Adopted Levels, Gammas

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	M. S. Basunia	NDS 107,2323 (2006)	15-Mar-2006

Q(β^-)=−1.48×10^3 *syst*; S(n)=5880.7 *21*; S(p)=5.57×10^3 *5*; Q(α)=5748.3 *23* 2012Wa38
Note: Current evaluation has used the following Q record −1480 syst 5880.7 *21* 5570 50 *5748.4 23* 2003Au03.
ΔQ(β^-)=60(syst) 2003Au03.
Calculation of energies and wavefunctions for nonrotational states was reported in 1971Ko31 and 1982Li02.

^{237}Pu Levels

The configurations given below are the dominant components.

Cross Reference (XREF) Flags

A	^{241}Cm α decay	D	^{239}Pu(p,t)
B	^{237}Am ε decay	E	^{237}Pu IT decay (0.18 s)
C	^{238}Pu(d,t)		

E(level)†	Jπ‡	$T_{1/2}$	XREF	Comments
0.0@	7/2−	45.64 d *4*	ABC E	%α=0.0042 *4*; %ε=99.9958 *4* α branching was calculated from γ intensities measured in α and ε decays of ^{237}Pu (1979El05) (see ^{237}Pu α decay). %α=0.0033 *3* was calculated from α activities of ^{237}Pu, ^{236}Pu in a source with known fractions, and K x-ray counting (1957Th10). Other: a%=0.0020 *4* in 1957Ho68. Jπ: 145.544γ from 1/2$^+$ level is E3. ε decay to ^{237}Np, α decay of ^{241}Cm, and (d,t) data are consistent with the assignment. $T_{1/2}$: Weighted average of 44.66 d *4* (1994Ta25), 45.63 d *20* (1957Th10,1957Ho68), 45.3 d *2* (1977Sm02), and 45.12 d *3* (1981Ba15).
47.71@ *4*	9/2−		ABC	Jπ: 47.71γ M1+E2 to 7/2− state; (d,t) data.
106@ *5*	11/2−		A C	Jπ: (d,t) data; fit to band.
145.543& *8*	1/2+	0.18 s *2*	ABCDE	%IT=100 Jπ: L=0 in ^{239}Pu(p,t) reaction; (d,t) data. $T_{1/2}$: From $\alpha\gamma$(t) in ^{241}Cm α decay.
155.456& *12*	3/2+		ABC	Jπ: 9.903γ M1+E2 to 1/2+ state; α hindrance factor; (d,t) data.
175@ *7*	13/2−		A C	Jπ: (d,t) and ^{241}Cm α decay data; fit to the rotational band.
201.179& *12*	5/2+		ABCD	Jπ: 45.724γ to 3/2+ is M1+E2, 55.638γ to 1/2+ state is (E2); (d,t), (p,t) and ^{241}Cm α decay data.
224.25& *5*	7/2+		ABCD	Jπ: 68.8γ (E2) to 7/2+ state; (d,t) and ^{241}Cm α decay data; fit to the rotational band.
257@	15/2−		C	Jπ: (d,t) data; fit to the rotational band.
280.222a *14*	5/2+		BC	Jπ: 280.22γ E1 to 7/2− state; 124.72γ to 3/2+ state is not E2.
304& *4*	9/2+		A CD	Jπ: (d,t) reaction; fit to the rotational band.
320.970a *16*	7/2+		B	Jπ: 40.748γ M1+E2 to 5/2+ state, 321.0γ E1 to 7/2−, 273.3γ to 9/2− state.
370.40b *4*	3/2+		AB	Jπ: 224.86γ (M1) to 1/2+ state, it is not pure E2 or pure E1; therefore, J^π Ne 5/2, 1/2−, 3/2−; and J^π Ne 1/2+ from log *ft*=7.33 for ε branch in 5/2$^{(-)}$ ^{237}Am ε decay.
371a *5*	9/2+		C	Jπ: (d,t) data; fit to the rotational band.
404.19b *5*	5/2+		ABC	Jπ: M1+E2 γ transitions to 3/2+, 5/2+, 7/2+ states. Low α hindrance factor is probably due to Coriolis interaction of the 3/2[631] band with the 5/2[633] and 1/2[631] bands.

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Adopted Levels, Gammas (continued)

^{237}Pu Levels (continued)

E(level)[†]	Jπ[‡]	XREF	Comments
407.82[c] 6	5/2+	BCD	Jπ: 183.7γ and 252.2γ to 7/2+ and 3/2+ states, respectively, are M1(+E2).
438.41[c] 7	7/2+	BC	Jπ: 438.4γ E1 and 390.7γ E1 to 7/2− and 9/2− states, respectively , log *ft*=6.57 for ε branch from 5/2(−) ^{237}Am ε decay rules out 9/2+.
453.29[b] 14	7/2+	BC	Jπ: 455.8γ M1 from 7/2+ state; log *ft*=7.53 for ε branch in 5/2(−) ^{237}Am ε decay; fit to the rotational band.
473.52[d] 7	7/2+	BC	Jπ: 473.5, 425.8 γ's to 7/2−, 9/2− states are E1; log *ft*=6.7 for ε branch in ^{237}Am ε decay.
486[c]	(9/2+)	C	Jπ: (d,t) data.
513[b]	9/2+	C	Jπ: (d,t) data; fit to the rotational band.
545[e]	(1/2−)#	C	Jπ: 1/2[501] band assignment.
582[e]	(5/2−)#	C	Spin assignment is tentative.
591[e]	(3/2−)#	C	Jπ: Band member.
655		c	This level, observed in (d,t) reaction, may be identical to the 655.3-keV, 5/2−, K=5/2 level observed in ^{237}Am ε decay. See the comment on Nilsson assignment for the band based on 655.3-keV level.
655.39[f] 15	(5/2)−	Bc	Jπ: 655.3γ to 7/2− g.s. is M1; populated in ^{237}Am ε decay. Energy difference from the 7/2− state at 696.2 keV (which yields A=5.8) suggests that these levels are members of a K=5/2 band.
691[e]	(7/2−)#	C	Jπ: Band member. Spin assignment is tentative.
696.14[f] 15	7/2−	B	Jπ: 696.2, 648.5 gammas to 7/2−, 9/2− states are M1; log *ft*≤7.5 for ε branch from 5/2(−) ^{237}Am ε decay.
716		C	
741		C	
757		C	
775		C	
800[g] 2	1/2+	D	Jπ: L=0 in (p,t).
809		C	
840		C	
851 5	3/2+,5/2+	D	Jπ: L=2 in ^{239}Pu(p,t) reaction. This level may be the 5/2+ member of K=1/2 band at 800 keV.
852		C	5/2−, 5/2[503] state assignment was tentatively proposed in (d,t) dataset (1973Gr26).
884		C	
908.90 12	7/2+	B	Jπ: 501.2 and 435.2 gammas to 5/2+ and 7/2+ states are M1, 861.2γ to 9/2− level. The 7/2[613] state assignment was proposed from ^{237}Am ε decay (1975Ah05).
933		C	
964		C	
998 5		cD	
1000.6 3	3/2+,5/2,7/2	Bc	Jπ: log *ft* of 7.13 for the ε branch from 5/2(−) ^{237}Am and 1000.6γ to 7/2− state suggest J^{π}=3/2+, 5/2±, or 7/2±.
1014		C	3/2−, 3/2[501] state assignment was tentatively proposed in 1973Gr26 from (d,t) data.
1025 3		D	
1053		C	
1104		C	
1189		C	
1216		C	
1250		C	
1264		C	
1348		C	
1383		C	
1397		C	
1463		C	
1481		C	
1534		C	

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Adopted Levels, Gammas (continued)

^{237}Pu Levels (continued)

E(level)†	$T_{1/2}$	XREF	Comments
26.0×10^2 *20*	97 ns *4*		%SF>0 SF decay observed. Other decay mode not reported. E(level): From 1978De07 (fit to excitation function)- ΔE=200 by the evaluator. 2900 *200* in 1971Br39 (fit to excitation function), 3400 *200* from threshold energies (1970Bu02), 3100 *150* from fit to excitation function (1973Va16), 2300 *200* recommended in 1973Br38 from lowest threshold. $T_{1/2}$: Weighted average of 77 ns *16* (1979Gu03), 120 ns *30* (1969VaZX), 60 ns *20* (1969Me11,1971Re11), 120 ns *50* (1970Bu02), 88 ns *35* (1971Ru03), 114 ns *12* (1971Te07), 100 ns *50* and 120 ns *50* (1971Br39), 130 ns *20* (1972Vi10), 110 ns *9* (1974Ba82), 110 ns *30* (1969La14), 85 ns *7* (1982Ra04). Other: 60 ns (1970Po01; reevaluated measurement of 1969La14), 70 ns (1972Ga42). For calculated level energy and $T_{1/2}$(level), see 1972We09, 1990Bh02. For calculations and evaluations of fission-barrier parameters see, for example, 1972We09, 1976Ga11, 1978Fl05, 1980Bj02, 1981Re06, 1984Ku05. g=−0.45 *3* by perturbed angular distribution of fission fragments (1982Ra04, 1983Ra36). J^π: for suggested spins and discussions, see 1971Ru03, 1972Vi10, 1973Va16, 1975Ha09, 1975Kh06, 1979Gu03, 1980Bj02, 1980Li15, 1982Ra04, 1984Du03.
29.0×10^2 *25*	1.1 μs *1*		%SF>0 Only SF decay has been observed, it is not established whether the level decays by γ to the 85-ns SF isomer or by SF only, or both. E(level): from fit to excitation functions, 1973Va16 deduced that 1.1−μs isomer is 300±150 keV above the 82-ns (97-ns in current evaluation) isomer. $T_{1/2}$: Weighted average of 900 ns *150* (1970Po01), 1120 ns *80* (1971Ru03), 950 ns *300* (1971Te07), 1000 ns *200* (1972Vi10), 1310 ns *260* (1974Ba82), 1050 ns *400* (1979Gu03). Assignment: ^{237}Np(d,2n) exit (1970Po01). g=+0.14 *2* by time-dependent, perturbed angular distribution of fission fragments (1974Ka06). For suggested spins see 1979Gu03, 1984Du03, for example.

† From a least squares fit to the adopted γ-ray energies.

‡ Assignments are based on the measured absolute cross sections in (d,t) data, expected pattern of the rotational bands, and deduced L transfer values.

From (d,t) data.

@ Band(A): 7/2[743] band.

& Band(B): 1/2[631] band.

a Band(C): 5/2[622] band.

b Band(D): 3/2[631] band.

c Band(E): 5/2[633] band.

d Band(F): 7/2[624] band.

e Band(G): 1/2[501] band.

f Band(H): K=5/2 band. 5/2[752] Nilsson assignment was proposed by analogy to 633-keV level in ^{235}U (1975Ah05). Large log *ft* values (7.1 and 7.5) for the allowed feedings from ^{237}Am decay to $5/2^-$ and $7/2^-$ levels are consistent with the fact that 5/2[752] is a hole state. ε transitions from 5/2[523] state could be hindered by a factor of 10 because of N-forbiddenness. However, if the level seen in (d,t) at 655 keV is the state seen at 655.3 keV in ^{237}Am decay, the observed (d,t) cross section is not consistent with $5/2^-$, 5/2[752] assignment. A possible assignment could be $5/2^-$, 5/2[503] state. This assignment was tentatively proposed for a level observed at 852 keV in (d,t) (1973Gr26).

g Band(I): K=1/2 : 0^+ phonon coupled to 1/2[631] state. If 851-keV level is $5/2^+$ member of this band, and if decoupling parameter a=−0.47, same as that of 1/2[631] band, then band parameter A=5.2. $3/2^+$ member would be expected at about 808 keV.

Adopted Levels, Gammas (continued)

γ(^{237}Pu)

E_i(level)	J_i^π	E_γ[†]	I_γ[‡]	E_f	J_f^π	Mult.[#]	δ[#]	α[@]	Comments
47.71	9/2$^-$	47.71 *4*	100	0.0	7/2$^-$	M1+E2	0.24 *8*	79 *15*	
145.543	1/2$^+$	145.542 *8*	100	0.0	7/2$^-$	E3		51.6	B(E3)↓=0.028 *4* B(E3)(W.u.)=0.028 *4* E_γ: weighted average of 145.536 *9* (^{241}Cm α decay) and 145.552 *12* (^{237}Am ε decay). The unweighted average is 145.544 *8*.
155.456	3/2$^+$	9.903 *16*	100	145.543	1/2$^+$	M1+E2	0.07 *2*	3.2×10^3 *10*	
201.179	5/2$^+$	45.724 *8*	46 *12*	155.456	3/2$^+$	M1+E2	0.47 *13*	170 *60*	
		55.638 *11*	100 *16*	145.543	1/2$^+$	(E2)		261	
224.25	7/2$^+$	68.8 *1*	100	155.456	3/2$^+$	(E2)		94.2	
280.222	5/2$^+$	79.05 *2*	0.42 *7*	201.179	5/2$^+$	(M1)		12.0	
		124.72 *3*	0.59 *11*	155.456	3/2$^+$	(M1)		15.1	
		280.23 *2*	100 *5*	0.0	7/2$^-$	E1		0.0484	
320.970	7/2$^+$	40.748[&] *6*	2.0[&] *4*	280.222	5/2$^+$	M1+E2	0.19 *3*	123 *14*	
		273.3 *1*	54 *4*	47.71	9/2$^-$				
		321.0 *1*	100 *8*	0.0	7/2$^-$	E1		0.036	
370.40	3/2$^+$	214.9 *2*	100 *21*	155.456	3/2$^+$	(M1)		3.23	
		224.86 *4*	100 *21*	145.543	1/2$^+$	(M1)		2.85	
404.19	5/2$^+$	123.8 *3*	≈7	280.222	5/2$^+$				
		179.94 *2*	41 *9*	224.25	7/2$^+$	(M1(+E2))	0.7 *7*	4.0 *14*	
		203.03 *5*	71 *9*	201.179	5/2$^+$	M1(+E2)	0.4 *4*	3.4 *5*	
		248.7 *2*	100 *10*	155.456	3/2$^+$	(M1(+E2))	0.6 *6*	1.7 *5*	
407.82	5/2$^+$	127.5 *2*	17 *4*	280.222	5/2$^+$				
		183.7 *2*	30 *8*	224.25	7/2$^+$	M1(+E2)	0.7 *7*	3.8 *13*	
		206.7 *1*	52 *7*	201.179	5/2$^+$	M1(+E2)	0.3 *3*	3.4 *2*	
		252.2[a] *2*	43[a] *12*	155.456	3/2$^+$	M1(+E2)	0.6 *6*	1.6 *5*	
		407.8 *1*	100 *8*	0.0	7/2$^-$	(E1)		0.0218	
438.41	7/2$^+$	158.3 *3*	0.8 *3*	280.222	5/2$^+$				
		390.7 *1*	6.6 *5*	47.71	9/2$^-$	E1		0.0238	
		438.4 *1*	100 *5*	0.0	7/2$^-$	E1		0.0188	
453.29	7/2$^+$	229.1 *3*	100 *34*	224.25	7/2$^+$				
		252.2[a] *2*	100[a] *34*	201.179	5/2$^+$				
		453.2 *3*	67 *14*	0.0	7/2$^-$				
473.52	7/2$^+$	193.4 *3*	2.1 *7*	280.222	5/2$^+$				
		425.8 *1*	45 *3*	47.71	9/2$^-$	E1		0.0200	
		473.5 *1*	100 *7*	0.0	7/2$^-$	E1		0.0161	
655.39	(5/2)$^-$	655.3 *2*	100	0.0	7/2$^-$	M1		0.153	
696.14	7/2$^-$	40.748[&] *6*	[&]	655.39	(5/2)$^-$				
		648.5 *3*	100 *16*	47.71	9/2$^-$	M1		0.158	
		696.2 *3*	77 *16*	0.0	7/2$^-$	M1		0.131	

$^{237}_{94}Pu_{143}$-4

Adopted Levels, Gammas (continued)

γ(^{237}Pu) (continued)

E_i(level)	J_i^π	E_γ[†]	I_γ[‡]	E_f	J_f^π	Mult.[#]	α[@]
908.90	7/2$^+$	435.2 *3*	9.6 *16*	473.52	7/2$^+$	M1	0.462
		455.8 *3*	3.5 *8*	453.29	7/2$^+$	M1	0.407
		501.2 *3*	10.8 *16*	407.82	5/2$^+$	M1	0.315
		504.8 *3*	7.3 *16*	404.19	5/2$^+$	M1	0.309
		861.2 *3*	14.2 *16*	47.71	9/2$^-$		
		908.8 *2*	100 *6*	0.0	7/2$^-$		
1000.6	3/2$^+$,5/2,7/2	720.4 *5*	100 *21*	280.222	5/2$^+$		
		1000.6 *3*	79 *21*	0.0	7/2$^-$		

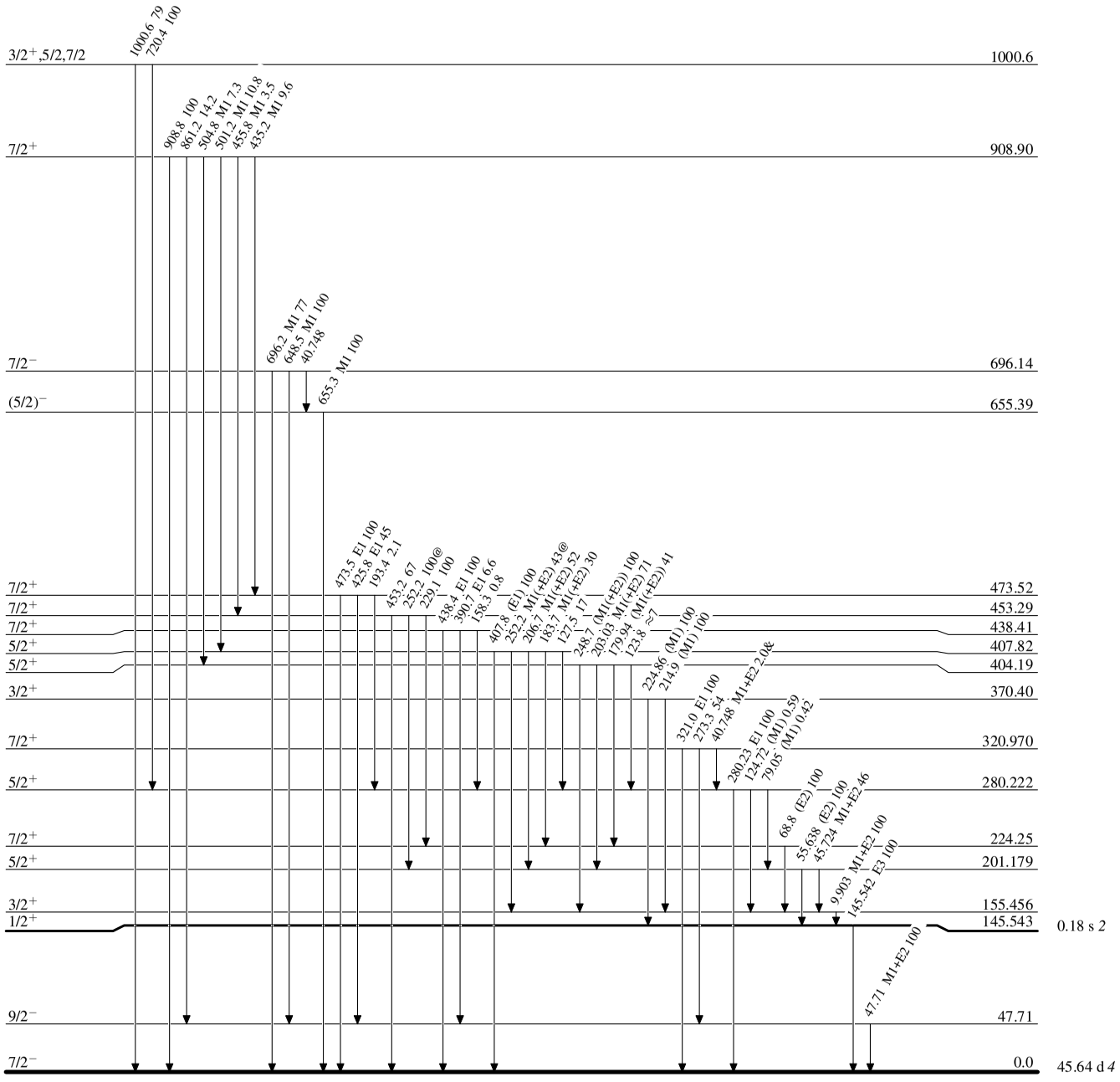
[†] Except for 145.544γ, all energies are from ^{237}Am ε decay.
[‡] From ^{237}Am ε decay.
[#] From ce measurements in ^{237}Am ε decay.
[@] Total theoretical internal conversion coefficients, calculated using the BrIcc code (2008Ki07) with Frozen orbital approximation based on γ-ray energies, assigned multipolarities, and mixing ratios, unless otherwise specified.
[&] Multiply placed with undivided intensity.
[a] Multiply placed with intensity suitably divided.

$^{237}_{94}Pu_{143}$-5

Adopted Levels, Gammas

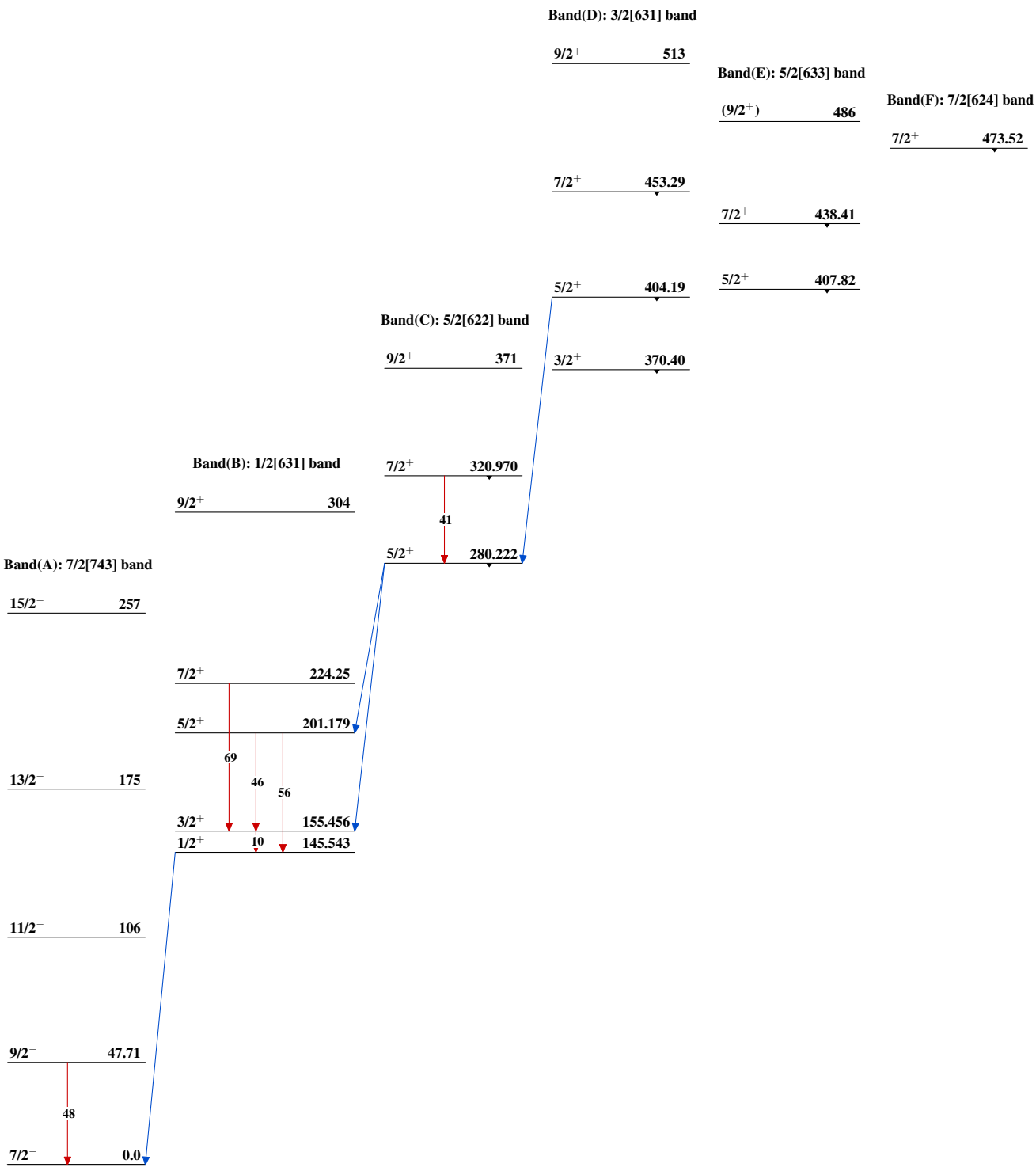
Level Scheme

Intensities: Relative photon branching from each level
& Multiply placed: undivided intensity given
@ Multiply placed: intensity suitably divided



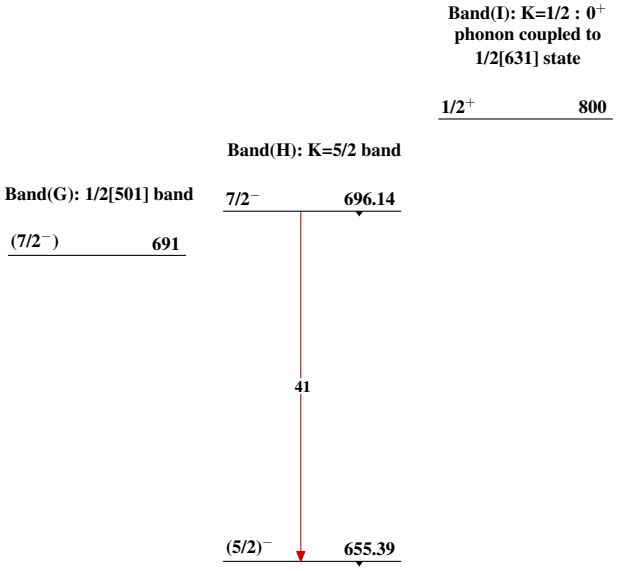
$^{237}_{94}Pu_{143}$

Adopted Levels, Gammas



$^{237}_{94}Pu_{143}$

Adopted Levels, Gammas (continued)



(3/2−) 591

(5/2−) 582

(1/2−) 545

$^{237}_{94}Pu_{143}$