^{229}Pa α decay (1.50 d) 1987Ah05,1973Ag01,1958Hi78

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Balraj Singh	ENSDF	25-Oct-2019

Parent: ^{229}Pa: E=0.0; J$^\pi$=(5/2$^+$); $T_{1/2}$=1.50 d *5*; Q(α)=5835 *4*; %α decay=0.48 *5*

^{229}Pa-J$^\pi$: From ^{229}Pa Adopted Levels in the ENSDF database, as of June 2008), with proposed configuration=π5/2[642].

^{229}Pa-$T_{1/2}$: From ^{229}Pa Adopted Levels in the ENSDF database, where the value is adopted from the measurement by 1987Ah05.
A recent measurement by 2018Gr09 reports $T_{1/2}$=1.55 d *1* (weighted average of the following eight values deduced from decay curves for 117.2- and 119.0-keV γ rays at four different proton bombarding energies: 1.83 d *5*, 1.49 d *2*, 2.08 d *6*, 1.60 d *2*, 1.66 d *5*, 1.47 d *2*, 1.78 d *10*, 1.43 d *3*). Evaluator's analysis of this result: eight values from 2018Gr09 form a discrepant dataset, as regular weighted average gives 1.55 d *5* (not an uncertainty of 0.01 d as given in 2018Gr09), but reduced χ^2 of 24 is very large in comparison to critical χ^2=2.1 at 95% confidence level. Weighted average by the method of limitation of relative statistical weights (LRSW) method gives 1.53 d *5*, but still with reduced χ^2=14, and rejecting the 2.08 d *6* value as an outlier. Weighted average by Normalized Residuals method (NRM), which adjusts uncertainties in data points considered as outliers, gives 1.50 d *3*, with reduced χ^2=5, still too large to be acceptable. It would seem that unweighted average, which gives a value of 1.67 d *8* is perhaps an appropriate way to deal with this dataset. Based on above problematic issues with these data, reported $T_{1/2}$ from 2018Gr09 is omitted in the adopted half-life of ^{229}Pa decay.

^{229}Pa-Q(α): From 2017Wa10.

^{229}Pa-%α decay: %α=0.48 *5* for ^{229}Pa α decay (from ^{229}Pa Adopted Levels in the ENSDF database, as of June 2008).

1987Ah05: measured Eγ, Iγ, E(x ray), I(x ray), ce, $\gamma\gamma$-coin, $\alpha\gamma$-coin.

1973Ag01: measured Eα, Eγ, Iγ(in $\alpha\gamma$-coin mode), $\alpha\gamma$-coin.

1963Su10 (thesis): measured Eα, Iα, Eγ, $\alpha\gamma$-coin.

1958Hi78 (thesis): measured Eα, Iα.

^{225}Ac Levels

E(level)[†]	J$^\pi$[‡]	$T_{1/2}$[‡]	Comments
0.0[@]	(3/2$^-$)	9.920 d *3*	
29.91[@] *6*	(5/2$^-$)		
40.10[&] *4*	(3/2$^+$)		J$^\pi$: 3/2$^+$ in 1987Ah05.
64.69[&] *5*	(5/2$^+$)	0.72 ns *3*	J$^\pi$: 5/2$^+$ in 1987Ah05.
77.13[@] *9*	(7/2$^-$)		J$^\pi$: 7/2$^-$ in 1987Ah05.
105.01[&] *7*	(7/2$^+$)		J$^\pi$: 7/2$^+$ in 1987Ah05.
120.81[a] *4*	(5/2$^-$)		J$^\pi$: 5/2$^-$ in 1987Ah05.
144.96[&] *9*	(9/2$^+$)		J$^\pi$: 9/2$^+$ in 1987Ah05.
155.64[b] *5*	(5/2$^+$)		J$^\pi$: 5/2$^+$ in 1987Ah05.
170.75[a] *8*	(7/2$^-$)		J$^\pi$: 7/2$^-$ in 1987Ah05.
199.86[b] *6*	(7/2$^+$)		J$^\pi$: 7/2$^+$ in 1987Ah05.
221[#] *7*			J$^\pi$: 11/2$^+$ in 1973Ag01.
235.53[@] *13*	(9/2$^-$)		J$^\pi$: 9/2$^-$ in 1987Ah05.
256.97[b] *9*	(9/2$^+$)		J$^\pi$: 9/2$^+$ in 1987Ah05.
≈318?[#]			J$^\pi$: (11/2$^-$) in 1973Ag01.
327[#] *7*			J$^\pi$: 11/2$^+$ in 1973Ag01.
421?[#] *7*			

[†] From least-squares fit to Eγ data.
[‡] From the Adopted Levels. The J^π assignments in 1987Ah05 and 1973Ag01 are given without parentheses.
[#] Level not in 1987Ah05.
[@] Band(A): π3/2[532] band.

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^{229}Pa α decay (1.50 d) 1987Ah05,1973Ag01,1958Hi78 (continued)

^{225}Ac Levels (continued)

& Band(B): π3/2[651] band.
a Band(C): π5/2[523] band.
b Band(D): π5/2[642] band.

α radiations

Eα[†]	E(level)	Iα[‡&]	HF[#]	Comments
5320[@] *5*	421?	0.05 *4*	53 *43*	
5413 *5*	327	0.1	90	Iα: other: 0.15 (1958Hi78).
≈5422[@]	≈318?	0.07 *2*	≈144	
5479 *5*	256.97	1.7	13	
5501 *5*	235.53	0.7	41	
5517 *5*	221	0.6	57	
5536 *5*	199.86	8.5	5.3	
5565 *5*	170.75	3.9	16	
5580 *5*	155.64	36.0	2.1	
5591 *5*	144.96	4.6	19	
5615 *5*	120.81	13.3	8.9	
5630 *5*	105.01	9.7	15	
5656 *4*	77.13	<0.2	>887	Eα: from Q(α)=5835 *4* and level energy.
5670 *5*	64.69	18.5	13	
5695 *5*	40.10	0.2	1553	Iα: other: ≈1.5% (1963Su10) is in disagreement.
5703 *4*	29.91	<0.2	≥1557	Eα: from Q(α)=5835 *4* and level energy.
5733 *4*	0.0	<0.5	≥887	Eα: from Q(α)=5835 *4*. This α group was assigned by 1958Hi78 and 1963Su10 to ^{225}Ac α decay. Iα: ≈0.5% (1963Su10).

† From 1958Hi78, except where noted otherwise. Original energies have been increased by 5 keV because of changes in calibration energies, as recommended by 1979Ry03. Other measurement: 1963Su10.
‡ From 1973Ag01. Other measurements: 1958Hi78, 1963Su10; both are theses from Berkeley Laboratory.
\# The nuclear radius parameter $r_0(^{225}Ac)$=1.53293 *31* is deduced from interpolation (or unweighted average) of radius parameters of the adjacent even-even nuclides. Radius parameter used from 2019 updated table.
@ Existence of this α group (reported by 1958Hi78) could not be confirmed by the measurements of 1973Ag01.
& For absolute intensity per 100 decays, multiply by 0.0048 *5*.

γ(^{225}Ac)

Iγ normalization: 1987Ah05 give Iγ/100 decays.
Ac x-ray data from 1987Ah05:
Ac $K\alpha_2$: E(x ray)=87.68 *5*, %I(x ray)=15.5 *12* (1987Ah05).
Ac $K\alpha_1$: E(x ray)=90.88 *5*, %I(x ray)=25.7 *18* (1987Ah05).
Ac $K\beta_1'$: E(x ray)=102.9 *1*, %I(x ray)=8.5 *7* (1987Ah05).
Ac $K\beta_2'$: E(x ray)=105.8 *1*, %I(x ray)=3.1 *3* (1987Ah05).

E_γ[†]	E_i(level)	J_i^π	E_f	J_f^π	Comments
24.6[d]	64.69	$(5/2^+)$	40.10	$(3/2^+)$	E_γ: from level scheme, transition was not observed. Existence is inferred from observation of 40.09γ in coincidence with 5670α populating the 64.70-keV level. In level-scheme Fig. 4, 1973Ag01, I(γ+ce)(24.6)/I(γ+ce)(64.7)=10/45.
30.0 *2*	29.91	$(5/2^-)$	0.0	$(3/2^-)$	E_γ: from αγ-coin (1973Ag01). This γ ray at 30.1 keV was interpreted by

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^{229}Pa α decay (1.50 d) 1987Ah05,1973Ag01,1958Hi78 (continued)

γ(^{225}Ac) (continued)

E_γ[†]	I_γ[‡a]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[#]	α[b]	Comments
								1987Ah05 as an escape peak in their αγ-coin spectrum Fig. 2. A general uncertainty of 0.2 keV for Eγ was assigned by 1973Ag01.
34.8[c] *1*	0.54[c]	64.69	(5/2$^+$)	29.91	(5/2$^-$)	[E1]	1.88	α(L)=1.415 *23*; α(M)=0.353 *6* α(N)=0.0912 *15*; α(O)=0.0193 *3*; α(P)=0.00288 *5*; α(Q)=0.0001062 *16* I_γ: total Iγ(34.8γ)=1.04 *9* (1987Ah05) was measured. Iγ(34.8γ) deexciting the 64.7-keV level was determined by 1987Ah05 from γ spectrum in coincidence with the 5670α populating the 64.70-keV level.
34.8[c] *1*	0.5[c]	155.64	(5/2$^+$)	120.81	(5/2$^-$)	[E1]	1.88	α(L)=1.415 *23*; α(M)=0.353 *6* α(N)=0.0912 *15*; α(O)=0.0193 *3*; α(P)=0.00288 *5*; α(Q)=0.0001062 *16* I_γ: obtained by 1987Ah05 from subtraction of the component from the 64.7 level determined from αγ-coin gated with α to the 64.7 level.
39.9[@d]		144.96	(9/2$^+$)	105.01	(7/2$^+$)			In level-scheme Fig. 4, 1973Ag01, I(γ+ce)(39.9)/I(γ+ce)(67.8)=70/30.
40.09 *5*	21.6 *18*	40.10	(3/2$^+$)	0.0	(3/2$^-$)	E1	1.293	α(L)=0.974 *14*; α(M)=0.241 *4* α(N)=0.0624 *9*; α(O)=0.01336 *20*; α(P)=0.00203 *3*; α(Q)=7.96×10^{-5} *12* Mult.: from the Adopted Gammas, based on L-subshell data in ^{225}Ra β$^-$.
40.1[@d]		105.01	(7/2$^+$)	64.69	(5/2$^+$)			In level-scheme Fig. 4, 1973Ag01, I(γ+ce)(40.1)/I(γ+ce)(75.1)=45/55.
44.2[@d]		199.86	(7/2$^+$)	155.64	(5/2$^+$)			
50.6[@d]		155.64	(5/2$^+$)	105.01	(7/2$^+$)			
54.9[@d]		199.86	(7/2$^+$)	144.96	(9/2$^+$)			
64.70 *5*	9.4 *8*	64.69	(5/2$^+$)	0.0	(3/2$^-$)	[E1]	0.362	α(L)=0.273 *4*; α(M)=0.0667 *10* α(N)=0.01735 *25*; α(O)=0.00380 *6*; α(P)=0.000613 *9*; α(Q)=2.90×10^{-5} *4*
67.80 *5*	1.35 *12*	144.96	(9/2$^+$)	77.13	(7/2$^-$)	[E1]	0.319	α(L)=0.241 *4*; α(M)=0.0588 *9* α(N)=0.01531 *22*; α(O)=0.00336 *5*; α(P)=0.000545 *8*; α(Q)=2.62×10^{-5} *4*
75.12 *5*	7.2 *6*	105.01	(7/2$^+$)	29.91	(5/2$^-$)	[E1]	0.243	α(L)=0.184 *3*; α(M)=0.0447 *7* α(N)=0.01165 *17*; α(O)=0.00257 *4*; α(P)=0.000420 *6*; α(Q)=2.10×10^{-5} *3*
79.00 *7*	0.36 *3*	199.86	(7/2$^+$)	120.81	(5/2$^-$)	[E1]	0.213	α(L)=0.1608 *23*; α(M)=0.0391 *6* α(N)=0.01019 *15*; α(O)=0.00225 *4*; α(P)=0.000370 *6*; α(Q)=1.88×10^{-5} *3*
80.6 *1*	0.12 *2*	120.81	(5/2$^-$)	40.10	(3/2$^+$)	[E1]	0.202	α(L)=0.1524 *22*; α(M)=0.0370 *6* α(N)=0.00966 *14*; α(O)=0.00213 *3*; α(P)=0.000351 *5*; α(Q)=1.80×10^{-5} *3*
90.9[@d]		155.64	(5/2$^+$)	64.69	(5/2$^+$)			In level-scheme Fig. 4, 1973Ag01, I(γ+ce)(90.9)/I(γ+ce)(115.5)=5/92.
93.6 *1*	0.21 *3*	170.75	(7/2$^-$)	77.13	(7/2$^-$)	[M1+E2]	6.2[&] *30*	α(L)=4.6 *22*; α(M)=1.17 *63* α(N)=0.31 *17*; α(O)=0.070 *36*; α(P)=0.0120 *52*; α(Q)=6.3×10^{-4} *20*
94.86 *7*	0.45 *5*	199.86	(7/2$^+$)	105.01	(7/2$^+$)	[M1]	4.00	α(L)=3.03 *5*; α(M)=0.726 *11* α(N)=0.193 *3*; α(O)=0.0448 *7*; α(P)=0.00829 *12*; α(Q)=0.000736 *11*

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^{229}Pa α decay (1.50 d) 1987Ah05,1973Ag01,1958Hi78 (continued)

γ(^{225}Ac) (continued)

E_γ[†]	I_γ[‡a]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[#]	δ	α[b]	Comments
111.9 *1*	0.12 *2*	256.97	(9/2+)	144.96	(9/2+)	[M1]		12.33	α(K)=9.85 *14*; α(L)=1.88 *3*; α(M)=0.451 *7* α(N)=0.1195 *17*; α(O)=0.0278 *4*; α(P)=0.00514 *8*; α(Q)=0.000456 *7*
115.55 *5*	3.8 *3*	155.64	(5/2+)	40.10	(3/2+)	M1		11.28	α(K)exp=9.5 *7* (1987Ah05) α(K)=9.02 *13*; α(L)=1.713 *24*; α(M)=0.411 *6* α(N)=0.1090 *16*; α(O)=0.0253 *4*; α(P)=0.00469 *7*; α(Q)=0.000416 *6* Mult.: from I[(40γ)(K x-ray)-coin]/I[(40γ)(115γ)-coin] (1987Ah05).
120.80 *5*	2.4 *2*	120.81	(5/2−)	0.0	(3/2−)	M1(+E2)	0.5 *5*	8.9 *16*	α(K)=6.4 *23*; α(L)=1.84 *50*; α(M)=0.46 *16* α(N)=0.123 *41*; α(O)=0.0279 *84*; α(P)=0.0049 *12*; α(Q)=3.01×10^{-4} *98* Mult.: multipolarity was deduced from I(K x-ray)/I(121γ)=7 *2* (1973Ag01) in αγ spectrum.
122.8 *1*	0.17 *2*	199.86	(7/2+)	77.13	(7/2−)	[E1]		0.297	α(K)=0.231 *4*; α(L)=0.0502 *8*; α(M)=0.01213 *18* α(N)=0.00318 *5*; α(O)=0.000711 *10*; α(P)=0.0001208 *17*; α(Q)=7.05×10^{-6} *10*
125.71 *7*	0.74 *7*	155.64	(5/2+)	29.91	(5/2−)	[E1]		0.281	α(K)=0.218 *3*; α(L)=0.0473 *7*; α(M)=0.01141 *16* α(N)=0.00299 *5*; α(O)=0.000669 *10*; α(P)=0.0001139 *16*; α(Q)=6.69×10^{-6} *10*
135.20 *7*	0.72 *7*	199.86	(7/2+)	64.69	(5/2+)	[M1]		7.22	α(K)=5.78 *9*; α(L)=1.091 *16*; α(M)=0.262 *4* α(N)=0.0694 *10*; α(O)=0.01613 *23*; α(P)=0.00298 *5*; α(Q)=0.000265 *4*
140.85 *7*	0.45 *5*	170.75	(7/2−)	29.91	(5/2−)	[M1+E2]		5.6[&] *12*	α(K)=4.2 *15*; α(L)=1.09 *19*; α(M)=0.27 *6* α(N)=0.072 *16*; α(O)=0.016 *4*; α(P)=0.0029 *4*; α(Q)=1.93×10^{-4} *63*
152.0 *1*	0.11 *2*	256.97	(9/2+)	105.01	(7/2+)	[M1]		5.18	α(K)=4.15 *6*; α(L)=0.780 *11*; α(M)=0.187 *3* α(N)=0.0496 *7*; α(O)=0.01154 *17*; α(P)=0.00213 *3*; α(Q)=0.000189 *3*
155.65 *7*	≈0.2	155.64	(5/2+)	0.0	(3/2−)	[E1]		0.1680	α(K)=0.1321 *19*; α(L)=0.0272 *4*; α(M)=0.00655 *10* α(N)=0.001717 *25*; α(O)=0.000387 *6*; α(P)=6.66×10^{-5} *10*; α(Q)=4.15×10^{-6} *6*
158.4 *1*	0.05 *1*	235.53	(9/2−)	77.13	(7/2−)	[M1]		4.61	α(K)=3.69 *6*; α(L)=0.694 *10*; α(M)=0.1663 *24* α(N)=0.0441 *7*; α(O)=0.01026 *15*; α(P)=0.00190 *3*; α(Q)=0.0001682 *24*
169.90 *10*	0.40 *5*	199.86	(7/2+)	29.91	(5/2−)	[E1]		0.1362	α(K)=0.1075 *16*; α(L)=0.0217 *3*; α(M)=0.00523 *8* α(N)=0.001372 *20*; α(O)=0.000310

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^{229}Pa α decay (1.50 d) 1987Ah05,1973Ag01,1958Hi78 (continued)

γ(^{225}Ac) (continued)

E_γ [†]	I_γ [‡a]	E_i(level)	J^π_i	E_f	J^π_f	Mult. [#]	α [b]	Comments
								5; α(P)=5.36×10^{-5} *8*; α(Q)=3.42×10^{-6} *5*
179.90 *10*	0.08 *2*	256.97	(9/2$^+$)	77.13	(7/2$^-$)	[E1]	0.1187	α(K)=0.0939 *14*; α(L)=0.0188 *3*; α(M)=0.00452 *7* α(N)=0.001186 *17*; α(O)=0.000268 *4*; α(P)=4.65×10^{-5} *7*; α(Q)=3.01×10^{-6} *5*

† From 1987Ah05 unless otherwise stated. Other measurements: 1973Ag01, 1963Su10, 1958Hi78.

‡ Absolute intensities per 100 α decays, measured by 1987Ah05. Intensities from $\alpha\gamma$-coincidences are given by 1973Ag01.

\# Multipolarities in square brackets assumed from ΔJ^π.

@ Transition not seen but shown in level-scheme Fig. 4 of 1973Ag01 without any explanation. This transition is not included in the Adopted dataset.

& For δ=0.5 *5* in analogy with the mixing ratio for 120.80γ.

a For absolute intensity per 100 decays, multiply by 0.0048 *5*.

b 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.

c Multiply placed with intensity suitably divided.

d Placement of transition in the level scheme is uncertain.

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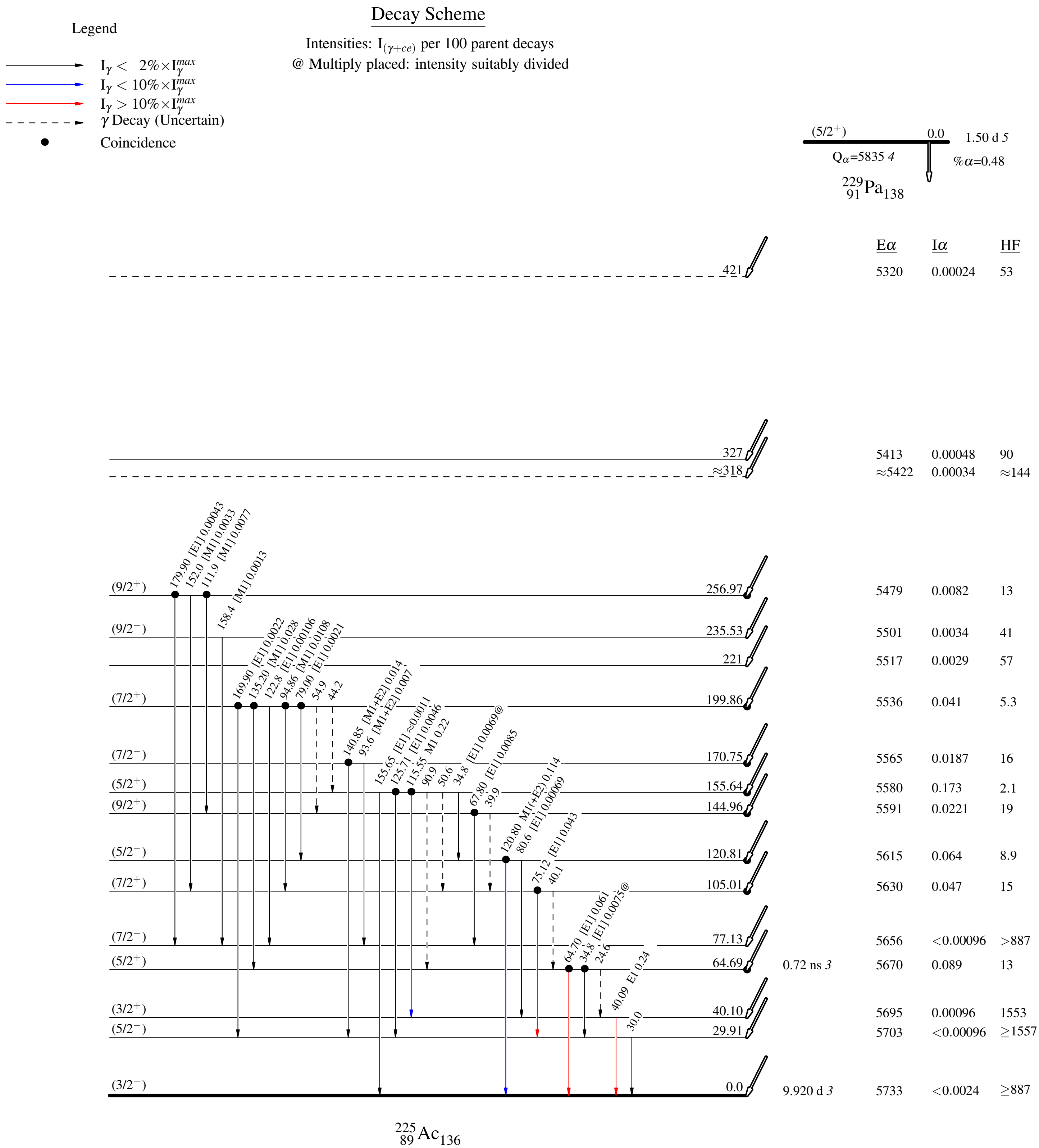

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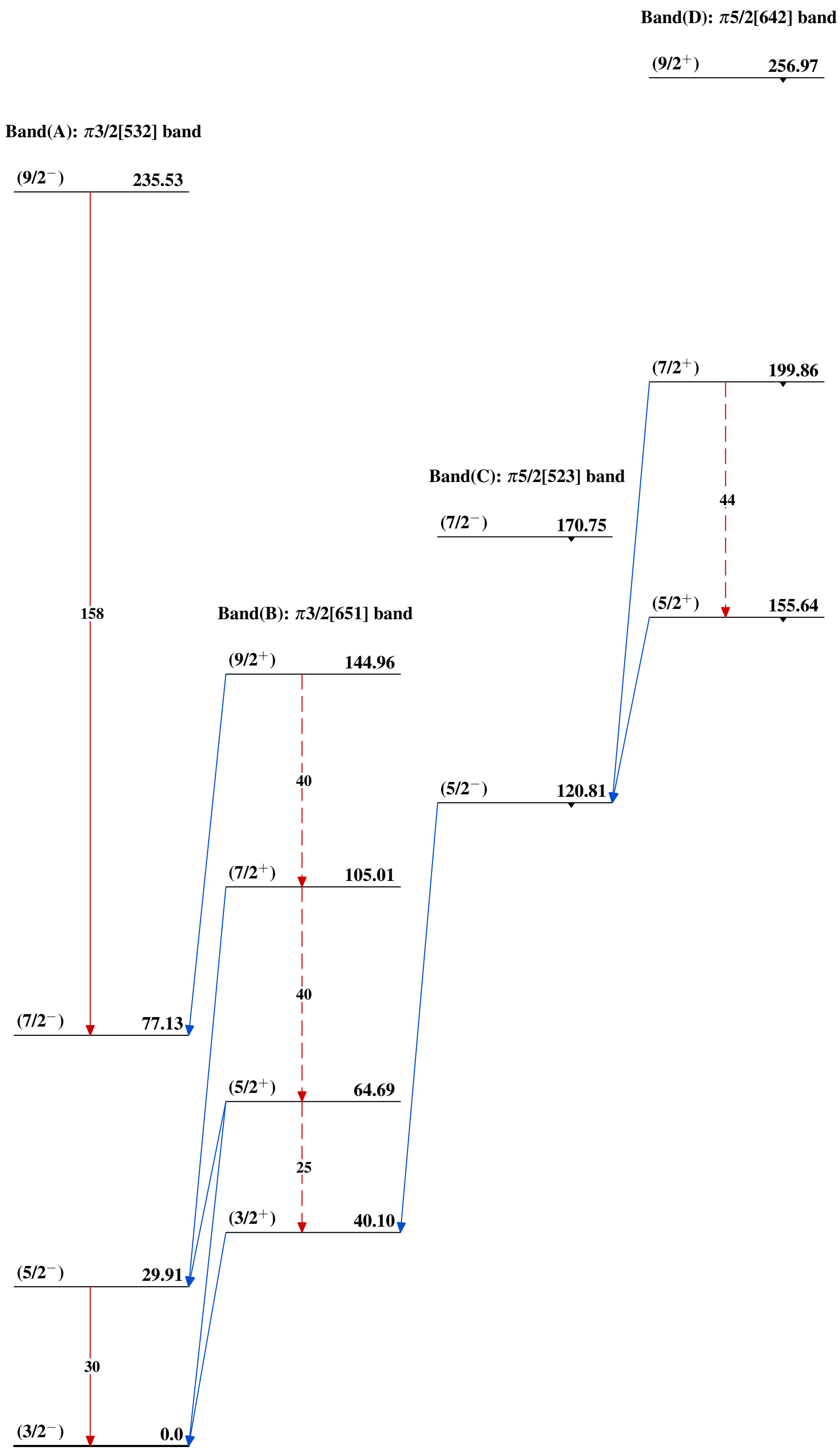

$^{225}_{89}Ac_{136}$