-T_{1/2}: From 2002Ch52 evaluation.

Q(α) 6215.56 8 from 1995Au04.

αγ: 1963Bj03, 1964Ba31.

γγ: 1960As10, 1955As64.

αγ(θ): 1953Mo74.

T_{1/2} from 1986LoZT.

X-Rays: M_{α,β}:L_e:L_α:L_{η,β}:L_γ= 30 3:4.9 8: 66. 7: 100 16: 23. 3 (1990Po14).

²³⁸Pu Levels

E(level)	Jπ [†]	T _{1/2}	Comments
0.0	0+	87.74 y 4	
44.08 3	2+	177 ps 5	T _{1/2} : from 1970To08. Other: 183 ps 15 (1960Be25).
146.00 5	4+		
303.42 7	6+		
513.62 16	8+		
605.08 7	1-		
661.28 11	3-		
763.22 12	5-		
941.44 9	0+		
962.72 8	1-		
983.00 9	2+		
1018.6? 3			
1028.62 5	2+		
1125.79 17	(4+)		
1228.69 22	0+		
1264.29 22	2+		

[†] From adopted levels.

α radiations

Eα [‡]	E(level)	Iα ^{†§}	HF	Comments
4869.43 23	1264.29	5.2×10 ⁻⁷ 15	5.9 18	
4904.44 23	1228.69	5.5×10 ⁻⁷ 15	10 3	
5005.64 19	1125.79	3.1×10 ⁻⁷ 8	88 23	
5101.21 10	1028.62	3.7×10 ⁻⁶ 8	32 7	
5111.1 3	1018.6?	≤2×10 ⁻⁷	≥686	
5146.07 12	983.00	1.7×10 ⁻⁶ 4	137 33	Iα: 1966Ba07 report Iα≤5×10 ⁻⁶ .
5165.95 16	962.72	1.13×10 ⁻⁶ 21	278 52	
5186.95 12	941.44	3.6×10 ⁻⁵ 7	11.9 24	Iα: weighted average of 3.4×10 ⁻⁵ 8 (1963Bj01), 2.5×10 ⁻⁵ 8 (1966Ba07, with a 30% uncertainty assigned by the evaluators), and 3.5×10 ⁻⁵ 7 from the γ intensities.
5366.22 15	763.22	2.2×10 ⁻⁷ 3	24432	
5462.47 14	661.28	1.26×10 ⁻⁵ 24	1712 32	
5517.75 11	605.08	2.5×10 ⁻⁴ 5	183 22	Iα: weighted average of 2.8×10 ⁻⁴ 5 (1963Bj01), 2.5×10 ⁻⁴ 6 (1966Ba07, with a 20% uncertainty assigned by the evaluators), and 2.6×10 ⁻⁴ 5 from the γ intensities.
5607.76 16	513.62	2×10 ⁻⁵	7544	Eα: 1966Ba07 report 5614.
5816.39 11	303.42	0.0046 5	458 50	Iα: from 1966Ba07. Eα: measured values are 5811 (1953As14), 5809 2 (1958Ko87), and 5816 (1966Ba07).
5969.24 9	146.00	0.035 2	395 23	Iα: from 1958Ko87. Other: 0.0046 (1966Ba07). Eα: measured values are 5964 (1953As14), 5961 2 (1958Ko87), 5971 3 (1963Dz07), and 5971.4 (1966Ba07).
6069.43 12	44.08	25.92 6	1.733 5	Iα: from 1963Dz07. Other: 0.035 (1953As14), 0.030 1 (1958Ko87), 0.036 (1966Ba07). Eα: energy adjusted by 1991Ry01 due to change in calibration energy.
6112.72 8	0.0	74.08 7	1.000	Iα: from 1998Ya17. Others: 26.3 5 (1953As14), 26.5 5 (1958Ko87), and 25.8 (1966Ba07). Eα: from 1991Ri01. Iα: from 1998Ya17. Others: see 44 level. ΣI(a to g.s. +44 level)=100.

Footnotes continued on next page

²⁴²Cm α Decay (continued)

α radiations (continued)

† Absolute intensity per 100 decays.

‡ Except for the g.s. and 44 level, the Eα values are obtained from Q(α) and the E(level) values. Experimental values are listed where available. Values are reported by 1971Gr17 (s), 1971Bb10 (s), 1966Ba07 (s), 1963Bj03 (αγ), 1963Dz07 (s), 1958Ko87 (s), and 1953As14 (s).

§ Deduced from level scheme of 1981Le15, unless otherwise noted. See also 2002Ch52.

γ(²³⁸Pu)

Iγ normalization, I(γ+ce) normalization: 1981Le15 deduce Iγ(561γ)=0.00015% 4 based on their relative Iγ data and a previous unpublished value by the authors, based on αγ, of the sum of intensities per 100 α decays for the 515, 561, 605, and 617 γ's.

Eγ [‡]	E(level)	Iγ ^{†§}	Mult.#	δ [#]	α	I(γ+ce) [†]	Comments
44.08 ^{@ 3}	44.08	0.03345 ^{& 8}	E2		775	25.96 ^{& 6}	α: the value given is the E2 theory value lowered by 3% (see 1987Ra01). Iγ: an unweighted average of the directly measure Iγ values gives Iγ=0.033 3.
101.93 4	146.00	0.00253 ^{& 12}	E2		14.8	0.040 ^{& 2}	Iγ: a weighted average of the directly measured values is 0.0033 8. An unweighted average is 0.0055 13.
157.42 5	303.42	0.00142 ^{& 15}	[E2]		2.24	0.0046 ^{& 5}	Iγ: a weighted average of the directly measured values is 0.0020 5.
210.20 14	513.62	1.2×10 ⁻⁵ ^{&}	E2		0.73	2×10 ⁻⁵ ^{&}	Eγ: from in-beam studies. Not seen in α decay.
336.38 15	941.44	7×10 ⁻⁷ 3	[E1]				Iγ: Iγ(336)/Iγ(561)=0.0045 15.
357.62 ^{@ 7}	962.72	4.5×10 ⁻⁸ 9	M1+E2	2.43 20	0.224 15		Iγ: from Iγ/Iγ(919γ+963γ)=0.0424 11 in β ⁻ decay. Note that there is an unplaced 358.0 5 transition with Iγ=5.9×10 ⁻⁷ 25, part of which probably corresponds to the 358γ from the 962 level.
459.80 20	763.22	6×10 ⁻⁸ 3					Iγ: Iγ(459.8)/Iγ(561)=0.00038 16.
515.25 19	661.28	4.5×10 ⁻⁶ 12	E1+M2	0.114 17	0.023 3		Iγ: Iγ(515)/Iγ(561)=0.0297 20.
561.02 10	605.08	1.5×10 ⁻⁴ 4	E1		0.0116		
605.04 10	605.08	1.0×10 ⁻⁴ 3	E1		0.0101		Iγ: Iγ(605)/Iγ(561)=0.698 20.
617.22 ^{b 12}	661.28	7.9×10 ⁻⁶ ^{ba 21}	E1+M2	0.077 17	0.0122 13		Iγ: Iγ(617)/Iγ(561)=0.0525 20.
	763.22	1.6×10 ⁻⁷ ^{ba}					Iγ: Iγ(617)/Iγ(561)=0.0011.

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^{242}Cm α Decay (continued) $\gamma(^{238}\text{Pu})$ (continued)

$E\gamma^{\ddagger}$	E(level)	$I\gamma^{\ddagger\S}$	Mult.#	$\delta^{\#}$	α	$I(\gamma+ce)^{\dagger}$	Comments
837.01 15	983.00	1.9×10^{-7} 6	[E2]		0.0176		$I\gamma: I\gamma(837)/I\gamma(561)=$ 0.00124 20.
(882.63 3)	1028.62	6.7×10^{-8} 15	(E2)		0.0159		$E\gamma, I\gamma$: not seen in α decay. E is from β^- decay, and $I\gamma$ is from $I\gamma/I\gamma(984\gamma+1028\gamma)=$ 0.01866 19 in β^- decay.
897.33 10	941.44	2.2×10^{-5} 6	(E2)		0.0154		$I\gamma: I\gamma(897)/I\gamma(561)=$ 0.145 10.
918.7 2	962.72	5.4×10^{-7} 15	E1		0.00471		$I\gamma: I\gamma(918)/I\gamma(561)=$ 0.0036 3.
938.91 10	983.00	1.8×10^{-7} 6	E0+E2		4.4 4		α : from β^- decay. $I\gamma: I\gamma(939)/I\gamma(561)=$ 0.00117 20.
941.5 2	941.44		E0			1.3×10^{-5} 4	$E\gamma$: from ϵ decay. $I(\gamma+ce)$: from $I(\gamma+ce)/I\gamma(897\gamma)=$ 0.59 8 in ϵ decay. 1960As10 report 0.62 in α decay. The value of 1.4 2 in β^- decay appears to be discrepant.
962.8 2	962.72	5.3×10^{-7} 15	E1		0.00434		$I\gamma: I\gamma/I\gamma(561\gamma)=$ 0.0035 3.
974.5 ^c 3	1018.6?	$\leq 2 \times 10^{-7}$					
979.80 20	1125.79	2.6×10^{-7} 8					$I\gamma: I\gamma(979)/I\gamma(561)=$ 0.00173 30.
983.0 3	983.00	5.0×10^{-7} 18	[E2]		0.0129		$I\gamma: I\gamma(983)/I\gamma(561)=$ 0.0033 8.
984.5 1	1028.62	2.0×10^{-6} 6	M1+E2	>+23	0.00129		$I\gamma: I\gamma(984)/I\gamma(561)=$ 0.0131 20.
1028.5 2	1028.62	1.6×10^{-6} 5	E2		0.0119		$I\gamma: I\gamma(1028)/I\gamma(561)=$ 0.0105 10.
1081.7 3	1125.79	5.0×10^{-8} 20					$I\gamma: I\gamma(1081)/I\gamma(561)=$ 0.00033 10.
1118.3 3	1264.29	1.7×10^{-7} 9	[E2]				$I\gamma: I\gamma(1118)/I\gamma(561)=$ 0.0011 5.
1184.6 3	1228.69	5.0×10^{-7} 15	E2				$I\gamma: I\gamma(1184)/I\gamma(561)=$ 0.0033 4.
1220.2 3	1264.29	2.8×10^{-7} 9	E0+E2+M1		0.26 3		$I\gamma: I\gamma(1220)/I\gamma(561)=$ 0.00187 30.
(1228.7 3)	1228.69		E0			4.6×10^{-8} 15	$E\gamma$: from ϵ decay. $I(\gamma+ce)$: from $I(\gamma+ce)/I\gamma(1184\gamma)=$ 0.092 11 in ϵ decay.

[†] Absolute intensity per 100 decays.[‡] From 1981Le15, except where noted otherwise.[§] From 1981Le15, except where noted otherwise.[#] From adopted gammas. ce measurements have been made in α decay by 1952Du12, 1956Ba95, 1956Sm18, 1960As10, and 1965Ak02.[@] From β^- decay.[&] $I(\gamma+ce)$ is deduced from the requirement of an intensity balance utilizing the γ branchings and the γ and α feedings. $I\gamma$ is then deduced from $I(\gamma+ce)$ and α .^a 1981Le15 report $E=617.22$ 12 with $I\gamma/I\gamma(561\gamma)=0.0536$ 20 for a doubly placed transition. The authors divide the intensity on the basis of model-dependent arguments.^b Multiply placed; intensity suitably divided.^c Placement of transition in the level scheme is uncertain.

242Cm α Decay (continued)

Decay Scheme

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

238U(α ,4n γ) 1983Ha31

E=40 MeV.

238Pu Levels

E(level)	$J\pi^\dagger$
0.0	0+
44.08 $\frac{3}{2}$	2+
145.95 $\frac{3}{2}$	4+
303.38 $\frac{3}{2}$	6+
513.4	8+
772.8	10+
1078.5	12+
1427.2	14+
1816.2	16+
2240.5	18+

 † From adopted levels. $\frac{3}{2}$ Rounded-off value from adopted levels. **$\gamma(^{238}\text{Pu})$**

$E\gamma$	E(level)	Mult.	I(γ +ce) †	Comments
210.0	513.4	E2	67 4	Mult.: from ce(L2)/ce(L3).
259.4	772.8		40 2	
305.7	1078.5		28 2	
348.7	1427.2		12 1	

Continued on next page (footnotes at end of table)

²³⁸U(α ,4n γ) ¹⁹⁸³Ha31 (continued)

 $\gamma(^{238}\text{Pu})$ (continued)

E_γ	E(level)	I(γ +ce) [†]
389.0 3	1816.2	6 1
424.3 4	2240.5	4 1

[†] The quoted numbers were normalized to I(γ +ce)(10+ to 8+)=40.

Level Scheme

Intensities: relative
I(γ +ce)

Coulomb Excitation

²³⁸Pu(α , α') E=17 MeV (1973Be44,1974Mc15).

Quadrupole and hexadecupole parameters were deduced by 1973Be44 from B(E2) and B(E4) values.

For calculated deformation parameters see 1970Ga12, for example.

²³⁸Pu Levels

E(level) [†]	J π	T _{1/2}	Comments
0.0 [‡]	0+		
44.08	2+	174 ps 3	B(E2) [†] =12.63 17 (1973Be44). T _{1/2} : from B(E2) and α =775. This α is the E2 theory value lowered by 3% (see 1987Ra01). Other B(E2): 12.58 35 (1971Fo17).
146 [‡]	4+		B(E4) [†] =1.9 7 (1973Be44).
661 [§]	3-		B(E3) [†] =0.71 12 (1974Mc15).
983 [#]	2+	0.55 ps +15-11	B(E2) [†] =0.166 22 (1974Mc15). T _{1/2} : from B(E2) with I γ (983 γ)=30% +7-6.

[†] Rounded-off values from adopted levels.

[‡] (A): K=0 g.s. band.

[§] (B): K=0 octupole-vibrational band.

[#] (C): K=0 β -vibrational band.

²³⁹Pu(d,t) 1973Fr01

Q(d,t)=604 10.

E=12 MeV, FWHM=15 KeV, estimated by the evaluators.

The ratio of the cross sections for populations of the K π =0+ excited states to those for the population of the ground state were compared, and these ratios were found to be of the same order of magnitude as the ratios for the (p,t) reaction. It was suggested by 1973Fr01 that weak pairing between oblate and prolate levels would not explain the comparable relative populations of the K π =0+ states in (p,t) and (d,t) reactions.

²³⁸Pu Levels

E(level)	J π [†]
0.0	0+
44	2+
146	4+
943	0+
984	2+
1228	0+
1264	2+

[†] Adopted values.

²³⁹Pu(²⁰⁷Pb,²⁰⁸Pb γ) 2007WaZV

2007WaZV: ²³⁹Pu(²⁰⁷Pb,²⁰⁸Pb γ), Gammasphere; measured $\gamma\gamma$. Extended Yrast band beyond 26+ given by 1993De12. Observed K π =0- octupole band. No transtions observed from Yrast to K π =0- band. The intensities given relative within the same band.

1993De12: (¹¹⁷Sn,¹¹⁸Sn γ) E(¹¹⁷Sn)=630 MeV. Includes ²³⁹Pu(⁹⁰Zr,⁹¹Zr) data as quoted by 1993De12 from M. A. Stoyer, LBL-29357 (1990), Reference 3 in 1993De12.

²³⁸Pu Levels

E(level) [†]	J π	E(level) [†]	J π	E(level) [†]	J π
0.0 [‡]	0+	1101.8 [§] 13	9-	3194.5 [‡] 16	22+
43.4 [‡] 10	2+	1339.8 [§] 14	11-	3610.2 [§] 16	23-
145.3 [‡] 12	4+	1426.0 [‡] 14	14+	3716.2 [‡] 17	24+
302.2 [‡] 13	6+	1621.3 [§] 14	13-	4104.8 [§] 17	25-
511.9 [‡] 13	8+	1815.0 [‡] 15	16+	4262.8 [‡] 18	26+
(605.2 [§])	1-	1944.3 [§] 14	15-	4622.8 [§] 19	27-
(661.4 [§])	3-	2241.2 [‡] 15	18+	4832.4 [‡] 19	28+
(763.2 [§])	5-	2307.8 [§] 15	17-	5161.3 [§]	(29-)
771.3 [‡] 13	10+	2701.8 [‡] 16	20+	5426.5 [‡] 9	(30+)
910.9 [§] 13	7-	2708.3 [§] 15	19-		
1077.2 [‡] 14	12+	3143.4 [§] 16	21-		

[†] From least-squares fit to E γ .

[‡] (A): g.s. Band.

[§] (B): K π =0- Octupole Vibrational Band.

γ (²³⁸Pu)

E γ	E(level)	I γ [†]	Mult. [‡]	Comments
(43.4)	43.4			
101.9 5	145.3	100 13	E2	
156.9 5	302.2	125 25	E2	A ₂ =0.25 13; A ₄ =-0.2 2.
190.8 6	1101.8	84 26		
209.70 5	511.9	155 34	E2	A ₂ =0.24 3; A ₄ =-0.11 4.
238.0 6	1339.8	130 44	E2	A ₂ =0.21 2; A ₄ =-0.09 2.
259.4 5	771.3	164 36	E2	A ₂ =0.24 6; A ₄ =-0.17 10.
262.6 [§]	1339.8			E γ : From authors' figure, not in their table.
281.5 6	1621.3	163 63		A ₂ =0.25 5; A ₄ =-0.13 9.
305.9 5	1077.2	135 35	E2	A ₂ =0.16 3; A ₄ =-0.13 4.

Continued on next page (footnotes at end of table)

²³⁹Pu(²⁰⁷Pb, ²⁰⁸Pbγ) 2007WaZV (continued)

γ(²³⁸Pu) (continued)

Eγ	E(level)	Iγ [†]	Mult. [‡]	Comments
323.1 5	1944.3	150 66		
330.5 § 6	1101.8	49 16		
348.8 5	1426.0	112 30	E2	A ₂ =0.24 5; A ₄ =-0.14 7.
363.5 5	2307.8	127 61	E2	A ₂ =0.4 3; A ₄ =-0.05 45.
389.0 5	1815.0	89 25	E2	A ₂ =0.18 11; A ₄ =-0.08 17.
400.5 5	2708.3	107 52	E2	A ₂ =0.31 16; A ₄ =-0.1 2.
415.7 § 5	3610.2	33 19		
426.2 5	2241.2	57 17	E2	A ₂ =0.33 5; A ₄ =-0.15 8.
435.1 5	3143.4	100 49	E2	A ₂ =0.14 18; A ₄ =-0.09 24.
441.6 § 5	3143.4	38 20		
460.6 5	2701.8	47 14	E2	A ₂ =0.24 4; A ₄ =-0.04 6.
466.8 5	3610.2	82 28		A ₂ =0.4 2; A ₄ =-0.2 3.
467.1 5	2708.3	41 69		
492.7 5	3194.5	26 10	E2	A ₂ =0.22 4; A ₄ =-0.07 6.
492.8 5	2307.8	58 58		
494.6 6	4104.8	53 23	E2	A ₂ =0.5 3; A ₄ =-0.1 5.
518.0 7	4622.8	35 16		
518.3 5	1944.3	86 43		
521.7 5	3716.2	20 8	E2	A ₂ =0.20 9; A ₄ =-0.15 11.
538.5 § 7	5161.3			
544.1 6	1621.3	119 53	E1	A ₂ =-0.26 16; A ₄ =-0.02 22.
546.6 5	4262.8	14 6		
568.5 6	1339.8	175 51	E1	A ₂ =-0.20 14; A ₄ =0.05 17.
569.6 6	4832.4	8 4		
589.9 5	1101.8	140 33	E1	A ₂ =-0.4 2; A ₄ =0.1 2.
592.2 § 6	5426.5?	2.0 14		
608.7 § 5	910.9	99 25		

[†] Relative to Iγ(101.9γ) in g.s. band and Iγ(435.1γ) in Kπ=0- band.

[‡] From γ(0). Quadrupole transitions are assumed to be E2 and dipoles as E1.

§ Placement of transition in the level scheme is uncertain.

$^{239}\text{Pu}(^{207}\text{Pb}, ^{208}\text{Pb}\gamma)$ 2007WaZV (continued)

Level Scheme

Intensities: relative I_γ **$^{240}\text{Pu}(p,t)$ 1974Fr01** $Q(p,t) = -3692.15$. $E = 16.5$ MeV, FWHM = 15 keV estimated by the evaluators. ^{238}Pu Levels

E(level)	$L^\dagger$	$S^\ddagger$
0.0	0	1.84
45	1	(2)
146	2	(4)
306	2	(6)
945	3	0.25
985	2	(2)
1032	2	(2)
1134	4	(0)
1252	2	0.05

† From angular distributions. The L Ne 0 angular distributions were not determined uniquely (1974Fr01). The parentheses for L Ne 0 are added by the evaluators.

 $^{240}\text{Pu}(\text{p,t})$ **1974Fr01 (continued)**

 ^{238}Pu Levels (continued)

$\ddagger$ $\sigma(\text{exp})/\sigma(\text{DWBA})$ See 1974Fr01 for the optical-potential parameters used. For calculated (p,t) strengths to 0+ levels, see 1972Va20, 1972Ab10, 1973Im02.

Adopted Levels

$Q(\beta^-) = -1022.52$; $S(n) = 6219$ SY; $S(p) = 3959.51$; $Q(\alpha) = 6042.50$ 2012Wa38.

$\Delta S(n) = 78$ syst (2012Wa38).

Cluster Decay:

$^{238}\text{Am}(^{28}\text{Mg})$, $^{238}\text{Am}(^{33}\text{Si})$ (2012Ba35).

$^{238}\text{Am}(^{32}\text{Si})$ (2011Sh13).

Fission: 2009Mo18, 2005Re16.

Calculated t, $Q(\alpha)$: 2008Do12.

Superdeformed states: 2001Ma74.

 ^{238}Am Levels

E(level)	$J\pi$	$T_{1/2}$	Comments
0.0	1+	98 min 2	<p>$\% \alpha = 1.0 \times 10^{-4}$ 4 (1972Ah04); $\% \epsilon + \% \beta^+ = 100$.</p> <p>From log ft values of ϵ decays to 0+...3- levels, $J\pi(^{238}\text{Am}) = 1+$ or 2-. $J\pi = 2-$ is ruled out from ratios of ft values for ϵ feeding to band members.</p> <p>Configuration = $((\pi 5/2[523]) - (\nu 7/2[743]))$, in analogy to ^{241}Am for the proton state, and to ^{235}U for the neutron state (see 1972El21 for systematics of odd-nucleon states).</p> <p>$T_{1/2}$: rounded-off value from 97.8 min (1972PoZS). Others: 98 min 3 (1972Ah04), 112 min 5 (1960Gl01), earlier measurement (1950St61).</p>
≈ 2500		35 μs	<p>$\% \text{SF} \leq 100$.</p> <p>$\% \text{SF}$: only SF decay observed.</p> <p>$T_{1/2}(\text{SF})$ and $T_{1/2}(\gamma)$ were calculated by 1972We09 as 93 μs and 510 s, respectively.</p> <p>$T_{1/2}$: from 1969JoZU. This value supersedes that of 60 μs 15 from 1967Bo23.</p> <p>Assignment: $^{239}\text{Pu}(p, 2n)$ excit (1967Bo23, 1972Br35), $^{237}\text{Np}(\alpha, 3n)$ excit (1973Fl03).</p> <p>E(level): SF isomeric level energy was calculated: $E = 2.29$ MeV (1972We09), $E = 2.72$ MeV (1971Br39).</p> <p>Other calculations: 1970Ja16, 1972Ma11. See 1971Br39 and 1972We09 for calculations of double-humped barrier parameters.</p>

Adopted Levels

Q(β⁻)=-4770 SY; S(n)=7874 72; S(p)=4415 SY; Q(α)=6670 10 2012Wa38.

Db=-255 syst, ΔS(p)=61 syst (2012Wa38).

Assignment: ²³⁹Pu(α,5n) chem, p ²³⁴Pu (6.1-MeV a) 1952Hi63.

2006As03: Produced in ²³⁷Np(⁶Li,5n), E=41-48 MeV at isol facility, measured a(t). Others (same authors): 2003Na10, 2002As08, 2002AsZX.

Delayed fission after ε+β⁺ decay of ²³⁸Bk was observed by 1994Kr03 and 1994La25, but energy level of shape isomer is unknown.

Others:

Discovery of ²³⁸Cm: 2013Fr02.

Nuclear Reactions: ²⁰⁸Pb(³⁰Si,X) ²³⁸Cm (2013Du17).

Alpha decay, calculated T_{1/2}: 2013Ra05, 2013Se17, 2013Wi05, 2013Zd01, 2012Co10, 2012Is08, 2012Po01, 2012Pr09, 2011Zh36, 2010Is01, 2009Ni06, 2009Qi07, 2008Ro06, 2001Mo07.

Calculated Q(α): 2010Wa23.

Cluster decay: ²³⁸Cm(³⁸Si): 2012Ba25; ²³⁸Cm(³⁰Si): 2012Ku29; ²³⁸Cm(³⁴Si): 2012Sa31, 2011Sh13,.

Fission: 2009Mo18.

²³⁸Cm Levels

E(level)	Jπ	T _{1/2}	Comments
0.0	0+	2.2 h 4	%α=3.84 18; %ε=96.16 18; %SF=0.048 2. T _{1/2} : From 2006As03 a(t). Others: 2.5 h (1948St43) and 2.3 h (1952Hi63). ε/6520α=240 50 from disintegration rate and α decay rate (1952Hi63). 1952Hi63 believe that possible systematic errors in counting efficiency could reduce this value by a factor of 3 or 4. %α is obtained from estimated %α to g.s., from systematics of HF and relative Iα to 2+ sate in ²³⁴ Pu. Revised Eα to ²³⁴ Pu g.s. is 6558 10 (2006As03). %SF from ef-K x ray coin (1994Kr03). T _{1/2} (α) systematics for g.s.-to-g.s. transitions from even curium isotopes suggests that α branching is about 5%. Systematics of radius parameter r ₀ suggests that α branching is about 4%. Large uncertainties on measured E(α) and T _{1/2} give an upper limit of 10% for the α branching.
35 7	2+		E(level): from α decay of ²⁴² Cf.

²³⁸Bk ε Decay 1994Kr03

Parent ²³⁸Bk: E=0; Jπ=?; T_{1/2}=144 s 5; Q(g.s.)=4893 syst; %ε+%β⁺ decay=100.

1994Kr03: ²⁴¹Am(α,7n), E=75 MeV, assignment by chemical separation, observation of daughter a activity. Measured ef, ef-K x ray coin.

²³⁸Cm Levels

E(level)	Jπ	T _{1/2}
0.0	0+	2.2 h 4

²⁴²Cf α Decay

Parent ²⁴²Cf: E=0.0; Jπ=0+; T_{1/2}=3.49 min 12; Q(g.s.)=7516 4; %α decay=?

Q(α)=7516 4 from 1995Au04.

²³⁸Cm Levels

E(level)	Jπ [†]
0.0	0+
35 7	2+

[†] from adopted levels.

²⁴²Cf α Decay (continued)

α radiations

Eα [†]	E(level)	Iα [‡]	HF	Comments
7358 6	35	≈20	≈2.7	α hindrance-factor systematics suggest that ratio of I(7392α)/I(7358α) should be 70/30.
7392 4	0.0	≈80	1.0	

[†] From 1991Ry01. Measurements: 1970Si19 (semi), 1967Fi04, 1967Si07, 1967Il01.

[‡] From 1970Si19.

Adopted Levels 1994Kr03,1994La25

Q(β^-)=-3061 SY; S(n)=7043 SY; S(p)=2320 SY; Q(α)=7330 SY 2012Wa38.
 $\Delta Q(\beta^-)$ =392 syst, $\Delta S(n)$ =340 syst, $\Delta S(p)$ =265 syst, $\Delta Q(\alpha)$ =200 syst (2012Wa38).
 Assignment: ²⁴¹Am(α ,7n) chem,parent of ²³⁸Cm (1994Kr03), ²⁰⁹Bi,²⁰⁸Pb(HI,X) chem (1994La25).

²³⁸Bk Levels

E(level)	T _{1/2}	Comments
0.0	144 s 5	% ϵ +% β^+ =100 (1994Kr03); % ϵ F=0.048 20 (1994Kr03). % ϵ +%B: No α branch was observed (1994Kr03). T _{1/2} : from 1994Kr03. Other: T _{1/2} =2 Min (1994La25). 1994Kr03 and 1994La25 observed delayed fission with probability 4.8×10^{-4} 20 (1994Kr03).

²⁴²Es α Decay 2010An08

Parent ²⁴²Es: E=0; J π =?; T_{1/2}=17.8 s 16; Q(g.s.)=8250 syst; % α decay=43 3.
²⁴²Es-T_{1/2}: Measured in 2010An08. Other: 11 S 3 (2000SH10), 16 D +6-4 (2006NI09).
²⁴²Es-Q(α): 8250 150 (sys,2003Au03,2009AuZZ).
²⁴²Es-% α decay: % α =43 3, % ϵ =57 3 (2010An08, private communication to evaluators).
²⁴²Es source from ²⁴⁶Md α decay.
²⁴⁶Md was produced via ²⁰⁹Bi(⁴⁰Ar,3N). ⁴⁰Ar beam with E=187 and 198 MeV bombarded a 0.450 $\mu\text{g}/\text{cm}^2$ metallic ²⁰⁹Bi target evaporated on a 40 $\mu\text{g}/\text{cm}^2$ Carbon backing. The target was covered with a 10 $\mu\text{g}/\text{cm}^2$ Carbon foil. The experiments were performed at the velocity filter SHIP at GSI.
 Measured: E γ , I γ , ce, E α , $\alpha\gamma$ coin, α (ce) coin, (recoil) α , (recoil) $\alpha\gamma$ coin, half-lives, α decay branching ratios.
 Detection system in the focal plane of SHIP consisted of two time-of-flight detectors, an array of position-sensitive Si detectors detectors, and a Ge clover detector.
 No decay scheme is given.

α radiations

E α	I $\alpha^\dagger$	Comments
7870 90	=95	E α : 7780 to 7960 region (2010An08).
8025 20	=5	

† For α intensity per 100 decays, multiply by 0.43 3.

$\gamma(^{238}\text{Bk})$

E γ

^x86.6
^x107.0
^x122.4

^x γ ray not placed in level scheme.

Adopted Levels 1995La09

S(n)=8731 SY; S(p)=3200 SY; Q(α)=8129 SY 2012Wa38.
2012Wa38: ΔS(n)=311 syst, ΔS(p)=373, ΔQ(α)=299 syst.
1995IA09: ²⁰⁸Pb(³⁴S,4n),²⁰⁷Pb(³⁴S,3n),²⁰⁶Pb(³⁴S,2n),²⁰⁶Pb(³⁶S,4n), E=215 MeV. Measured σ, SF.
2001Og03: ²⁰⁷Pb(³⁴S,3n), E=160.5–180.2 MeV, measured σ, SF.
2010Kh06: ²⁰⁴Pb(³⁶S,2n), E=170–173 MeV, measured σ, SF, a.

²³⁸Cf Levels

E(level)	Jπ	T _{1/2}	Comments
0 . 0	0+	21 . 1 ms <i>I3</i>	%SF>95 (2010Kh06); %α<5 (2010Kh06). T _{1/2} : weighted average: 22 ms 5 (2010Kh06),21 ms 2 (1995La09), 21.1 ms + <i>I9–I7</i> (2001Og08).

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