^{152}Eu(n,γ) E=thermal 1970Mu04,1985Vo15

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	N. Nica	NDS 170, 1 (2020)	16-Aug-2020

The reactions studied are ^{151}Eu(n,γ)^{152}Eu(n,γ) and ^{151}Eu(n,γ)^{152}Eu^{m}(n,γ); that is, the former involves n capture in the ground state of ^{152}Eu and the latter involves n capture in the 9.3-hour isomer at 45 keV.

1966Ne06: measured 2 γ energies with curved-crystal spectrometer.

1970Mu04: measured secondary γ's with curved-crystal spectrometer.

1983Bo38: measured conversion electrons.

1985Vo15: measured primary γ's with Ge detector in pair spectrometer.

^{153}Eu Levels

E(level)[†]	J$^\pi$[‡]	Comments
0.0	5/2$^+$	
83.3682 *4*	7/2$^+$	
97.4311 *5*	5/2$^-$	
103.1807 *5*	3/2$^+$	
151.6257 *5*	(7/2)$^-$	
172.8540 *5*	5/2$^+$	
193.0667 *7*	9/2$^+$	
235.2818 *6*	(9/2$^-$)	
269.7370 *7*	(7/2$^+$)	
321.8606 *7*	(11/2)$^-$	
325.0676 *10*	(11/2$^+$)	
396.4046 *9*	(9/2$^+$)	
403.292? *5*		
442.624? *4*	($^+$)	
448.1409? *13*		
477.9292 *13*	(13/2$^-$)	
481.0536 *15*	(13/2$^+$)	
537.9437 *13*	(11/2$^+$)	
552.4749? *18*		
559.7424? *17*		
569.24 *18*	(7/2$^+$)	
589.512? *8*	(15/2$^-$)	
617.83 *10*	(5/2$^+$)	
634.59 *6*	(1/2$^+$)	
636.522 *18*	(3/2,5/2)	J$^\pi$: Assigned 3/2$^-$ in ^{153}Eu Adopted Levels.
641.591? *3*		
654.706? *9*	(15/2$^+$)	
681.86 *8*		J$^\pi$: Assigned (5/2$^-$) in ^{153}Eu Adopted Levels.
694.180 *23*	5/2$^+$	
706.622 *23*	5/2$^+$	
713.62 *23*		
716.177? *7*	(13/2$^+$)	
718.5 *4*	(3/2$^+$)	
732.6 *3*	(7/2$^+$)	
783.24 *10*		
797.136? *23*		
840.75 *22*	(3/2$^+$)	
887.6 *4*	(7/2$^+$)	
897.52 *12*		
970.3 *4*		
1012.2 *3*		
1023.10 *16*		
1149.87 *21*		

Continued on next page (footnotes at end of table)

^{152}Eu(n,γ) E=thermal 1970Mu04,1985Vo15 (continued)

^{153}Eu Levels (continued)

E(level)†	J$^{\pi}$‡	Comments
1225.3 *3*		
1350.89 *16*		
1396.03 *9*		
1417.66 *9*		
(8550.28 *12*)	$5/2^-$ & $7/2^-$	
(8595.88 *12*)	$1/2^-$	E(level): This state is from thermal neutron capture in the 9-h, 0^- isomer in ^{152}Eu.

† From least-squares fit to γ energies, including γ's which are tentatively assigned, with separate fits carried out for primary and secondary γ rays. In the fit for the primary γ's, the energies of the capture levels were fixed.

‡ As given in 1970Mu04 or 1985Vo15 and, except as noted, assignments are the same in ^{153}Eu Adopted Levels where the band structure is also given.

γ(^{153}Eu)

E_γ[†‡]	I_γ[#]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[@]	δ[@]	Comments
39.3324[&] 25	2.5 4	442.624?	(+)	403.292?				
42.2147[&] 25	0.5 4	235.2818	(9/2−)	193.0667	9/2+			
x47.4304 10	1.57[c] 19							
54.1934 4	12.4 21	151.6257	(7/2)−	97.4311	5/2−	M1		Mult.,δ: from α_{L1}=1.5 4 and δ < 0.18.
68.2557 5	10.1 10	151.6257	(7/2)−	83.3682	7/2+			
69.6731 5	37 4	172.8540	5/2+	103.1807	3/2+	M1+E2	1.55 +26−20	Mult.: from α_{L1}=0.34 2.
74.5451[e&] 12	0.43[e] 7	396.4046	(9/2+)	321.8606	(11/2)−			
74.5451[e&] 12	0.43[e] 7	552.4749?		477.9292	(13/2−)			
75.4228 7	1.33 13	172.8540	5/2+	97.4311	5/2−			
76.6693 20	0.23 5	269.7370	(7/2+)	193.0667	9/2+			
81.8476[&] 25	0.29[c] 4	641.591?		559.7424?				
83.3675 5	44 4	83.3682	7/2+	0.0	5/2+	M1+E2	0.69 9	Mult.,δ: from L subshell ratios.
83.6567[a] 6	21.7 20	235.2818	(9/2−)	151.6257	(7/2)−	M1		Mult.: from α_{L1}=0.39 12.
86.5783 6	11.5 8	321.8606	(11/2)−	235.2818	(9/2−)	M1(+E2)	0.6 +9−6	Mult.: from α_{L1}=0.27 7.
x88.2951 9	0.47 4							
89.4848 7	1.19 11	172.8540	5/2+	83.3682	7/2+			
89.7858 15	3.4 5	325.0676	(11/2+)	235.2818	(9/2−)			
x90.1244 12	0.36 5							
90.5152[&] 15	0.26 3	797.136?		706.622	5/2+			
96.8825 7	39 3	269.7370	(7/2+)	172.8540	5/2+	E2(+M1)		Mult.: from α_K=1.26 20.
97.4309 7	192 15	97.4311	5/2−	0.0	5/2+	E1		Mult.: from α_K(exp)=0.26 4 and L subshell ratios.
x99.9598 10	1.91[c] 29							
102.9576[&] 17	0.17 4	797.136?		694.180	5/2+			
103.1802 7	121 9	103.1807	3/2+	0.0	5/2+	M1		Mult.: from α_K=1.45 22.
104.3352[&f] 15	0.26[c] 7	552.4749?		448.1409?				
x107.873 6	0.12[c] 3							
109.6988 8	16.3 12	193.0667	9/2+	83.3682	7/2+	M1+E2	0.80 16	Mult.: from α_K=1.09 18 and L subshell ratios.
x109.7600 9	2.14 15							
111.6004[&] 12	0.89 13	559.7424?		448.1409?				
118.1117 10	2.26 18	269.7370	(7/2+)	151.6257	(7/2)−			
123.0724[&] 9	4.7 9	448.1409?		325.0676	(11/2+)			
126.6664 10	23.5 19	396.4046	(9/2+)	269.7370	(7/2+)	M1(+E2)	0.3 +13−3	Mult.: from α_K=0.78 12.
128.7936 9	6.1 5	321.8606	(11/2)−	193.0667	9/2+	E1		Mult.: from α_K=0.12 4.
132.0002 10	3.9 4	325.0676	(11/2+)	193.0667	9/2+	M1		Mult.: from α_K=0.79 14.
137.8498 20	2.05 25	235.2818	(9/2−)	97.4311	5/2−			
141.5381 10	7.5 6	537.9437	(11/2+)	396.4046	(9/2+)	M1		Mult.: from α_K=0.57 10.
151.6245 12	48 4	151.6257	(7/2)−	0.0	5/2+	E1		Mult.: from α_K=0.092 20.
151.9135 12	26.1 21	235.2818	(9/2−)	83.3682	7/2+	E1		Mult.: from α_K=0.069 15.
152.862 4	1.0 3	477.9292	(13/2−)	325.0676	(11/2+)			
155.9849 20	0.78 8	481.0536	(13/2+)	325.0676	(11/2+)			

γ(^{153}Eu) (continued)

E_γ[†‡]	I_γ[#]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[@]	Comments
156.0674 12	5.8 5	477.9292	(13/2$^-$)	321.8606	(11/2)$^-$		
159.1908 20	1.30 13	481.0536	(13/2$^+$)	321.8606	(11/2)$^-$		
161.128 12	0.9 5	396.4046	(9/2$^+$)	235.2818	(9/2$^-$)		
166.5548 15	5.3 4	269.7370	(7/2$^+$)	103.1807	3/2$^+$	E2	Mult.: from α_K=0.25 5.
170.2344 25	3.1 3	321.8606	(11/2)$^-$	151.6257	(7/2)$^-$	(E2)	Mult.: M1,E2 from α_K=0.21 11, $\Delta(J^\pi)$ requires E2.
172.3035 20	4.0 4	269.7370	(7/2$^+$)	97.4311	5/2$^-$	E1	Mult.: from α_K=0.073 20.
172.860 5	0.63 10	172.8540	5/2$^+$	0.0	5/2$^+$	M1	Mult.: from α_K=0.69 20, but includes 172.887 and this γ.
172.887[&f] 5	0.45[c] 9	442.624?	($^+$)	269.7370	(7/2$^+$)	M1	Mult.: from α_K=0.69 20, but includes 172.860 and this γ.
173.640 10	0.16[c] 4	654.706?	(15/2$^+$)	481.0536	(13/2$^+$)		
178.229[&] 7	1.5 5	716.177?	(13/2$^+$)	537.9437	(11/2$^+$)		
186.216[&] 7	0.68[c] 17	589.512?	(15/2$^-$)	403.292?			
193.063 3	47 5	193.0667	9/2$^+$	0.0	5/2$^+$	E2	Mult.: from α_K=0.15 2 and L subshell ratios.
198.967[&] 4	0.83[c] 17	641.591?		442.624?	($^+$)		
[x]201.007 6	0.56[c] 14						
216.086 5	1.1 3	537.9437	(11/2$^+$)	321.8606	(11/2)$^-$		
223.545 3	11.1 9	396.4046	(9/2$^+$)	172.8540	5/2$^+$	E2	Mult.: from α_K=0.11 2.
237.889[&] 12	1.5[c] 5	559.7424?		321.8606	(11/2)$^-$		
241.6962 25	28.3 20	325.0676	(11/2$^+$)	83.3682	7/2$^+$	E2	Mult.: from α_K=0.085 12.
242.645 4	4.0 6	477.9292	(13/2$^-$)	235.2818	(9/2$^-$)	(E2)	Mult.: M1,E2 from α_K=0.21 11, $\Delta(J^\pi)$ requires E2.
244.777 4	10.5 7	396.4046	(9/2$^+$)	151.6257	(7/2)$^-$	E1	Mult.: from α_K=0.039 13.
[x]247.940 4	4.3 4						
249.558[&] 5	2.35 24	442.624?	($^+$)	193.0667	9/2$^+$		
255.103[&] 20	0.73 15	448.1409?		193.0667	9/2$^+$		
268.205 5	7.5 5	537.9437	(11/2$^+$)	269.7370	(7/2$^+$)	E2	Mult.: from α_K=0.067 17.
287.993 5	8.5 7	481.0536	(13/2$^+$)	193.0667	9/2$^+$	E2	Mult.: from α_K=0.060 15.
302.660 6	7.0 6	537.9437	(11/2$^+$)	235.2818	(9/2$^-$)		
305.87[&] 4	0.9 4	403.292?		97.4311	5/2$^-$		
319.784[e&] 15	3.0[e] 5	589.512?	(15/2$^-$)	269.7370	(7/2$^+$)		
319.784[e&] 15	3.0[e] 5	716.177?	(13/2$^+$)	396.4046	(9/2$^+$)		
329.652 15	2.8[c] 14	654.706?	(15/2$^+$)	325.0676	(11/2$^+$)		
[x]338.252 20	1.1[c] 3						
[x]338.361 17	1.9[c] 3						
[x]352.984 20	3.7[c] 6						
[x]353.151 25	3.0[c] 5						
359.427[&] 15	2.9 7	552.4749?		193.0667	9/2$^+$		
[x]361.190 20	2.5[c] 6						
463.64 5	3.0[c] 6	636.522	(3/2,5/2)	172.8540	5/2$^+$		
509.02 12	3.9 20	681.86		172.8540	5/2$^+$		
[x]513.87 3	7.8[c] 12						
521.37 3	6.8[c] 10	694.180	5/2$^+$	172.8540	5/2$^+$		

$^{153}_{63}$Eu$_{90}$-4

γ(^{153}Eu) (continued)

E_γ[†‡]	I_γ[#]	E_i(level)	J^π_i	E_f	J^π_f
531.40 *6*	6.0 *9*	634.59	$(1/2^+)$	103.1807	$3/2^+$
533.372 *25*	8.8 *13*	636.522	(3/2,5/2)	103.1807	$3/2^+$
539.04 *3*	8.0 *12*	636.522	(3/2,5/2)	97.4311	$5/2^-$
554.89[b] *12*	10.[c] *2*	706.622	$5/2^+$	151.6257	$(7/2)^-$
578.67 *9*	5.4[c] *11*	681.86		103.1807	$3/2^+$
596.61 *10*	8.2[c] *20*	694.180	$5/2^+$	97.4311	$5/2^-$
603.31 *10*	4.3[c] *11*	706.622	$5/2^+$	103.1807	$3/2^+$
609.21 *4*	11.8 *14*	706.622	$5/2^+$	97.4311	$5/2^-$
^{x}667.94 *6*	5.8[c] *9*				
7132.45 *9*	20.4 *8*	(8550.28)	$5/2^-$ & $7/2^-$	1417.66	
7154.08 *9*	29.9 *12*	(8550.28)	$5/2^-$ & $7/2^-$	1396.03	
7199.22 *16*	16.0 *10*	(8550.28)	$5/2^-$ & $7/2^-$	1350.89	
7324.8 *3*	15.2 *9*	(8550.28)	$5/2^-$ & $7/2^-$	1225.3	
^{x}7329.8[d] *6*	4.4 *8*				
^{x}7335.8[d] *10*	1.7 *5*				
^{x}7357.9[d] *9*	1.7 *5*				
^{x}7374.8[d] *4*	5.2 *7*				
^{x}7394.9[d] *7*	3.5 *7*				
7400.23 *21*	13.8 *10*	(8550.28)	$5/2^-$ & $7/2^-$	1149.87	
^{x}7479.4[d] *5*	2.6 *5*				
7526.99 *16*	12.1 *6*	(8550.28)	$5/2^-$ & $7/2^-$	1023.10	
^{x}7554.2[d] *8*	1.7 *5*				
^{x}7575.8[d] *6*	2.2 *5*				
7583.7 *3*	4.6 *5*	(8595.88)	$1/2^-$	1012.2	
7625.6 *4*	5.5 *7*	(8595.88)	$1/2^-$	970.3	
7652.56 *12*	45.3 *18*	(8550.28)	$5/2^-$ & $7/2^-$	897.52	
7662.5 *4*	7.7 *10*	(8550.28)	$5/2^-$ & $7/2^-$	887.6	$(7/2^+)$
^{x}7669.7[d] *11*	2.4 *9*				
7709.33 *22*	23.0 *23*	(8550.28)	$5/2^-$ & $7/2^-$	840.75	$(3/2^+)$
^{x}7719.0[d] *3*	6.4 *6*				
7766.84 *10*	27.6 *8*	(8550.28)	$5/2^-$ & $7/2^-$	783.24	
^{x}7799.4[d] *8*	1.3 *4*				
7817.5 *3*	3.7 *4*	(8550.28)	$5/2^-$ & $7/2^-$	732.6	$(7/2^+)$
7831.6 *4*	4.7 *7*	(8550.28)	$5/2^-$ & $7/2^-$	718.5	$(3/2^+)$
7836.1 *10*	2.0 *6*	(8550.28)	$5/2^-$ & $7/2^-$	713.62	
7842.8 *3*	4.3 *4*	(8550.28)	$5/2^-$ & $7/2^-$	706.622	$5/2^+$
7855.90 *23*	5.5 *5*	(8550.28)	$5/2^-$ & $7/2^-$	694.180	$5/2^+$
^{x}7864.3[d] *5*	2.3 *4*				
7877.0 *9*	2.1 *6*	(8595.88)	$1/2^-$	718.5	$(3/2^+)$
7882.24 *23*	9.9 *8*	(8595.88)	$1/2^-$	713.62	
^{x}7893.9[d] *4*	3.9 *5*				
^{x}7912.0[d] *7*	1.7 *4*				
7932.24 *10*	33.0 *10*	(8550.28)	$5/2^-$ & $7/2^-$	617.83	$(5/2^+)$
^{x}7941.5[d] *8*	1.6 *4*				
^{x}7948.9[d] *6*	2.0 *4*				
7960.7 *3*	4.6 *5*	(8595.88)	$1/2^-$	634.59	$(1/2^+)$
7980.82 *18*	9.2 *6*	(8550.28)	$5/2^-$ & $7/2^-$	569.24	$(7/2^+)$
8153.59 *9*	55.6 *13*	(8550.28)	$5/2^-$ & $7/2^-$	396.4046	$(9/2^+)$
8280.43 *12*	18.8 *8*	(8550.28)	$5/2^-$ & $7/2^-$	269.7370	$(7/2^+)$
8357.4 *5*	2.4 *4*	(8550.28)	$5/2^-$ & $7/2^-$	193.0667	$9/2^+$
8377.23 *11*	63.1 *12*	(8550.28)	$5/2^-$ & $7/2^-$	172.8540	$5/2^+$
8452.3 *4*	2.3 *4*	(8550.28)	$5/2^-$ & $7/2^-$	97.4311	$5/2^-$
8466.70 *14*	16.7 *7*	(8550.28)	$5/2^-$ & $7/2^-$	83.3682	$7/2^+$
8492.69 *3*	4.2 *4*	(8595.88)	$1/2^-$	103.1807	$3/2^+$
8549.5 *8*	0.94 *25*	(8550.28)	$5/2^-$ & $7/2^-$	0.0	$5/2^+$

† The energy calibration by 1970Mu04 was based on the values of 1959Be51 for the energies of the Kα x rays of Eu and Sm (1973Sc04). However, it is now possible to use the precise energies for the seven lines given in 2000He14 from the ^{153}Gd ε decay to compute a scaling factor for the reported energies. For the γ rays of 69.6, 75.4, 83.3, 89.4, 97.4, 103.1, and 172 keV, the scaling factors give an increase in the energies from 1970Mu04 of 26 *7*, 18 *10*, 24 *7*, 40 *8*, 28 *8*, 26 *7*, and −11 *29* ppm, respectively. The scaling factor used is the weighted average of these values which is 27 *3* ppm with a reduced-χ^2 of 0.90. This scaling factor is precise enough that its uncertainty is negligible.

‡ The Eγ for the primary γ's are from 1985Vo15.

Given as two sets of relative intensities, one set for the primary γ's (1985Vo15) and one for the secondaries (1970Mu04).

@ From 1983Bo38 and based on their conversion-electron intensities and Iγ of 1970Mu04. Some conversion coefficients are included here, others are given in γ(^{153}Eu) (continued)

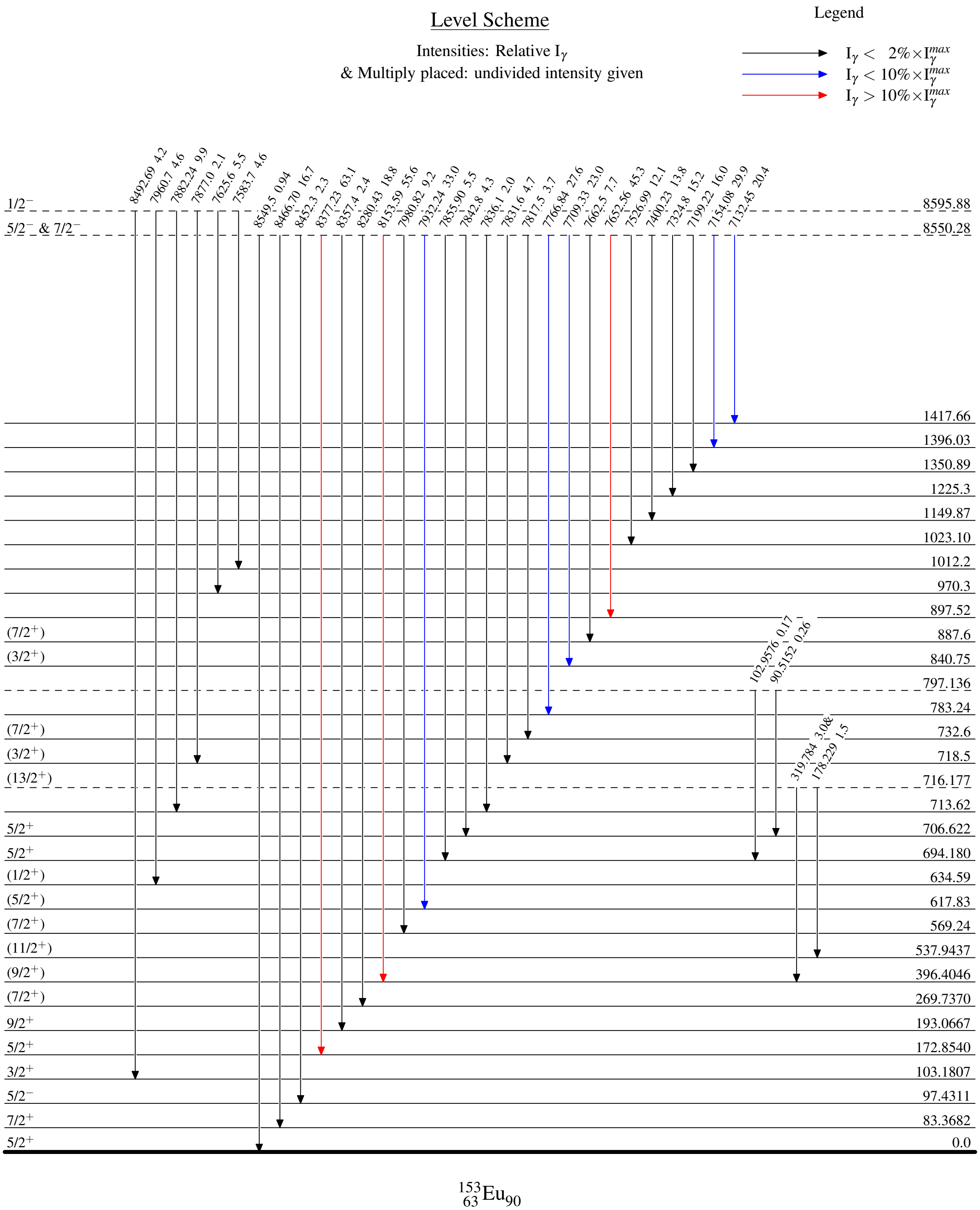
1983Bo38. See Adopted γ data for consideration of all data.
[&] Assignment or placement of transition in the level scheme is uncertain.
[a] Line is questionable.
[b] Line is probably complex.
[c] Observed growth in Iγ does not unambiguously allow assignment to the double capture process.
[d] Assignment to either the 8550- or 8596-keV capture level has not been made.
[e] Multiply placed with undivided intensity.
[f] Placement of transition in the level scheme is uncertain.
[x] γ ray not placed in level scheme.

$^{152}Eu(n,\gamma)$ E=thermal 1970Mu04,1985Vo15

Level Scheme

Intensities: Relative I_γ

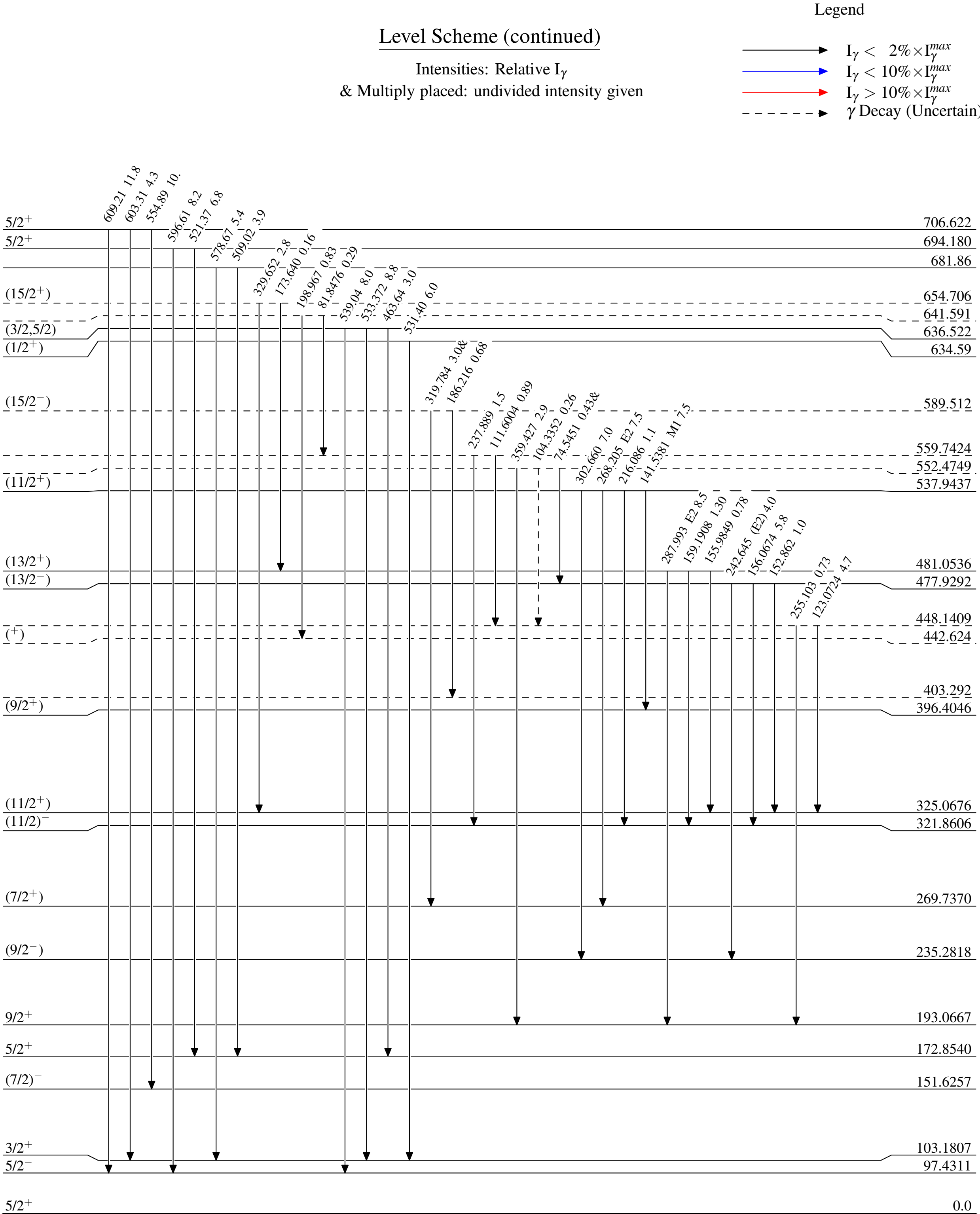
& Multiply placed: undivided intensity given



^{152}Eu(n,γ) E=thermal 1970Mu04,1985Vo15

Level Scheme (continued)

Intensities: Relative I_γ
& Multiply placed: undivided intensity given



$^{153}_{63}Eu_{90}$

^{152}Eu(n,γ) E=thermal 1970Mu04,1985Vo15

Level Scheme (continued)

Intensities: Relative I_γ

& Multiply placed: undivided intensity given

Legend

$I_\gamma < 2\% \times I_\gamma^{max}$

$I_\gamma < 10\% \times I_\gamma^{max}$

$I_\gamma > 10\% \times I_\gamma^{max}$

γ Decay (Uncertain)