Adopted Levels, Gammas

History			
Type	Author	Citation	Literature Cutoff Date
Full Evaluation	P. K. Joshi, B. Singh, S. Singh, A. K. Jain	NDS 138, 1 (2016)	15-Oct-2016

Q(β^-)=−2806 *28*; S(n)=9761 *16*; S(p)=4541 *12*; Q(α)=−603 *12* 2012Wa38
S(2n)=17762 *11*, S(2p)=12258 *8* (2012Wa38).

^{139}Pr Levels

Band assignments are from (^{19}F,4nγ) (2012Ye06).

Cross Reference (XREF) Flags

A	^{139}Nd ε decay (29.7 min)	E	^{139}La(^{3}He,3nγ)	I	^{140}Ce(p,2nγ):delayed
B	^{139}Nd ε decay (5.50 h)	F	^{139}La(α,4nγ):prompt	J	^{141}Pr(p,t)
C	^{124}Sn(^{19}F,4nγ)	G	^{139}La(α,4nγ):delayed	K	^{142}Nd(p,α),(pol p,α)
D	^{130}Te(^{14}N,5nγ)	H	^{140}Ce(p,2nγ):prompt		

E(level)	J$^\pi$[†]	T$_{1/2}$	XREF	Comments
0.0	5/2$^+$	4.41 h *4*	ABCDEFGHIJK	%ε+%β^+=100 J$^\pi$: spin from ABMR (1972Ek04); π from L(p,t)=0 from 5/2$^+$ target; also $\sigma(\theta)$ and A$_y(\theta)$ in (pol p,α). T$_{1/2}$: from 1968Li08 (γ decay; Ge(Li)). Others: 4.42 h *8* (1975Vy02), 4.92 h *8* (1963Bi20), 4.5 (1954Ha68), 4.5 h *2* (1951St03).
113.92 *5*	7/2$^+$[#]	2.60 ns *8*	ABCDEFGHI K	μ=1.19 *21* (1983AkZY) μ: perturbed angular correlation method in 29.7-min decay (1983AkZY). T$_{1/2}$: from 5.5-h ε decay. Other: 2.5 ns *2* (1964So03).
405.11 *7*	3/2$^+$		A EF H JK	J$^\pi$: $\sigma(\theta)$ and A$_y(\theta)$ in (pol p,α); M1 γ to 5/2$^+$.
589.41 *7*	5/2$^+$		A E HIJK	J$^\pi$: M1 γs to 3/2$^+$ and 7/2$^+$.
624			K	
821.98[e] *7*	11/2$^-$	43.4 ns *16*	BCDEFGHI K	μ=+6.6 *5* (1979Ke07,2014StZZ) J$^\pi$: from $\gamma\gamma(\theta)$ in 5.5-h ε decay and mult′s of deexciting. γ′s. T$_{1/2}$: weighted av of 45.5 ns *9* and 44 ns *4* from (p,2nγ), 43 ns *2* from (^{3}He,3nγ), and 36.8 ns *20* and 40 ns *2* from ε decay (5.5 h). Others: 35.5 ns *7* (1972Mo23), ≈36 ns (2012BhZZ, 2011Mu20). μ: TDPAD method in (p,2nγ) (1979Ke07). Other: +7.2 *6* (TDPAD, 1982Ri09).
827.92 *9*	9/2$^+$		B EF H JK	J$^\pi$: $\sigma(\theta)$ and A$_y(\theta)$ in (pol p,α); ΔJ=2, E2 γ to 5/2$^+$.
851.87 *9*	11/2$^+$		BCDEF HI K	J$^\pi$: stretched E2 to 7/2$^+$; $\sigma(\theta)$ and A$_y(\theta)$ in (pol p,α).
916.92 *23*	(1/2,3/2,5/2)$^+$		A H JK	J$^\pi$: L(p,t)=2 from 5/2$^+$ target; β feeding from 3/2$^+$ parent.
1009			K	
1023.92 *19*	9/2$^+$		B EF HIJ	J$^\pi$: 5/2$^+$, 9/2$^+$ from $\gamma(\theta)$ in (p,2nγ) and E2 γ to 7/2$^+$. ≠5/2$^+$ from E1 γ from 9/2$^-$,11/2$^-$.
1074.21 *21*	(1/2$^+$,3/2,5/2)[‡]		A	
1124.02 *11*			F	
1154			K	
1311.8 *4*	1/2$^-$		A jK	J$^\pi$: $\sigma(\theta)$ and A$_y(\theta)$ in (pol p,α).
1328.43 *21*	(3/2$^+$,5/2)[‡]		A jK	
1369.68 *12*	(9/2$^-$,13/2$^-$)		B EF HI	J$^\pi$: $\gamma(\theta)$ in (p,2nγ) and M1 γ to 11/2$^-$.
1405.5 *5*	(1/2$^+$,3/2,5/2)[‡]		A	
1449.0 *10*	3/2$^-$		A K	J$^\pi$: $\sigma(\theta)$ and A$_y(\theta)$ in (pol p,α).

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Adopted Levels, Gammas (continued)

^{139}Pr Levels (continued)

E(level)	Jπ†	T1/2	XREF	Comments
1478			K	
1492			A K	
1501.3 *4*	(1/2+,3/2,5/2)‡		A jk	
1523.11[e] *9*	13/2−		ABCDEFGHIj	Jπ: M1+E2 γ to 11/2− and M1 γ from 15/2−.
1532.0 *10*	(1/2+,3/2,5/2)‡		A jK	
1584.28 *22*			B H	
1624.32 *10*	9/2−		B HIJK	Jπ: 9/2−, 11/2− from E1 γ to 9/2+; log *ft*=6.4 via 11/2− parent. γ to 7/2+; L(p,t)=1,3 from 5/2+ gives negative parity. May be a doublet. See comment on branching ratios.
1650	1/2+		K	Jπ: σ(θ) and A_y(θ) in (pol p,α).
1722.18[e] *10*	15/2−		BCDEFGHI	Jπ: from γ(θ) in (p,2nγ) and E2 γ to 11/2−.
1762			K	
1790.23 *22*	13/2+		EF H K	XREF: K(1783). Jπ: σ(θ) and A_y(θ) in (pol p,α); stretched E2 cascade to 9/2+.
1834.00 *9*	(9/2−,11/2−)&		B EF H K	$β_2$=1.35 *4* (1982PrZV) $β_2$: from γ(θ,H,t) in 5.5-h decay.
1857			K	
1867.6 *4*	(15/2)+		CDEF HI	Jπ: stretched E2 cascade to 11/2+.
1908	7/2+		K	Jπ: σ(θ) and A_y(θ) in (pol p,α).
1926.91 *10*	(11/2,13/2)−&		B H K	
1941.51[e] *11*	17/2−		CDE HI	Jπ: Stretched M1 γ to 15/2−. No feeding to levels with J≥13/2.
1942.0 *7*			EFGH	
1952	5/2+		K	Jπ: σ(θ) and A_y(θ) in (pol p,α).
1975			K	
2029.52 *14*			H jK	
2048.58 *11*	9/2−,11/2−@		B jK	Jπ: also L(p,t)=1,3 for a level at 2050 keV *30*.
2050.1 *7*			E j	
2097			K	
2127			jK	
2149			jK	
2174.50 *12*	9/2−#		B E jK	Jπ: also L(p,t)=(3) for a level at 2160 keV *50*.
2187.49[e] *12*	(19/2)−	≈9 ns	CDEFGHI	Jπ: from γ(θ) in (α,4nγ) and M1+E2 γ to (17/2)−. $T_{1/2}$: from γγ(t) in ^{130}Te(^{14}N,5nγ) (2012BhZZ).
2196.46 *11*	9/2−,11/2,13/2−		B j	Jπ: log *ft*=6.1 via 11/2− parent; γs to 9/2− and 13/2−. Also L(p,t)=(3) for a level at ≈2240 from 5/2+ target suggests negative parity.
2205.8 *5*			E jK	
2277.97 *13*	(19/2)−		CDEFGHI	Jπ: from γ(θ) in (α,4nγ) and M1 γ to (17/2)−.
2291.9 *4*	9/2,11/2,13/2+		B	Jπ: γ to 9/2+ and log *ft*=6.8 via 11/2− parent.
2367.14[e] *13*	(21/2)−		CDEFGH	Jπ: from γ(θ) in (α,4nγ) and M1 γ to (19/2)−.
2456.30 *14*			H	
2481.39 *16*			F	
≈2660			J	
2700.65 *25*			H	
2726.1 *5*	19/2−		C	
2741.42 *19*			F J	XREF: J(2740).
2761.11 *13*	(19/2−)		CDEFG	
≈2800			J	
2821.0 *3*	(21/2)+		CDEFG	
2985.64 *16*	(21/2−)		C F	
3021.45 *14*	(23/2+)		CDEFG	Jπ: from γ(θ) in (α,4nγ) and ΔJ=1 γ to (21/2)+.
3139.5 *6*	(25/2)−		C	
3203.96 *14*			F	
3255.6 *6*	(25/2)−		C	
3265.88 *15*	(23/2)+&		CDEFG	

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Adopted Levels, Gammas (continued)

^{139}Pr Levels (continued)

E(level)	J^{π}[†]	$T_{1/2}$	XREF	Comments
3483.93 *16*			F	
3564.9 *4*	$(23/2)^-$		C	
3579.63 *17*	$(25/2^+)$		C F	
3627.34 *17*	$(25/2^+)$		CDEFG	
3697.90[a] *15*	$(25/2^-)$	≈12 ns	CD FG	$T_{1/2}$: from $\gamma\gamma$(t) in ^{130}Te(^{14}N,5nγ) (2012BhZZ).
3972.33 *20*	$(27/2^+)$		CD F	
4052.4 *4*	$(25/2^-)$		CD F	
4100.8[d] *4*	$(27/2^-)$		CD FG	
4276.3 *6*	$(27/2)^+$		C	
4316.6[a] *6*	$(29/2^-)$		C	
4377.37 *18*			F	
4412.4 *4*	$(27/2)^+$		C	
4444.0[b] *4*	$(27/2)^+$		C	
4536.8[d] *4*	$(29/2^-)$		CD FG	
4626.3[b] *5*	$(29/2)^+$		C	
4834.1 *6*	$(29/2^+)$		C	
4862.8[d] *4*	$(31/2^-)$		CD FG	
4906.3[b] *7*	$(31/2)^+$		C	
4947.4[a] *8*	$(33/2^-)$		C	
5056.2 *5*	$(31/2^+)$		C	
5171.3 *7*	$(33/2^-)$		C	
5222.4 *5*	$(31/2)^-$		C	
5283.4[b] *9*	$(33/2^+)$		C	
5363.8 *5*	$(33/2)^-$		C	
5406.2[d] *7*	$(33/2^-)$		CD	
5558.5 *7*	$(35/2^-)$		C	
5585.9 *8*	$(35/2^-)$		C	
5633.2[a] *9*	$(37/2)^-$		C	
5670.8 *7*	$(33/2^-)$		C	
5740.6[b] *10*	$(35/2)^+$		C	
5824.4[d] *8*	$(35/2^-)$		CD	
5861.9[c] *5*	$(35/2)^-$		C	
6039.0 *7*	$(35/2)^-$		CD	
6118.0[c] *8*	$(37/2)^-$		C	
6182.9 *8*	$(37/2^-)$		C	
6282.4[b] *11*	$(37/2^+)$		C	
6317.3 *8*	$(37/2^-)$		CD	
6371.4[a] *11*	$(41/2)^-$		C	
6387.2 *10*	$(39/2^-)$		CD	
6399.8[c] *9*	$(39/2)^-$		C	
6525.4[d] *10*	$(37/2^-)$		C	
6719.8 *9*	$(39/2^-)$		C	
6736.3[c] *10*	$(41/2)^-$		C	
6772.6 *10*	$(37/2^-)$		C	
6854.1 *10*	$(39/2^-)$		CD	
6916.4[b] *12*	$(39/2^+)$		C	
6938.2 *11*	$(41/2^-)$		C	
7219.3[a] *12*	$(45/2^-)$		C	
7219.5 *11*	$(41/2^-)$		D	

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Adopted Levels, Gammas (continued)

^{139}Pr Levels (continued)

† From (HI,xnγ) based on DCO measurements, γ placement or band assignments, unless otherwise stated. Some parentheses have been added by the evaluators.

‡ From log *ft* from $3/2^+$ parent and γ deexcitation pattern,

$J^\pi(114)=3/2^+,5/2^+,7/2^+$ from M1+E2 γ to $5/2^+$; J(2174)=9/2,11/2,13/2 from log *ft*=6.0 via $11/2^-$ parent. E1 γ connecting the two levels implies $J^\pi(114)=7/2^+$ and $J^\pi(2174)=9/2^-$.

@ $J^\pi(828)=1/2^+,9/2^+$ from stretched E2 to $5/2^+$; J(2048)=9/2,11/2,13/2 from log *ft*=6.5 via $11/2^-$ parent. E1 γ connecting the two levels implies $J^\pi(828)=9/2^+$ and $J^\pi(2048)=9/2^-,11/2^-$.

& From multipolarities of deexciting γ's.

a Band(A): $\pi h_{11/2}\otimes\nu(h_{11/2},1/2[541])$.

b Band(B): $\Delta J=1$ band based on $27/2^+$. Configuration=$\pi g_{7/2}\otimes\nu h^2_{11/2}$ or $\pi d_{5/2}\otimes\nu h^2_{11/2}$.

c Band(C): $\pi(g_{7/2}d_{5/2}h_{11/2})\otimes\nu h^2_{11/2}$.

d Band(D): $\pi 11/2[505]\otimes\nu h^2_{11/2}$.

e Band(E): γ sequence based on $11/2^-$.

Adopted Levels, Gammas (continued)

$\gamma(^{139}Pr)$

See 29.7-min and 5.5-h ε decay, (α,4nγ), and (p,2nγ) for unplaced gammas.

RI(R) TVDiscrepant branching ratios (Only those ratios which are discrepant with the adopted values are listed):
1624: TVI$_\gamma$(255γ):I$_\gamma$(797γ):I$_\gamma$(802γ)=100 7:24 5:64 5 in (p,2nγ).
1722: TVI$_\gamma$(199γ)/I$_\gamma$(900γ)=0.285 25 and 0.087 25 in (p,2nγ) and (α,4nγ), respectively
1834: TVI$_\gamma$(810γ)/I$_\gamma$(982γ)=1.5 3, 1.2 4, 1.78 15, and 0.241 25 in (^{3}He,3nγ), (α,4nγ), (p,2nγ), and 5.5-h ε decay.
1926: TVI$_\gamma$(1105γ)/I$_\gamma$(1075γ)=0.47 5 in (p,2nγ)
1941: TVI$_\gamma$(419γ)/I$_\gamma$(219γ)=0.30 19 in (p,2nγ)

E$_i$(level)	J$_i^\pi$	E$_\gamma$[†]	I$_\gamma$[†]	E$_f$	J$_f^\pi$	Mult.[‡]	δ	α[i]	Comments
113.92	7/2$^+$	113.94[#] 5	100[#]	0.0	5/2$^+$	M1+E2	0.16 10	0.904 21	α(K)=0.762 11; α(L)=0.112 12; α(M)=0.024 3; α(N)=0.0053 6; α(O)=0.00084 8 α(P)=5.80×10^{-5} 10 B(E2)(W.u.)=3.0 +40−26; B(M1)(W.u.)=0.00293 14 Mult.,δ: from α(exp) and conversion electron ratios in 5.5-h ε decay.
405.11	3/2$^+$	405.12[#] 8	100[#]	0.0	5/2$^+$	M1[@]		0.0288	α(K)=0.0246 4; α(L)=0.00328 5; α(M)=0.000689 10; α(N)=0.0001541 22; α(O)=2.49×10^{-5} 4 α(P)=1.86×10^{-6} 3
589.41	5/2$^+$	184.3[#] 1	53[&] 3	405.11	3/2$^+$	M1[a]		0.233	α(K)=0.199 3; α(L)=0.0271 4; α(M)=0.00571 8; α(N)=0.001277 18; α(O)=0.000206 3 α(P)=1.520×10^{-5} 22
		475.5[#] 1	100[&] 7	113.92	7/2$^+$	M1[@]		0.0191	α(K)=0.01639 23; α(L)=0.00217 3; α(M)=0.000456 7; α(N)=0.0001020 15 α(O)=1.648×10^{-5} 23; α(P)=1.236×10^{-6} 18
		589.4[#] 1	47[&] 3	0.0	5/2$^+$	[M1,E2]			
821.98	11/2$^-$	708.06[b] 6	100[b]	113.92	7/2$^+$	M2+E3	+0.07 4	0.0199	α(K)=0.01686 25; α(L)=0.00240 4; α(M)=0.000510 8; α(N)=0.0001141 17; α(O)=1.84×10^{-5} 3 α(P)=1.347×10^{-6} 20 B(E3)(W.u.)=1.2 +17−11; B(M2)(W.u.)=0.137 6 Mult.: from α(K)exp, conversion electron ratios, and $\gamma\gamma(\theta)$ in 5.5-h ε decay. δ: from $\gamma\gamma(\theta)$ in 5.5-h ε decay.
		821.9[b] 2	6.5[b] 12	0.0	5/2$^+$	E3[@]			B(E3)(W.u.)=5.8 11
827.92	9/2$^+$	827.86[c] 10	100[c]	0.0	5/2$^+$	E2[@d]			
851.87	11/2$^+$	737.96[c] 8	100 7	113.92	7/2$^+$	E2+M3	+0.20 4		Mult.: from α(K)exp, conversion electron ratios, and $\gamma\gamma(\theta)$ in 5.5-h ε decay. Stretched E2 from $\gamma(\theta)$ and α(K)exp in (^{3}He,3nγ) discrepant. δ: from $\gamma\gamma(\theta)$ in 5.5-h ε decay.
		852.0[&k] 3	≤0.5	0.0	5/2$^+$	[M3]		0.0263	α(K)=0.0220 3; α(L)=0.00338 5; α(M)=0.000723 11;

$^{139}_{59}Pr_{80}$-5

Adopted Levels, Gammas (continued)

γ(^{139}Pr) (continued)

E_i(level)	J_i^π	E_γ[†]	I_γ[†]	E_f	J_f^π	Mult.[‡]	δ	α[i]	Comments
									α(N)=0.0001618 *23*; α(O)=2.59×10^{-5} *4* α(P)=1.84×10^{-6} *3* E_γ: highly unlikely transition.
916.92	(1/2,3/2,5/2)$^+$	916.9[f] *3*	100[f]	0.0	5/2$^+$				
1023.92	9/2$^+$	910.1 *3*	100	113.92	7/2$^+$	E2(+M1)[@]	>1.1		
1074.21	(1/2$^+$,3/2,5/2)	485.0[f] *4*	18[f] *3*	589.41	5/2$^+$				
		669.0[f] *3*	60[f] *8*	405.11	3/2$^+$				
		1074.2[f] *4*	100[f] *11*	0.0	5/2$^+$				
1124.02		1010.1[e] *1*		113.92	7/2$^+$				
1311.8	1/2$^-$	1311.8[f] *4*	100[f]	0.0	5/2$^+$	[M2]			
1328.43	(3/2$^+$,5/2)	411.5[f] *2*	11[f] *3*	916.92	(1/2,3/2,5/2)$^+$				
		923.4[f] *3*	100[f] *10*	405.11	3/2$^+$				
		1213.4[f] *8*	24[f] *8*	113.92	7/2$^+$				
		1328.8[f] *6*	21[f] *6*	0.0	5/2$^+$				
1369.68	(9/2$^-$,13/2$^-$)	547.7[&] *1*	100[&]	821.98	11/2$^-$	M1[ad]		0.01343	α(K)=0.01151 *17*; α(L)=0.001518 *22*; α(M)=0.000319 *5*; α(N)=7.13×10^{-5} *10* α(O)=1.152×10^{-5} *17*; α(P)=8.66×10^{-7} *13*
1405.5	(1/2$^+$,3/2,5/2)	1405.5[f] *5*	100[f]	0.0	5/2$^+$				
1449.0	3/2$^-$	1449.0[f] *10*	100[f]	0.0	5/2$^+$				
1501.3	(1/2$^+$,3/2,5/2)	1096.5[f] *4*	100[f] *20*	405.11	3/2$^+$				
		1500.5[f] *6*	65[f] *20*	0.0	5/2$^+$				
1523.11	13/2$^-$	701.12[c] *10*	100[c]	821.98	11/2$^-$	M1,E2[@]			
1532.0	(1/2$^+$,3/2,5/2)	1532.0[f] *10*	100[f]	0.0	5/2$^+$				
1584.28		732.4[&] *2*	100[&]	851.87	11/2$^+$				
1624.32	9/2$^-$	101.2 *1*	2.5 *8*	1523.11	13/2$^-$	E2		2.03	α(K)=1.171 *17*; α(L)=0.671 *10*; α(M)=0.1512 *23*; α(N)=0.0327 *5*; α(O)=0.00457 *7* α(P)=6.12×10^{-5} *9* Mult.: E2(+M1) from α(K)exp in 5.5-h ε decay. ≠M1 from decay scheme.
		254.6 *1*	17.2 *20*	1369.68	(9/2$^-$,13/2$^-$)	M1,E2		0.091 *6*	α(K)=0.075 *9*; α(L)=0.0129 *18*; α(M)=0.0028 *5*; α(N)=0.00061 *9*; α(O)=9.5×10^{-5} *10* α(P)=5.3×10^{-6} *11*
		601.2 *4*	8.1 *13*	1023.92	9/2$^+$				
		772.5[k] *6*	5.8 *10*	851.87	11/2$^+$				
		796.5 *3*	60 *6*	827.92	9/2$^+$	E1			
		802.0 *3*	100 *10*	821.98	11/2$^-$	E2(+M1)	>2.4		Mult.: from α(K)exp, conversion electron ratios in 5.5-h ε decay.
		1510.5 *5*	2.0 *8*	113.92	7/2$^+$				

$^{139}_{59}Pr_{80}$-6

Adopted Levels, Gammas (continued)

γ(^{139}Pr) (continued)

E_i(level)	J_i^π	E_γ[†]	I_γ[†]	E_f	J_f^π	Mult.[‡]	δ	α[i]	Comments
1722.18	15/2⁻	199.1[e] *1*	4.2[b] *7*	1523.11	13/2⁻	M1[@]		0.189	α(K)=0.1608 *23*; α(L)=0.0219 *3*; α(M)=0.00461 *7*; α(N)=0.001032 *15*; α(O)=0.0001662 *24* α(P)=1.229×10^{-5} *18*
		900.16[e] *8*	100[b] *7*	821.98	11/2⁻	E2[@]			
1790.23	13/2⁺	962.3[b] *2*	100[b]	827.92	9/2⁺	E2[@d]			
1834.00	(9/2⁻,11/2⁻)	209.65 *7*	6.8 *7*	1624.32	9/2⁻	(M1,E2)		0.1629 *25*	α(K)=0.131 *9*; α(L)=0.025 *6*; α(M)=0.0054 *14*; α(N)=0.0012 *3*; α(O)=0.00018 *4* α(P)=9.1×10^{-6} *16*
		809.6 *3*	24.1 *24*	1023.92	9/2⁺	E1			
		982.2 *2*	100 *3*	851.87	11/2⁺	E1			
		1006.2 *4*	12.2 *10*	827.92	9/2⁺	E1			
		1012.3 *3*	10.4 *8*	821.98	11/2⁻	E2,M1			
1867.6	(15/2)⁺	1015.7[b] *3*	100[b]	851.87	11/2⁺	E2[@d]			Eγ: 1014.7 *1* in (p,2nγ) and (α,4nγ).
1926.91	(11/2,13/2)⁻	92.91 *7*	29 *6*	1834.00	(9/2⁻,11/2⁻)	M1,E2		2.2 *6*	α(K)=1.43 *7*; α(L)=0.6 *4*; α(M)=0.13 *10*; α(N)=0.029 *20*; α(O)=0.004 *3*; α(P)=9.1×10^{-5} *14*
		302.7 *4*	16.2 *25*	1624.32	9/2⁻	[M1,E2]		0.055 *7*	α(K)=0.046 *7*; α(L)=0.0074 *4*; α(M)=0.00159 *11*; α(N)=0.000352 *21*; α(O)=5.47×10^{-5} *15* α(P)=3.3×10^{-6} *8*
		403.75 *8*	69 *6*	1523.11	13/2⁻	(M1)		0.0290	α(K)=0.0248 *4*; α(L)=0.00331 *5*; α(M)=0.000695 *10*; α(N)=0.0001555 *22*; α(O)=2.51×10^{-5} *4* α(P)=1.88×10^{-6} *3*
		1075.2 *3*	100 *7*	851.87	11/2⁺	E1			
		1105.3 *3*	78 *6*	821.98	11/2⁻	E2(+M1)	>1.5		δ: from α(K)exp in 5.5-h ε decay.
1941.51	17/2⁻	219.32[b] *5*	100[b] *7*	1722.18	15/2⁻	M1(+E2)[@]	<0.1[@]	0.1449	α(K)=0.1237 *18*; α(L)=0.0168 *3*; α(M)=0.00354 *6*; α(N)=0.000791 *12*; α(O)=0.0001275 *19* α(P)=9.44×10^{-6} *14*
		418.8[b] *4*	3.3[b] *12*	1523.11	13/2⁻				
1942.0		1090.1[bk] *4*	100[b]	851.87	11/2⁺				Alternatively placed with 1941.5 by 1988Ar07 in (p,2nγ).
2029.52		405.2[&] *1*	100[&]	1624.32	9/2⁻	D+Q			
2048.58	9/2⁻,11/2⁻	214.6 *1*	30 *5*	1834.00	(9/2⁻,11/2⁻)	E2,M1		0.152 *3*	α(K)=0.123 *9*; α(L)=0.023 *6*; α(M)=0.0050 *13*; α(N)=0.0011 *3*; α(O)=0.00017 *4* α(P)=8.5×10^{-6} *16*
		424.3 *1*	46 *6*	1624.32	9/2⁻	M1,E2		0.022 *4*	α(K)=0.018 *4*; α(L)=0.00270 *22*; α(M)=0.00057 *4*; α(N)=0.000127 *10*; α(O)=2.01×10^{-5} *20* α(P)=1.3×10^{-6} *4*
		1024.9 *4*	91 *7*	1023.92	9/2⁺	E1			
		1219.6 *4*	100 *11*	827.92	9/2⁺	E1			
		1226.7 *4*	81 *9*	821.98	11/2⁻	M1,E2			

$^{139}_{59}Pr_{80}$-7

Adopted Levels, Gammas (continued)

γ(^{139}Pr) (continued)

E_i(level)	J_i^π	E_γ[†]	I_γ[†]	E_f	J_f^π	Mult.[‡]	α[i]	Comments
2050.1		259.9[k] *3*	100	1790.23	13/2$^+$			
2174.50	9/2$^-$	340.5 *1*	12.6 *19*	1834.00	(9/2$^-$,11/2$^-$)	M1,E2	0.040 *6*	α(K)=0.033 *6*; α(L)=0.00516 *8*; α(M)=0.001100 *22*; α(N)=0.000244 *4*; α(O)=3.82×10^{-5} *11* α(P)=2.4×10^{-6} *6*
		1151.2[k] *4*	2.6 *5*	1023.92	9/2$^+$			
		1322.3 *3*	39 *4*	851.87	11/2$^+$	E1		
		2060.9 *3*	100 *11*	113.92	7/2$^+$	E1		
2187.49	(19/2)$^-$	245.95[e] *5*	100[e]	1941.51	17/2$^-$	M1[@]	0.1064	α(K)=0.0908 *13*; α(L)=0.01232 *18*; α(M)=0.00259 *4*; α(N)=0.000580 *9*; α(O)=9.35×10^{-5} *14* α(P)=6.92×10^{-6} *10* Mult.: stretched dipole from γ(θ) in (α,4nγ) discrepant.
2196.46	9/2$^-$,11/2,13/2$^-$	147.9 *1*	27 *4*	2048.58	9/2$^-$,11/2$^-$	(E2,M1)	0.48 *6*	α(K)=0.367 *6*; α(L)=0.09 *4*; α(M)=0.020 *9*; α(N)=0.0043 *20*; α(O)=0.0006 *3*; α(P)=2.4×10^{-5} *4*
		362.42 *8*	100 *8*	1834.00	(9/2$^-$,11/2$^-$)	(E2)	0.0283	α(K)=0.0230 *4*; α(L)=0.00417 *6*; α(M)=0.000900 *13*; α(N)=0.000198 *3*; α(O)=3.03×10^{-5} *5* α(P)=1.542×10^{-6} *22*
		572.3 *2*	33 *6*	1624.32	9/2$^-$	(M1)	0.01204	α(K)=0.01032 *15*; α(L)=0.001360 *19*; α(M)=0.000285 *4*; α(N)=6.38×10^{-5} *9* α(O)=1.032×10^{-5} *15*; α(P)=7.76×10^{-7} *11*
		673.3 *3*	27 *3*	1523.11	13/2$^-$	(M1,E2)		
		1344.8 *5*	20 *6*	851.87	11/2$^+$			
		1374.7 *5*	18 *6*	821.98	11/2$^-$			
2205.8		338.2[b] *3*	100[b]	1867.6	(15/2)$^+$			
2277.97	(19/2)$^-$	336.51[e] *10*	100[e]	1941.51	17/2$^-$	M1[@]	0.0464	α(K)=0.0397 *6*; α(L)=0.00532 *8*; α(M)=0.001119 *16*; α(N)=0.000250 *4*; α(O)=4.04×10^{-5} *6* α(P)=3.01×10^{-6} *5*
2291.9	9/2,11/2,13/2$^+$	1269.5[k] *8*	7.9 *18*	1023.92	9/2$^+$			
		1463.6 *5*	55 *18*	827.92	9/2$^+$			
		1470.2 *5*	100 *25*	821.98	11/2$^-$			
2367.14	(21/2)$^-$	179.64[c] *5*	100[c]	2187.49	(19/2)$^-$	M1	0.250	Mult.: stretched dipole from γ(θ) in (α,4nγ); M1(+E2), δ=0.0 *1* from α(K)exp and γ(θ) in (^{3}He,3nγ).
2456.30		622.3[&] *1*	100[&]	1834.00	(9/2$^-$,11/2$^-$)	D		
2481.39		293.9[e] *1*	100[e]	2187.49	(19/2)$^-$	D[g]		
2700.65		670.9[&k] *2*	100[&]	2029.52				
2726.1	19/2$^-$	1003.9 *5*	100	1722.18	15/2$^-$	Q		
2741.42		260.0[jek] *1*		2481.39				
2761.11	(19/2$^-$)	819.7[e] *1*	100[e]	1941.51	17/2$^-$	D[@d]		
2821.0	(21/2)$^+$	60.2[e] *1*	6.0[e] *4*	2761.11	(19/2$^-$)	(E1)	1.009	α(K)=0.846 *12*; α(L)=0.1291 *18*; α(M)=0.0271 *4*; α(N)=0.00592 *9*; α(O)=0.000890 *13* α(P)=4.68×10^{-5} *7*

$^{139}_{59}Pr_{80}$-8

Adopted Levels, Gammas (continued)

γ(^{139}Pr) (continued)

E_i(level)	J_i^π	E_γ[†]	I_γ[†]	E_f	J_f^π	Mult.[‡]	α[i]	Comments
2821.0	(21/2)$^+$	454.1[e] *1*	23.7[e] *4*	2367.14	(21/2)$^-$	(M2)	0.0730	Mult.: ΔJ=0 or 2 Q from γ(θ) in (α,4nγ). M2 from decay scheme.
		543.3[e] *1*	100[e] *10*	2277.97	(19/2)$^-$	E1[@d]		
		633.6 *1*	18.8 *24*	2187.49	(19/2)$^-$	D		
		879.9[e] *1*		1942.0				I_γ: weak transition.
2985.64	(21/2$^-$)	259.7 *5*	100	2726.1	19/2$^-$	D+Q		
3021.45	(23/2$^+$)	200.3[e] *1*	100[e]	2821.0	(21/2)$^+$	D+Q[@d]		α(K)=0.1582 *23*; α(L)=0.0215 *3*; α(M)=0.00454 *7*; α(N)=0.001015 *15*; α(O)=0.0001635 *23* α(P)=1.209×10^{-5} *17*
3139.5	(25/2)$^-$	772.4 *5*	100	2367.14	(21/2)$^-$	Q		
3203.96		182.5[e] *1*		3021.45	(23/2$^+$)			
		382.8[e] *1*	100[e] *8*	2821.0	(21/2)$^+$			
3255.6	(25/2)$^-$	888.5 *5*	100.0	2367.14	(21/2)$^-$	Q		
3265.88	(23/2)$^+$	244.5[e] *1*	75[h] *13*	3021.45	(23/2$^+$)			I_γ: others: 41 *12* in (^{3}He,3nγ); 6.7 *14* in (^{19}F,4nγ); the latter is in severe disagreement.
		444.6[e] *1*	100[h] *13*	2821.0	(21/2)$^+$	M1[@]	0.0227	α(K)=0.0194 *3*; α(L)=0.00258 *4*; α(M)=0.000542 *8*; α(N)=0.0001212 *17*; α(O)=1.96×10^{-5} *3* α(P)=1.467×10^{-6} *21*
3483.93		280.0[e] *1*	100[e]	3203.96		D		
3564.9	(23/2)$^-$	1197.7 *5*	42 *17*	2367.14	(21/2)$^-$	D+Q		
		1377.3 *5*	100 *25*	2187.49	(19/2)$^-$	Q		
3579.63	(25/2$^+$)	558.2[e] *1*	100[e]	3021.45	(23/2$^+$)	D+Q		
3627.34	(25/2$^+$)	605.9[e] *1*	100[e]	3021.45	(23/2$^+$)	D+Q		
3697.90	(25/2$^-$)	(71.1)		3627.34	(25/2$^+$)	(E1)	0.637	
		214.0[e] *1*	[e]	3483.93				I_γ: weak γ ray.
		1330.7[e] *1*	100[e] *7*	2367.14	(21/2)$^-$	Q		
3972.33	(27/2$^+$)	345.0[e] *1*	100[e]	3627.34	(25/2$^+$)	D+Q		
4052.4	(25/2$^-$)	354.5 *5*	58 *8*	3697.90	(25/2$^-$)	D+Q		
		487.4 *5*	46 *8*	3564.9	(23/2)$^-$	D+Q		
		786.7 *5*	100 *20*	3265.88	(23/2)$^+$	D		
4100.8	(27/2$^-$)	(48.2)		4052.4	(25/2$^-$)			
		128.7 *5*	1.2 *4*	3972.33	(27/2$^+$)	D		
		402.7 *5*	100 *5*	3697.90	(25/2$^-$)	D+Q		
4276.3	(27/2)$^+$	1010.4 *5*	100	3265.88	(23/2)$^+$	Q		
4316.6	(29/2$^-$)	618.7 *5*	100	3697.90	(25/2$^-$)	Q		
4377.37		1173.4[e] *1*		3203.96				
4412.4	(27/2)$^+$	833.0 *5*	38 *8*	3579.63	(25/2$^+$)	D+Q		
		1390.8 *5*	1.0×10^2 *4*	3021.45	(23/2$^+$)	Q		
4444.0	(27/2)$^+$	864.6 *5*	20 *6*	3579.63	(25/2$^+$)			
		1422.4 *5*	1.0×10^2 *4*	3021.45	(23/2$^+$)	Q		
4536.8	(29/2$^-$)	436.0[e] *1*	100[e]	4100.8	(27/2$^-$)	D+Q		
4626.3	(29/2)$^+$	182.3 *5*	96 *11*	4444.0	(27/2)$^+$	D+Q		

$^{139}_{59}Pr_{80}$-9

Adopted Levels, Gammas (continued)

$\gamma(^{139}Pr)$ (continued)

E_i(level)	J_i^π	E_γ[†]	I_γ[†]	E_f	J_f^π	Mult.[‡]	Comments
4626.3	$(29/2)^+$	213.9 *5*	100 *11*	4412.4	$(27/2)^+$	D+Q	
4834.1	$(29/2^+)$	421.7 *5*	100	4412.4	$(27/2)^+$	D+Q	
4862.8	$(31/2^-)$	326.0[e] *1*	100[e]	4536.8	$(29/2^-)$	D+Q	
4906.3	$(31/2)^+$	280.0 *5*	100	4626.3	$(29/2)^+$	D+Q	
4947.4	$(33/2^-)$	630.8 *5*	100	4316.6	$(29/2^-)$	Q	
5056.2	$(31/2^+)$	429.9 *5*	100	4626.3	$(29/2)^+$	D+Q	
5171.3	$(33/2^-)$	308.5 *5*	100	4862.8	$(31/2^-)$	D+Q	
5222.4	$(31/2)^-$	1121.5 *5*	100	4100.8	$(27/2^-)$	Q	
5283.4	$(33/2^+)$	377.1 *5*	100	4906.3	$(31/2)^+$	D+Q	
5363.8	$(33/2)^-$	141.4 *5*	56 *13*	5222.4	$(31/2)^-$	D+Q	
		307.7 *5*	28 *6*	5056.2	$(31/2^+)$		
		827.0 *5*	100 *23*	4536.8	$(29/2^-)$	Q	
5406.2	$(33/2^-)$	543.4 *5*	100	4862.8	$(31/2^-)$		
5558.5	$(35/2^-)$	194.7 *5*	100	5363.8	$(33/2)^-$	D+Q	
5585.9	$(35/2^-)$	414.6 *5*	100	5171.3	$(33/2^-)$	D+Q	
5633.2	$(37/2)^-$	685.8 *5*	100	4947.4	$(33/2^-)$	Q	
5670.8	$(33/2^-)$	1134.0 *5*	100	4536.8	$(29/2^-)$	Q	
5740.6	$(35/2)^+$	457.2 *5*	100	5283.4	$(33/2^+)$	D+Q	
5824.4	$(35/2^-)$	418.2 *5*	100	5406.2	$(33/2^-)$	D+Q	
5861.9	$(35/2)^-$	999.1 *5*	100 *17*	4862.8	$(31/2^-)$	Q	
		1325.1[k] *5*	18 *15*	4536.8	$(29/2^-)$	(M3+E4)	This transition, due to unexpected high multipolarity, is considered as uncertain.
6039.0	$(35/2)^-$	1176.2 *5*	100	4862.8	$(31/2^-)$	Q	
6118.0	$(37/2)^-$	256.1 *5*	100	5861.9	$(35/2)^-$	D+Q	
6182.9	$(37/2^-)$	776.7 *5*	100	5406.2	$(33/2^-)$	Q	
6282.4	$(37/2^+)$	541.8 *5*	100	5740.6	$(35/2)^+$		
6317.3	$(37/2^-)$	278.3 *5*	100	6039.0	$(35/2)^-$	D+Q	
6371.4	$(41/2)^-$	738.2 *5*	100	5633.2	$(37/2)^-$	Q	
6387.2	$(39/2^-)$	204.3 *5*	100	6182.9	$(37/2^-)$	D+Q	
6399.8	$(39/2)^-$	281.8 *5*	100	6118.0	$(37/2)^-$	D+Q	
6525.4	$(37/2^-)$	701.0 *5*	100	5824.4	$(35/2^-)$		
6719.8	$(39/2^-)$	1161.3 *5*	100	5558.5	$(35/2^-)$	Q	
6736.3	$(41/2)^-$	336.5 *5*	100	6399.8	$(39/2)^-$	D+Q	
6772.6	$(37/2^-)$	948.2 *5*	100	5824.4	$(35/2^-)$	D+Q	
6854.1	$(39/2^-)$	(81.5)		6772.6	$(37/2^-)$		
		1029.7 *5*	100 *14*	5824.4	$(35/2^-)$	Q	
6916.4	$(39/2^+)$	634.0 *5*	100	6282.4	$(37/2^+)$		
6938.2	$(41/2^-)$	551.0 *5*	100	6387.2	$(39/2^-)$	D+Q	
7219.3	$(45/2^-)$	847.9 *5*	100	6371.4	$(41/2)^-$		
7219.5	$(41/2^-)$	365.4 *5*	100	6854.1	$(39/2^-)$	D+Q	

[†] From 5.5-h ε decay or (HI,xnγ), unless otherwise noted.

$^{139}_{59}Pr_{80}$-10

Adopted Levels, Gammas (continued)

$\gamma(^{139}Pr)$ (continued)

‡ From α(K)exp in 5.5-h ε decay or DCO ratios in in-beam γ-ray data.
# From (p,2nγ) or (α,4nγ).
@ From α(exp)′s and $\gamma(\theta)$ in (^{3}He,3nγ).
& From (p,2nγ).
a From α(exp)′s in 29.7-min or 5.5-h ε decay and $\gamma(\theta)$ in (p,2nγ).
b From (^{3}He,3nγ).
c From (p,2nγ), (^{3}He,3nγ), or (α,4nγ).
d Stretched.
e From (α,4nγ).
f From 29.7-min ε decay.
g From $\gamma(\theta)$ in (α,4nγ).
h From (α,4nγ) delayed.
i 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.
j Multiply placed.
k Placement of transition in the level scheme is uncertain.

$^{139}_{59}Pr_{80}$-11

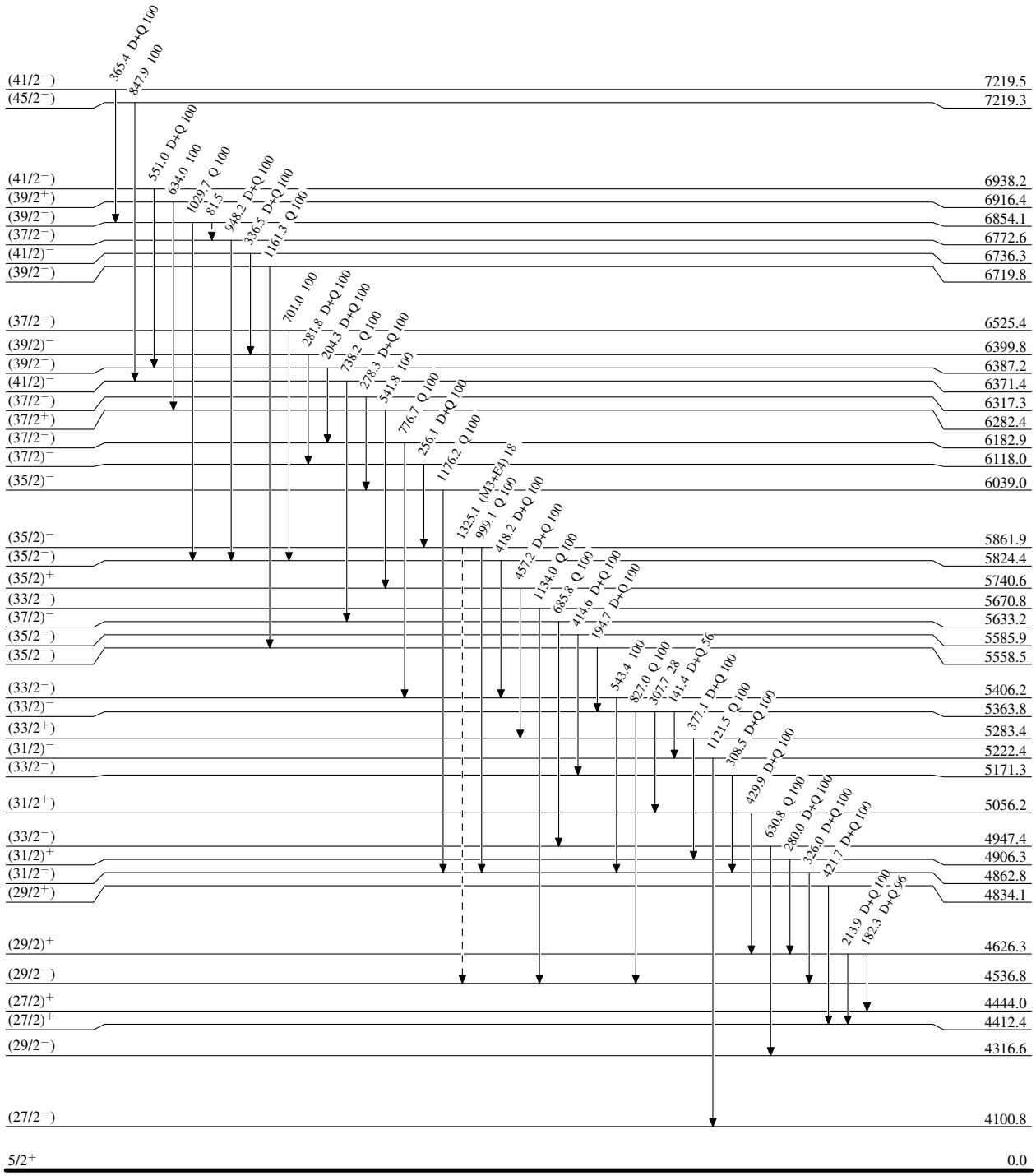
Adopted Levels, Gammas

Legend

Level Scheme

Intensities: Relative photon branching from each level

γ Decay (Uncertain)



$^{139}_{59}Pr_{80}$

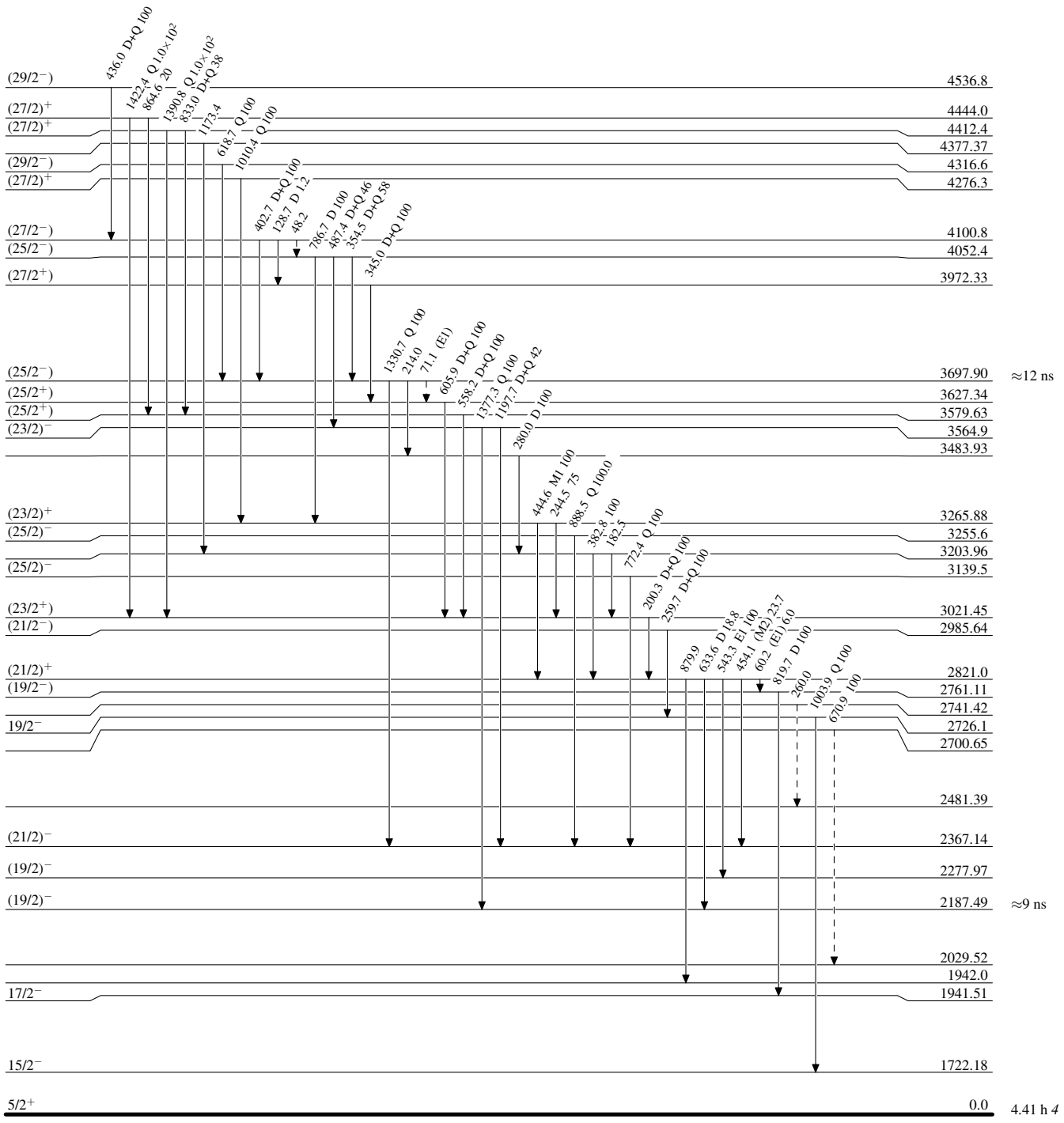
Adopted Levels, Gammas

Legend

Level Scheme (continued)

Intensities: Relative photon branching from each level

γ Decay (Uncertain)



$^{139}_{59}Pr_{80}$

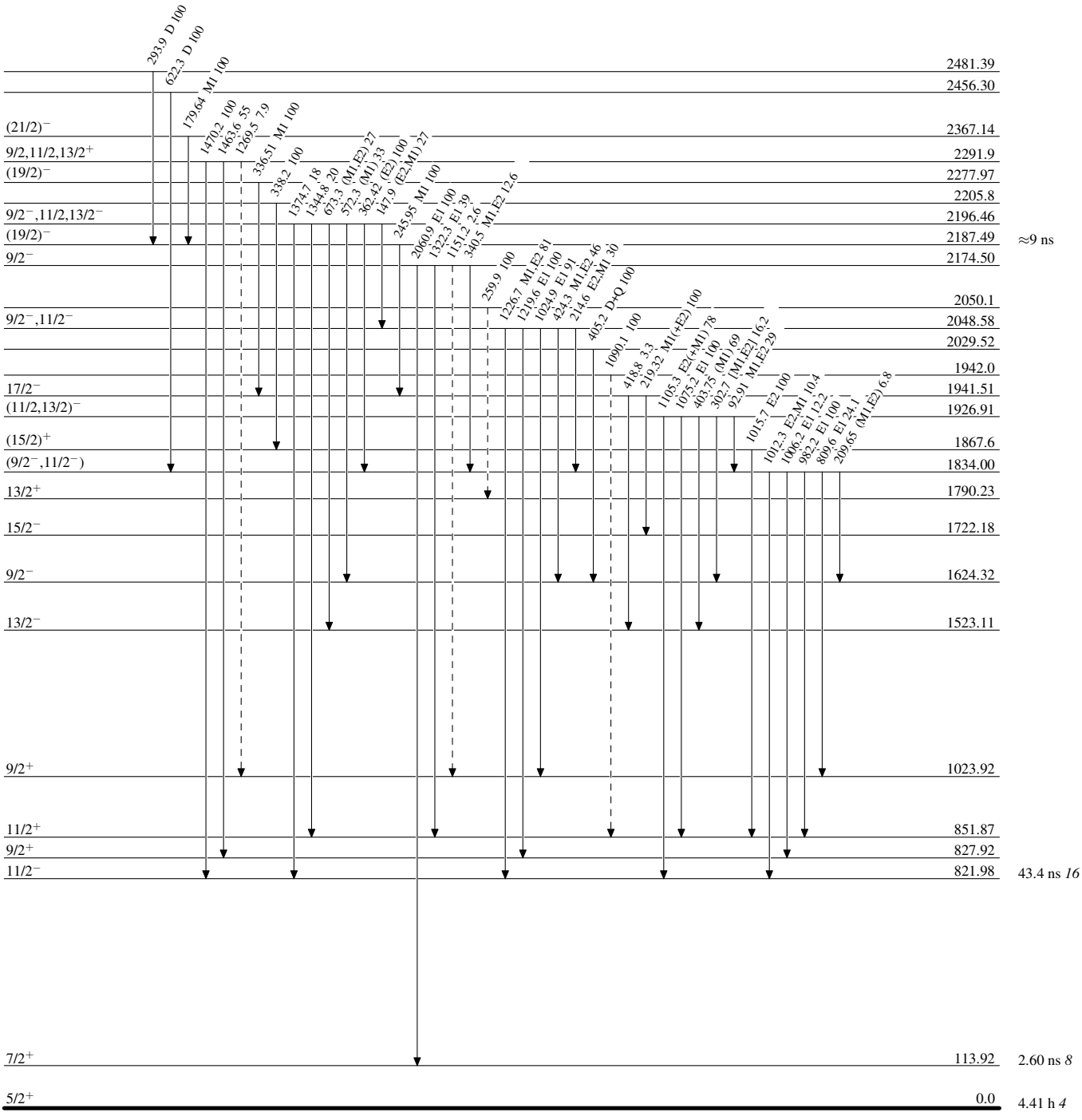
Adopted Levels, Gammas

Legend

Level Scheme (continued)

Intensities: Relative photon branching from each level

γ Decay (Uncertain)



$^{139}_{59}Pr_{80}$

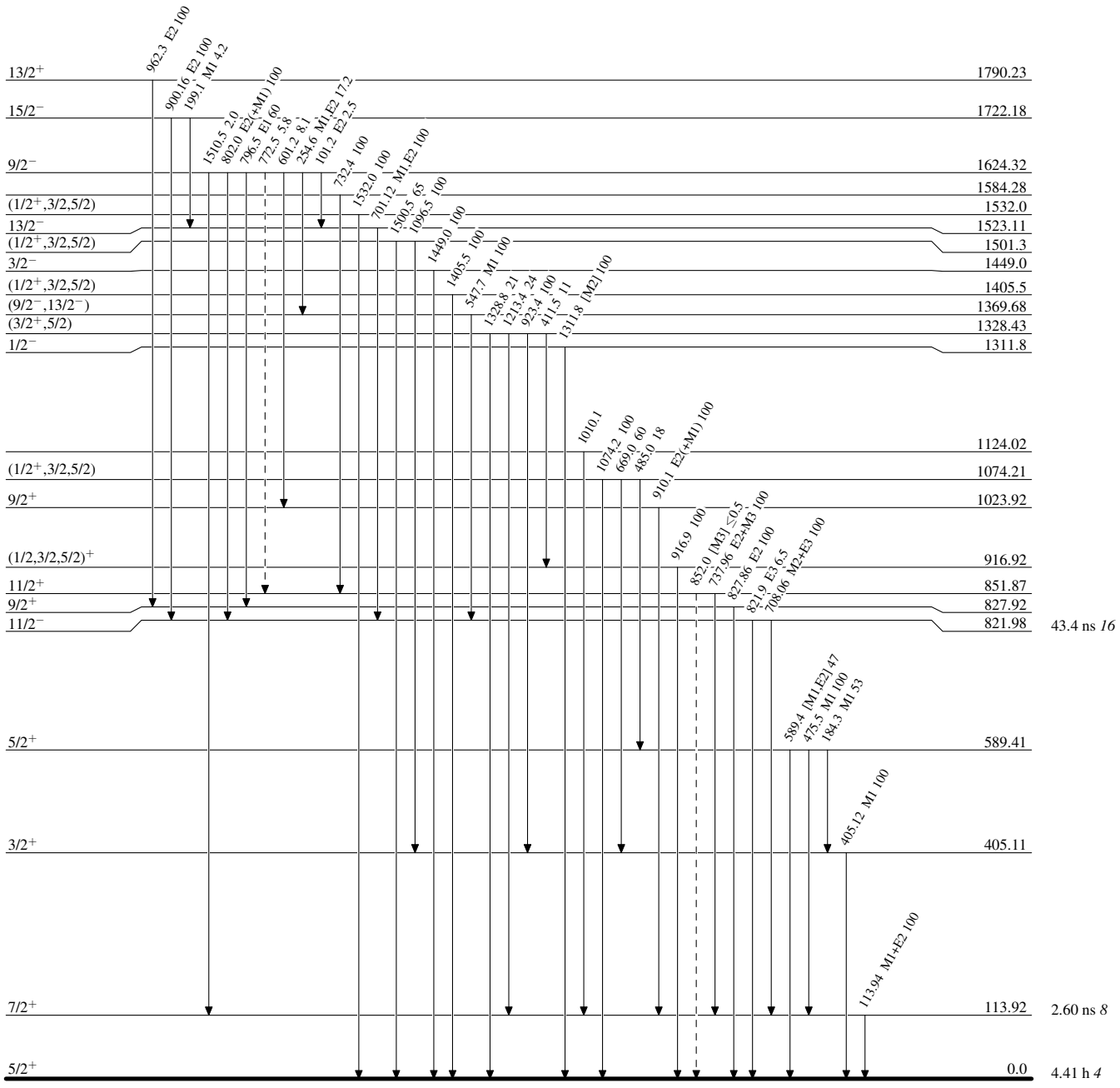
Adopted Levels, Gammas

Legend

Level Scheme (continued)

Intensities: Relative photon branching from each level

γ Decay (Uncertain)



$^{139}_{59}Pr_{80}$

Adopted Levels, Gammas