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^-)=−7770 *SY*; S(n)=11720 *30*; S(p)=1189 *18*; Q(α)=2200 *70* 2012Wa38
Estimated ΔQ(β^-)=200 (2012Wa38).
S(2n)=21420 *200* (syst), S(2p)=5903 *19*, Q(εp)=2250 *30* (2012Wa38).
2000Be42, 1997Be63; Mass measurements.

^{139}Eu Levels

Cross Reference (XREF) Flags

A	^{139}Gd ε decay (5.8 s)	D	^{92}Mo(^{50}Cr,3pγ)
B	^{139}Gd ε decay (4.8 s):?	E	^{92}Mo(^{50}Cr,3pγ),^{110}Cd(^{32}S,p2nγ)
C	^{140}Tb εp decay (2.0 s)	F	^{92}Mo(^{54}Fe,5p2nγ)

E(level)	J$^{\pi}$†	T$_{1/2}$‡	XREF	Comments
0.0[a]	(11/2)$^-$	17.9 s *6*	ABCDEF	%ε+%β^+=100 μ=6.1 *8* (1992Si22,2014StZZ) RMS charge radius <r^2>$^{1/2}$=4.9760 fm *93* (2013An02 evaluation). J$^{\pi}$: allowed ε decay to 11/2$^-$. T$_{1/2}$: from 1986De35. Others: 24 s *5* (1986Re11) and 22 s *3* (1973WeZK, Gd(p,xpxn), E(p)=600 MeV. ISOLDE; β^+(t), x(t)). See ^{139}Eu ε decay for details. μ: nuclear orientation with γ detected (1992Si22). 1987Al25 measured hyperfine structure.
116.16 *15*	(13/2$^-$)		A D F	
121.61 *18*	(9/2$^-$)		B F	
148.3 *3*	(7/2$^+$)	10 μs *2*	B F	%IT=100 T$_{1/2}$: from (recoils)γ(t) (2011Cu01).
206.66 *25*			A	
281.0 *4*			A	
319.46 *22*			AB	
322.85[a] *6*	(15/2$^-$)	36.0 ps *21*	A CDE	
346.5 *4*	(11/2$^+$)		F	
406.7 *4*			A	
426.68 *8*	(13/2$^-$)		A CD	
468.5 *4*			B	
507.8 *4*			B	
530.30[c] *7*	(13/2$^-$)		CD	
553.0 *4*			B	
588.1 *11*			A	
664.1 *4*			B	
675.1 *4*			B	
690.6 *4*			B	
808.7 *4*			B	
835.4 *4*	(15/2$^+$)		F	
865.42[d] *10*	(15/2$^-$)		D	
876.93[a] *11*	(19/2$^-$)	2.77 ps *35*	CDE	
969.33[c] *9*	(17/2$^-$)		D	
1025.4 *5*			B	
1039.88[e] *13*	(17/2$^-$)		D	
1417.7 *8*	(19/2$^+$)		F	
1438.03[d] *11*	(19/2$^-$)		D	

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Adopted Levels, Gammas (continued)

^{139}Eu Levels (continued)

E(level)	Jπ[†]	$T_{1/2}$[‡]	XREF
1589.37[a] *16*	(23/2⁻)	1.52 ps *35*	DE
1623.45[c] *12*	(21/2⁻)		D
1811.99[e] *24*	(21/2⁻)		D
1890.80[@] *18*	(19/2⁺)		D
2011.6 *9*	(23/2⁺)		F
2212.63[d] *15*	(23/2⁻)		D
2228.0[#] *3*	(21/2⁺)		D
2345.12[@] *17*	(23/2⁺)		D
2406.25[a] *17*	(27/2⁻)		DE
2431.53[c] *15*	(25/2⁻)		D
2482.3 *10*	(27/2⁺)		F
2611.7[e] *4*	(25/2⁻)		D
2693.91[b] *19*	(27/2⁻)		D
2699.84[#] *20*	(25/2⁺)		D
2878.19[@] *19*	(27/2⁺)		D
3097.31[b] *19*	(31/2⁻)		DE
3137.5 *11*	(31/2⁺)		F
3142.1[d] *4*	(27/2⁻)		D
3266.85[#] *19*	(29/2⁺)		D
3338.43[c] *25*	(29/2⁻)		D
3358.47[&] *19*	(29/2⁻)		D
3561.49[@] *21*	(31/2⁺)		D
3809.72[b] *21*	(35/2⁻)		D
3969.85[#] *22*	(33/2⁺)		D
4117.5 *4*	(33/2⁻)		D
4282.07[&] *22*	(33/2⁻)		D
4352.09[@] *24*	(35/2⁺)		D
4722.4 *4*	(37/2⁻)		D
4765.22[b] *24*	(39/2⁻)		D
4787.3[#] *3*	(37/2⁺)		D
5210.0[@] *3*	(39/2⁺)		D
5211.5[&] *3*	(37/2⁻)		D
5701.5[#] *4*	(41/2⁺)		D
5937.3[b] *3*	(43/2⁻)		D
6149.5[@] *4*	(43/2⁺)		D
6222.5[&] *5*	(41/2⁻)		D
6715.6[#] *5*	(45/2⁺)		D
7190.3[@] *4*	(47/2⁺)		D
7265.5[b] *10*	(47/2⁻)		D

[†] Except for the g.s., from DCO ratios in ^{92}Mo(^{50}Cr,3pγ) and systematics of other odd-proton, even-neutron nuclides in this mass region (parentheses added by evaluators). See comments for the individual bands for additional details.

[‡] From recoil-distance Doppler shift (RDDS) (1988Bi03) in ^{92}Mo(^{50}Cr,3p),^{110}Cd(^{32}S,Xγ), except as noted.

[#] Band(A): ΔJ=2 band based on 21/2⁺,α=+1/2. DCO ratios of in-band γ rays through spin 33/2 are consistent with stretched Q transitions. Average DCO ratio of 0.41 *4* for γ rays feeding the yrast band are consistent with a pure dipole character implying a band starting at 21/2.

[@] Band(a): ΔJ=2 band based on 19/2⁺,α=−1/2. DCO ratios of in-band γ rays through spin 33/2 are consistent with stretched Q transitions. DCO ratios of the three γ's feeding out of this band suggest either ΔJ=2 or ΔJ=0. The energy spacings and comparable Iγ values of this band and the ΔJ=2 band with J=21/2⁺ bandhead suggests the two bands are signature partners with a relatively small signature splitting. If this is true, this band most likely feeds out with a ΔJ=0 γ and, therefore, has a bandhead J=19/2 since ΔJ=2 would imply a very large signature splitting. π=+ is most likely for these two bands since stretched ΔJ=2 γ's were not observed in the decay out of the band based on 21/2⁺.

[&] Band(B): ΔJ=2 band based on 29/2⁻. Feeds out mainly into the yrast band through the 952γ. A weak 927γ from the first member of this band to 25/2⁻ rules out ΔJ=2 for the 952γ and requires π=− for this band if the 952γ is ΔJ=1. From the DCO ratio for 952γ+956γ and the expected stretched E2 character of the 956γ, the 952γ is not stretched E2 in character and, most likely, is not pure dipole. This implies a mixed ΔJ=1 transition and J^{π}=29/2⁻. If the 952γ were of a strongly mixed ΔJ=0 character, a bandhead J^{π}=27/2⁻ would be implied, placing the band too far above the yrast band to explain its considerable intensity.

[a] Band(C): Yrast band based on g.s. This band was established by 1985Lu06 and 1988Bi03 up to 31/2⁻. 1995Va22 extend the γ cascade to (47/2)⁻, with the interpretation that the yrast band undergoes backbend at 691-keV transition. DCO ratios of in-band γ rays through the 35/2⁻ state are consistent with stretched quadrupole transitions. A separate band is defined by 1995Va22 above the 31/2⁻ state.

[b] Band(D): ΔJ=2 band based on 27/2⁻. This band is an extension of the yrast band based on g.s.

[c] Band(E): ΔJ=2 band based on 13/2⁻. DCO ratios of in-band γ rays are consistent with stretched Q transitions. DCO ratios of γ rays feeding the yrast band suggest (M1+E2) admixture, implying a band starting at J^{π}=13/2⁻.

[d] Band(F): ΔJ=2 band based on 15/2⁻. This band decays by several transitions into the yrast band and a ΔJ=2 band based on

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Adopted Levels, Gammas (continued)

^{139}Eu Levels (continued)

13/2⁻. The 865γ (to g.s.) DCO ratio suggests stretched Q and 335γ and 469γ to ΔJ=2 band based on 13/2⁻ are consistent with ΔJ=1. This decay structure implies a band starting at J^π=15/2⁻.

[e] Band(G): ΔJ=2 band based on 17/2⁻. This band depopulates through the 613γ whose DCO ratio is consistent with stretched Q into a 13/2⁻ state.

γ(^{139}Eu)

E_i(level)	J^π_i	E_γ[†]	I_γ[†]	E_f	J^π_f	Mult.[‡e]	α[f]	Comments
116.16	(13/2⁻)	116.1 *2*	100	0.0	(11/2)⁻	(M1+E2)	1.31 *11*	α(K)=0.90 *13*; α(L)=0.32 *18*; α(M)=0.07 *5* α(N)=0.016 *10*; α(O)=0.0023 *12*; α(P)=9.E−5 *3* Eγ is Weighted av. (external) from ^{139}Gd β^+ decay (5.8 s) and ^{92}Mo(^{50}Cr,3pγ). Eγ=117.2 *1* in ^{92}Mo(^{54}Fe,5p2nγ) (2011Cu01) seems discrepant, too high by ≈1 keV.
121.61	(9/2⁻)	(4.6)		116.16	(13/2⁻)			Eγ: existence of this transition implied by γγ-coin data in ^{92}Mo(^{54}Fe,5p2nγ) (2011Cu01).
		121.6[#] *2*	100 *11*	0.0	(11/2)⁻	(E2)	1.199 *19*	α(K)=0.681 *10*; α(L)=0.402 *7*; α(M)=0.0934 *15*; α(N)=0.0208 *4*; α(O)=0.00285 *5* α(P)=5.19×10⁻⁵ *8* Mult.: from conversion coefficient measurement in ^{92}Mo(^{54}Fe,5p2nγ) (2011Cu01).
148.3	(7/2⁺)	26.7[#] *2*	100	121.61	(9/2⁻)	(E1)	1.85 *5*	α(L)=1.46 *4*; α(M)=0.317 *8*; α(N)=0.0694 *18*; α(O)=0.00928 *23*; α(P)=0.000478 *11* Mult.: from conversion coefficient measurement in ^{92}Mo(^{54}Fe,5p2nγ) (2011Cu01).
206.66		90.5[@] *2*		116.16	(13/2⁻)			
281.0		74.3[@] *3*		206.66				
319.46		197.8[#h] *2*		121.61	(9/2⁻)			
		203.4[@h] *3*		116.16	(13/2⁻)			
322.85	(15/2⁻)	322.85[&] *8*	100	0.0	(11/2)⁻	(E2)	0.0465	α(K)=0.0363 *5*; α(L)=0.00797 *12*; α(M)=0.00179 *3*; α(N)=0.000402 *6*; α(O)=5.93×10⁻⁵ *9* α(P)=3.41×10⁻⁶ *5* B(E2)(W.u.)=100 *6*
346.5	(11/2⁺)	198.2[d] *2*	100[d]	148.3	(7/2⁺)			
406.7		200.0[@] *3*		206.66				
426.68	(13/2⁻)	103.9[a] *1*	11 *6*	322.85	(15/2⁻)	(M1+E2)	1.88 *23*	α(K)=1.23 *17*; α(L)=0.5 *3*; α(M)=0.12 *8*; α(N)=0.026 *17*; α(O)=0.0037 *21*; α(P)=0.00012 *4*
		310.42 *24*	21 *6*	116.16	(13/2⁻)	(M1+E2)	0.066 *14*	α(K)=0.054 *14*; α(L)=0.00934 *23*; α(M)=0.00205 *3*; α(N)=0.000467 *8*; α(O)=7.1×10⁻⁵ *4* α(P)=5.6×10⁻⁶ *19*
		426.7 *1*	100 *11*	0.0	(11/2)⁻	D+Q		
468.5		149.0[#] *3*		319.46				
507.8		386.2[#] *3*		121.61	(9/2⁻)			

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Adopted Levels, Gammas (continued)

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

E_i(level)	J^π_i	E_γ[†]	I_γ[†]	E_f	J^π_f	Mult.[‡e]	α[f]	Comments
530.30	(13/2⁻)	207.5 *1*	11.1 *19*	322.85	(15/2⁻)	(M1+E2)	0.214 *24*	α(K)=0.17 *4*; α(L)=0.035 *7*; α(M)=0.0079 *18*; α(N)=0.0018 *4*; α(O)=0.00027 *5* α(P)=1.7×10⁻⁵ *6*
		530.3 *1*	100 *13*	0.0	(11/2)⁻	D+Q		
553.0		431.4[#] *3*		121.61	(9/2⁻)			
588.1		471.9[#]		116.16	(13/2⁻)			
664.1		542.5[#] *3*		121.61	(9/2⁻)			
675.1		553.5[#] *3*		121.61	(9/2⁻)			
690.6		371.1[#] *3*		319.46				
808.7		489.2[#] *3*		319.46				
835.4	(15/2⁺)	488.9[d] *2*	100[d]	346.5	(11/2⁺)			
865.42	(15/2⁻)	335.1 *1*	88 *7*	530.30	(13/2⁻)	D+Q		
		439.0 *2*	56 *7*	426.68	(13/2⁻)	D+Q		
		542.8 *2*	100 *7*	322.85	(15/2⁻)	D+Q		
		865 *1*	50 *13*	0.0	(11/2)⁻	Q		
876.93	(19/2⁻)	554.1[b] *1*	100	322.85	(15/2⁻)	(E2)	0.01022	α(K)=0.00842 *12*; α(L)=0.001414 *20*; α(M)=0.000310 *5*; α(N)=7.04×10⁻⁵ *10* α(O)=1.078×10⁻⁵ *16*; α(P)=8.46×10⁻⁷ *12* B(E2)(W.u.)=91 *12*
969.33	(17/2⁻)	439.1 *1*	50.0 *13*	530.30	(13/2⁻)	(E2)		
		646.3 *1*	100 *3*	322.85	(15/2⁻)	D+Q		
1025.4		903.8[#] *4*		121.61	(9/2⁻)			
1039.88	(17/2⁻)	613.2 *1*	100	426.68	(13/2⁻)	Q		
1417.7	(19/2⁺)	582.3[d] *7*	100[d]	835.4	(15/2⁺)			
1438.03	(19/2⁻)	468.6 *1*	47 *3*	969.33	(17/2⁻)	D+Q		
		572.7 *1*	100 *6*	865.42	(15/2⁻)	(E2)		
1589.37	(23/2⁻)	712.44[b] *22*	100	876.93	(19/2⁻)	(E2)		B(E2)(W.u.)=47 *11*
1623.45	(21/2⁻)	654.1 *1*	100.0 *23*	969.33	(17/2⁻)	Q		
		746.9 *3*	19.3 *23*	876.93	(19/2⁻)	D+Q		
1811.99	(21/2⁻)	772.1 *2*	100	1039.88	(17/2⁻)	Q		
1890.80	(19/2⁺)	1013.8 *2*	100	876.93	(19/2⁻)	(D)		
2011.6	(23/2⁺)	593.9[d] *3*	100[d]	1417.7	(19/2⁺)			
2212.63	(23/2⁻)	774.6 *1*	100	1438.03	(19/2⁻)	Q		
2228.0	(21/2⁺)	1350.8 *5*	100	876.93	(19/2⁻)	D		
2345.12	(23/2⁺)	454.3 *1*	18.0 *12*	1890.80	(19/2⁺)	(E2)	0.01732	α(K)=0.01404 *20*; α(L)=0.00256 *4*; α(M)=0.000567 *8*; α(N)=0.0001283 *18*; α(O)=1.94×10⁻⁵ *3* α(P)=1.385×10⁻⁶ *20*
		755.8 *1*	100.0 *12*	1589.37	(23/2⁻)	D		
2406.25	(27/2⁻)	816.88[c] *9*	100	1589.37	(23/2⁻)	Q		
2431.53	(25/2⁻)	808.1 *1*	100.0 *26*	1623.45	(21/2⁻)	Q		
		842.1 *2*	38.0 *26*	1589.37	(23/2⁻)			
2482.3	(27/2⁺)	470.7[d] *4*	100[d]	2011.6	(23/2⁺)			
2611.7	(25/2⁻)	799.7 *3*	100	1811.99	(21/2⁻)	(Q)		
2693.91	(27/2⁻)	287.6 *1*	13.1 *17*	2406.25	(27/2⁻)	D+Q		
		1104.4 *2*	100 *5*	1589.37	(23/2⁻)	Q		
2699.84	(25/2⁺)	471.8[g] *2*	17.5[g] *18*	2228.0	(21/2⁺)			
		1110.5 *2*	100 *6*	1589.37	(23/2⁻)	D		

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Adopted Levels, Gammas (continued)

γ(^{139}Eu) (continued)

E_i(level)	J^π_i	E_γ[†]	I_γ[†]	E_f	J^π_f	Mult.[‡e]	α[f]	Comments
2878.19	(27/2+)	471.8[g] *2*	11.3[g] *13*	2406.25	(27/2−)	D		
		533.1 *1*	100.0 *13*	2345.12	(23/2+)	(E2)	0.01131	α(K)=0.00929 *13*; α(L)=0.001584 *23*; α(M)=0.000348 *5*; α(N)=7.90×10^{-5} *11* α(O)=1.206×10^{-5} *17*; α(P)=9.30×10^{-7} *13*
3097.31	(31/2−)	403.3 *1*	8.0 *7*	2693.91	(27/2−)	(E2)	0.0242	α(K)=0.0194 *3*; α(L)=0.00375 *6*; α(M)=0.000832 *12*; α(N)=0.000188 *3*; α(O)=2.82×10^{-5} *4* α(P)=1.88×10^{-6} *3*
		691.14[c] *9*	100.0 *13*	2406.25	(27/2−)	Q		
3137.5	(31/2+)	655.2[d] *4*	100[d]	2482.3	(27/2+)			
3142.1	(27/2−)	929.5 *3*	100	2212.63	(23/2−)	Q		
3266.85	(29/2+)	567.0 *1*	97 *4*	2699.84	(25/2+)	(E2)		
		860.6 *1*	100 *7*	2406.25	(27/2−)	D		
3338.43	(29/2−)	906.9 *2*	100	2431.53	(25/2−)	Q		
3358.47	(29/2−)	927.1 *4*	13.4 *14*	2431.53	(25/2−)			
		952.2 *1*	100.0 *21*	2406.25	(27/2−)	D+Q		
3561.49	(31/2+)	683.3 *1*	100	2878.19	(27/2+)	Q		
3809.72	(35/2−)	712.4 *1*	100	3097.31	(31/2−)	Q		
3969.85	(33/2+)	703.0 *1*	100	3266.85	(29/2+)	Q		
4117.5	(33/2−)	779.1 *3*	100	3338.43	(29/2−)			
4282.07	(33/2−)	923.6 *1*	100	3358.47	(29/2−)			
4352.09	(35/2+)	790.6 *1*	100	3561.49	(31/2+)	Q		
4722.4	(37/2−)	912.7 *3*	100	3809.72	(35/2−)	D+Q		
4765.22	(39/2−)	955.5 *1*	100	3809.72	(35/2−)	(Q)		
4787.3	(37/2+)	817.4 *2*	100	3969.85	(33/2+)			
5210.0	(39/2+)	857.9 *1*	100	4352.09	(35/2+)			
5211.5	(37/2−)	929.4 *2*	100	4282.07	(33/2−)			
5701.5	(41/2+)	914.2 *2*	100	4787.3	(37/2+)			
5937.3	(43/2−)	1172.1 *2*	100	4765.22	(39/2−)			
6149.5	(43/2+)	939.5 *2*	100	5210.0	(39/2+)			
6222.5	(41/2−)	1011.0 *3*	100	5211.5	(37/2−)			
6715.6	(45/2+)	1014.1 *3*	100	5701.5	(41/2+)			
7190.3	(47/2+)	1040.8 *2*	100	6149.5	(43/2+)			
7265.5	(47/2−)	1328.2 *9*	100	5937.3	(43/2−)			

† From ^{92}Mo(^{50}Cr,3pγ), except as noted.
‡ From DCO in ^{92}Mo(^{50}Cr,3pγ) (parentheses added by evaluators), except as noted.
# From ^{139}Gd β^+ decay (4.8 s).
@ From ^{139}Gd β^+ decay (5.8 s).
& Weighted av. (external) from ^{139}Gd β^+ decay (5.8 s), ^{92}Mo(^{50}Cr,3pγ), and ^{92}Mo(^{50}Cr,3p),^{110}Cd(^{32}S,Xγ).
a Weighted av. (internal) from ^{139}Gd β^+ decay (5.8 s) and ^{92}Mo(^{50}Cr,3pγ).
b Weighted av. (external) from ^{92}Mo(^{50}Cr,3pγ) and ^{92}Mo(^{50}Cr,3p),^{110}Cd(^{32}S,Xγ).
c Weighted av. (internal) from ^{92}Mo(^{50}Cr,3pγ) and ^{92}Mo(^{50}Cr,3p),^{110}Cd(^{32}S,Xγ).
d From ^{92}Mo(^{54}Fe,5p2nγ).
e Assigned by the evaluators based on the DCO values in 1995Va22 for ΔJ=2 and ΔJ=1 transitions. Below 600 keV, RUL for E2 and M2 transitions is used to assign (E2) for stretched quadrupoles and below 300 keV, (M1+E2) for ΔJ=1 transitions, with the assumption that level half-lives are less than ≈10 ns. 1995Va22 assigned E2 for stretched quadrupoles, M1+E2 for ΔJ=1, mixed transitions, and E1 for ΔJ=1, dipole transitions. For γ rays where no DCO values were available, 1995Va22 assigned

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Adopted Levels, Gammas (continued)

γ(^{139}Eu) (continued)

multipolarities as implied by their J^π values.

[f] 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.

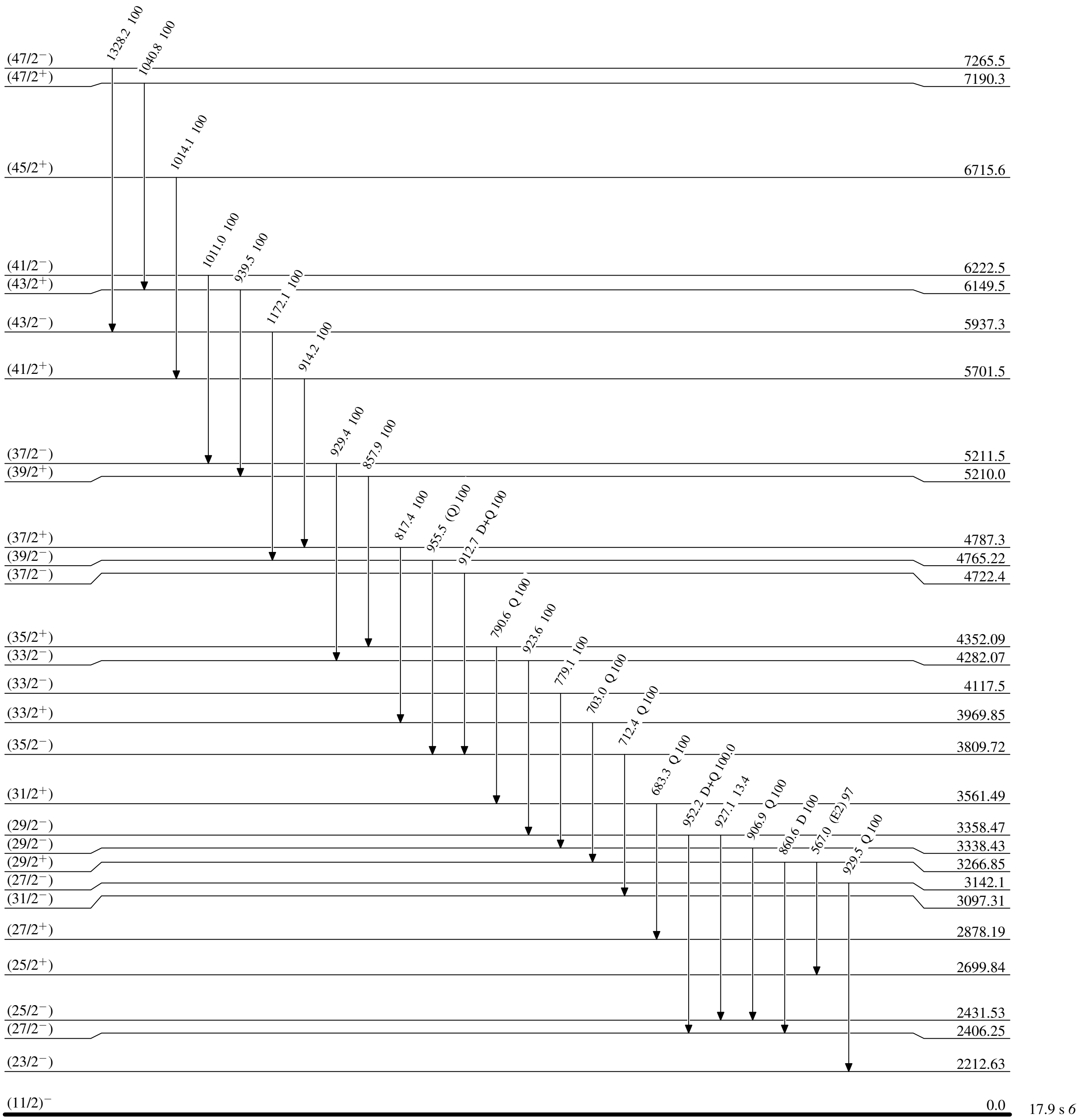
[g] Multiply placed with intensity suitably divided.

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

Adopted Levels, Gammas

Level Scheme

Intensities: Relative photon branching from each level

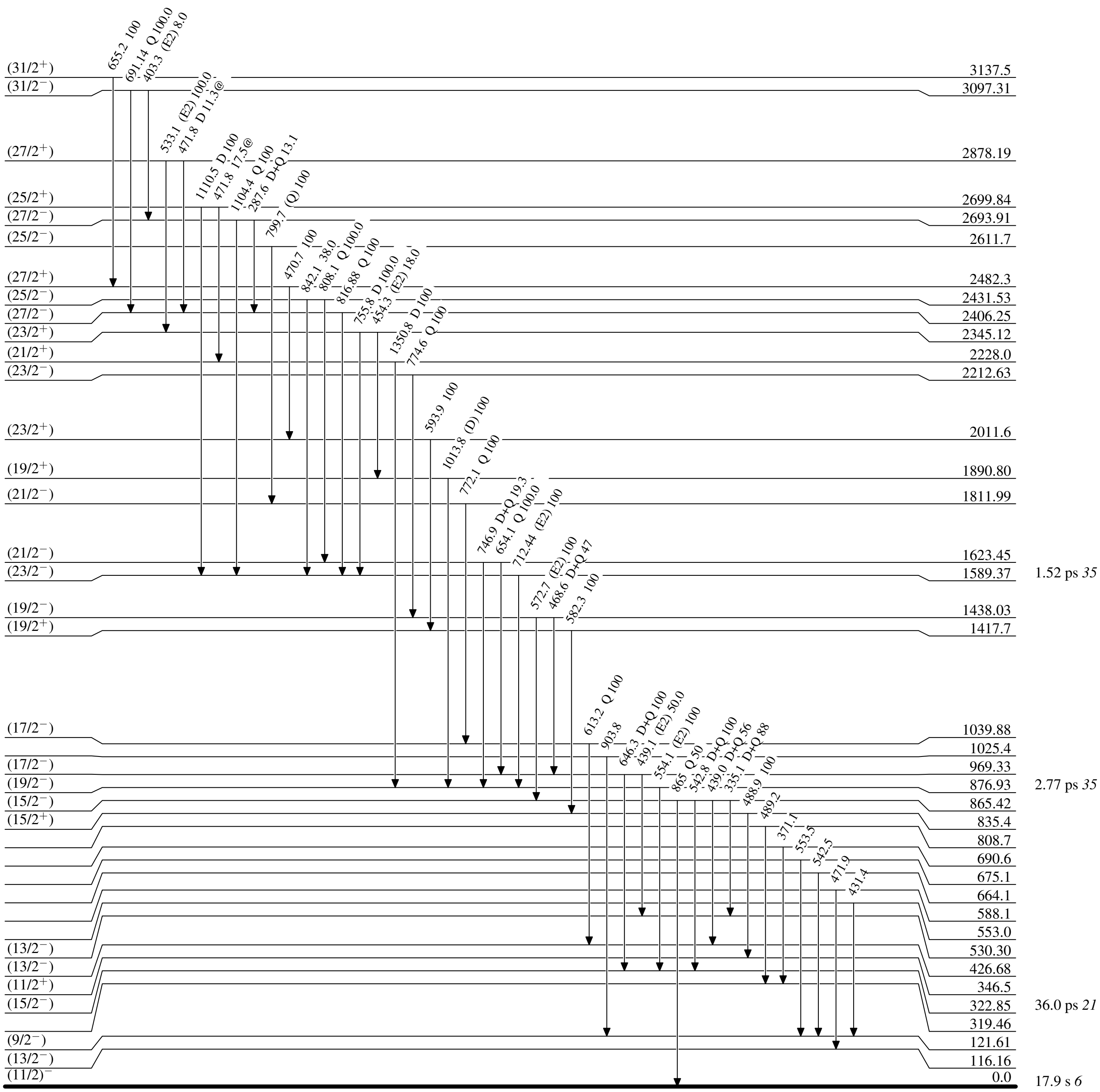


$^{139}_{63}Eu_{76}$

Adopted Levels, Gammas

Level Scheme (continued)

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



$^{139}_{63}Eu_{76}$

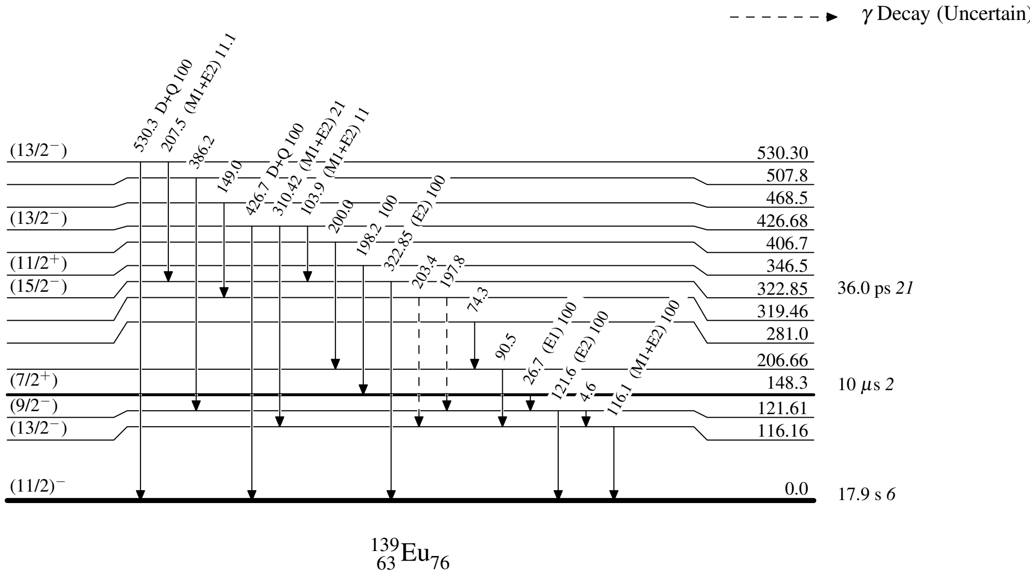
Adopted Levels, Gammas

Legend

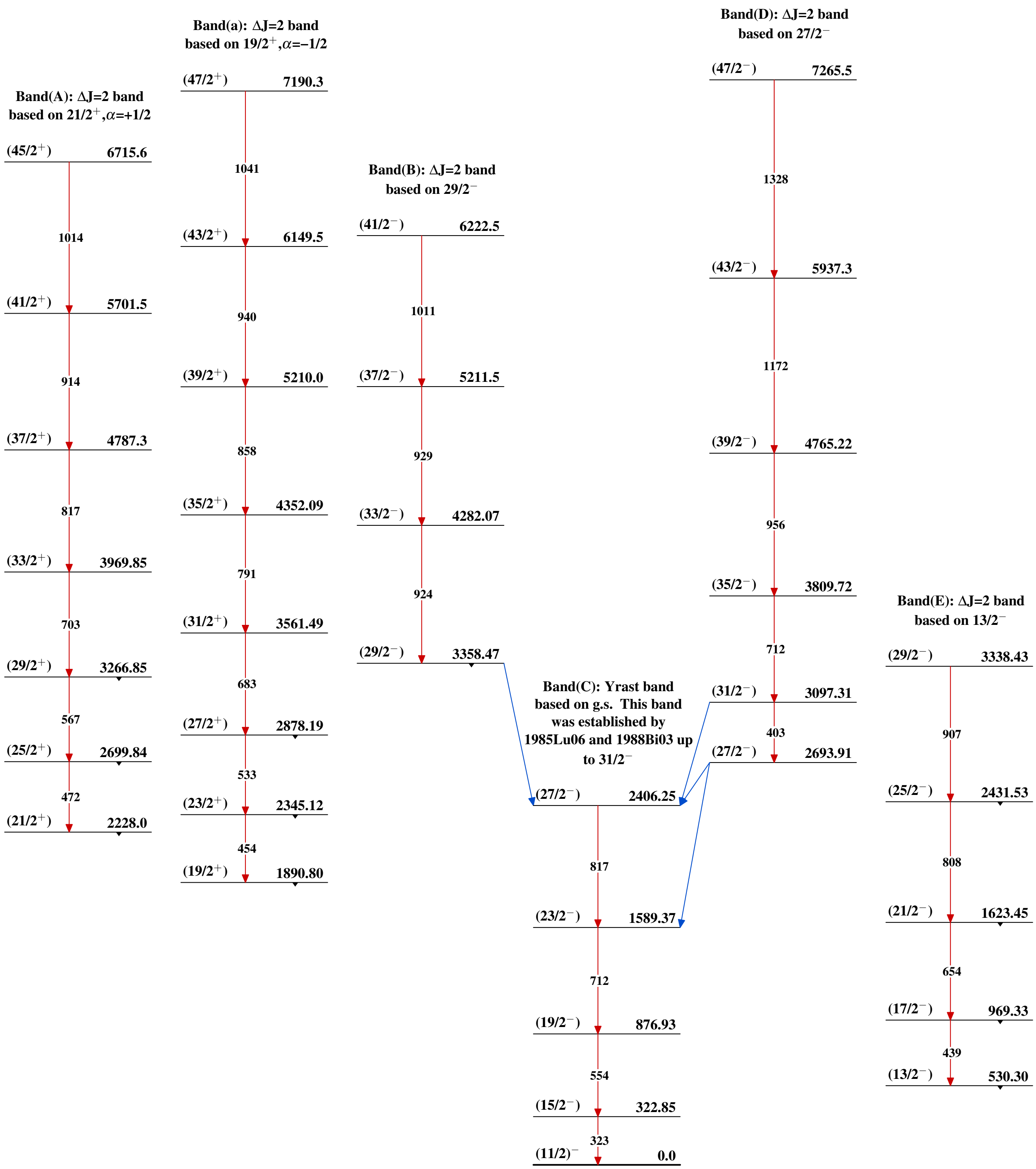
Level Scheme (continued)

Intensities: Relative photon branching from each level

@ Multiply placed: intensity suitably divided

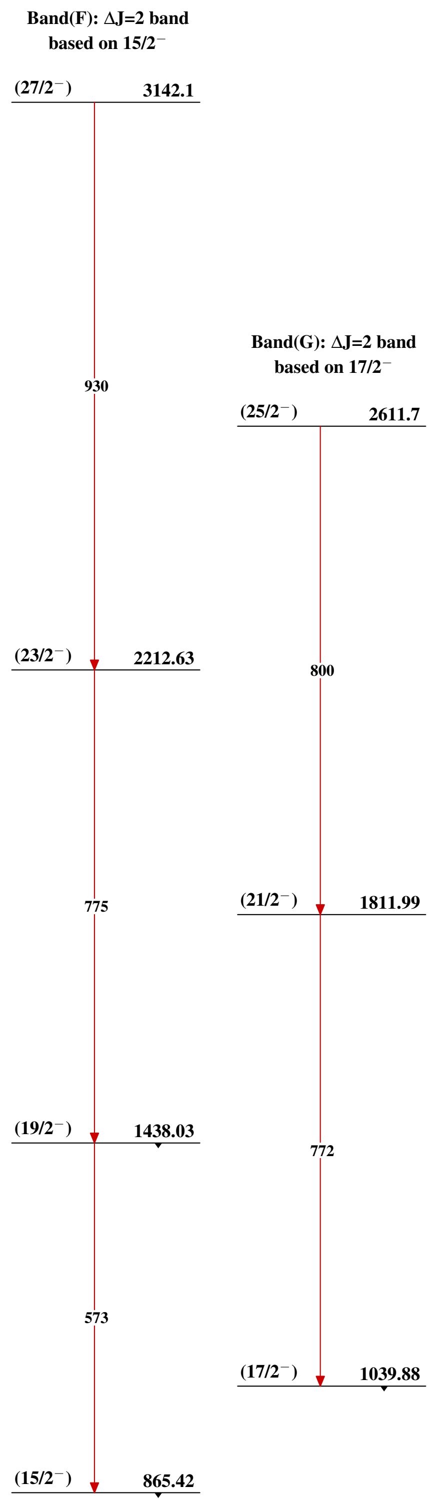


Adopted Levels, Gammas



$^{139}_{63}$Eu$_{76}$

Adopted Levels, Gammas (continued)



$^{139}_{63}Eu_{76}$