^{129}Ba ε decay (2.23 h) 1983TaZI,1973Is04,1972Ta02

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Janos Timar and Zoltan Elekes, Balraj Singh	NDS 121, 143 (2014)	31-May-2014

Parent: ^{129}Ba: E=0.0; $J^{\pi}=1/2^{+}$; $T_{1/2}$=2.23 h *11*; Q(ε)=2436 *11*; %ε+%β^{+} decay=100.0

^{129}Ba-Q(ε): From 2012Wa38.

^{129}Ba-J^{π},$T_{1/2}$: From ^{129}Ba Adopted Levels.

The decay schemes of the g.s. and isomer of ^{129}Cs seem complex, especially for the isomer decay. First level scheme was proposed in 1970Is04, later expanded by 1972Ta02 and 1973Is04. First attempt to tentatively separate the decay schemes was made in 1972-NDS (1972Ho55). Based on detailed $\gamma\gamma$ coincidences with two Ge detectors and producing the source in different reactions producing different composition of low-spin and high-spin activities, 1983TaZI present evidence for two separate decay schemes, which are adopted here, although labeled as tentative by 1983TaZI. For the isomer decay, the gamma-ray energies and the decay scheme are almost identical to those given in 1973Is04. There is good agreement of gamma-ray energies between 1973Is04 (and 1983TaZI) and 1972Ta02, but a large number of differences exist in the placement of transitions and levels. The evaluators prefer to adopt level schemes from 1983TaZI and 1973Is04 due to better $\gamma\gamma$ coincidence data with two Ge(Li) detectors. However, in the opinion of the evaluators, none of the studies cited above can be considered as well established, since many γ-ray remain either unplaced or unconfirmed. Further experiments are recommended to improve knowledge of these decay schemes using state-of-the-art detector systems and better source production methods to avoid large number of impurities present in previous studies.

1983TaZI: ^{129}Ba source formed in three reactions: ^{120}Sn(^{12}C,3n)^{129}Ba, ^{121}Sb(^{12}C,4n)^{129}La followed by ε decay of ^{129}La to ^{129}Ba g.s. and isomer, ^{130}Ba(γ,n). The other two reactions also form both the g.s. and isomer of ^{129}Ba, albeit in different proportions, thus facilitating separation of gamma rays and their intensities into separate decay schemes. Measured Eγ, Iγ, $\gamma\gamma$-coin using two Ge detectors. 1983TaZI is a short note in an annual laboratory report. In July 2011, the evaluators, on communication with T. Tamura (first author of 1983TaZI), were informed that there was no further report or follow-up of this work. work reported in 1983TaZI. Note that many features of the data presented in this short report are common with those in 1973Is04.

1973Is04 (also 1971Is02,1970Is04): mixed (g.s. and isomer) source from ^{133}Cs(p,5n); measured Eγ, Iγ, $\gamma\gamma$ coin with two Ge detectors, ce, ceγ(t) with $\pi\sqrt{2}$ air-core β-ray magnetic spectrometer. In 1971Is02, lifetime of 188-keV level was measured by (ce-L)(γ)(t) method. In 1970Is04, a first detailed decay scheme of ^{129}Ba was proposed with with 15 excited states and 49 γ rays. In 1973Is04, a total of 176 γ rays were reported with 107 γ rays placed in a composite level scheme from both activities, thus no ε,β^{+} feedings and log *ft* values were deduced. Half-lives of the two activities were measured.

1972Ta02: mixed source from ^{130}Ba(γ,n) with dominant activity from ^{129}Ba g.s. decay in contrast to other studies where dominant activity in the source material was from the decay of ^{129}Ba isomer. Measured Eγ, Iγ, $\gamma\gamma$ coin using Ge and NaI(Tl) detector. A total of 118 γ rays reported with 100 placed in a proposed decay scheme of ^{129}Ba. Conversion coefficients were deduced by using γ-ray data from this work and ce data from 1961Ar05. Since a composite decay scheme was proposed for g.s. and isomer decay of ^{129}Ba, no ε,β^{+} feedings and log *ft* values were deduced. Several levels and many placements differ from those in 1983TaZI and 1973Is04. Half-lives of the two activities were measured. Low-spin activity composition in the source material was about four times higher than in the source material used in 1973Is04.

1961Ar05: mixed source. Measured positron spectra, ce data. A total of about 62 transition energies were deduced up to 1624 keV from K-, L- and subshell lines. Another 45 lines in the ce-energy region of 49-1143 keV with half-life of ≈2 h were unassigned. Deduced intensities of three positron branches. Half-lives of most of the observed transitions were measured. No level scheme was proposed, however strong β^{+} branch feeding the g.s. of ^{129}Cs was indicated. Half-lives of the two activities were measured.

Others:

1976Be11: measured lifetime of 6.5-keV level by γ(ce)(t).

1966Li05: measured half-lives of the two activities from γ rays.

1963Ya05: measured half-life of the composite source.

1959He45: measured Eγ, $\beta\gamma$ coin, half-life, eight γ rays reported with a proposed 1450-182 γ cascade.

1950Th08, 1950Fi11: identification and production of ^{129}Ba isotope in proton bombardment of ^{133}Cs.

^{129}Ba ε decay (2.23 h) 1983TaZI,1973Is04,1972Ta02 (continued)

^{129}Cs Levels

In a composite level scheme for g.s. and isomer decay, 1970Is04 (earlier paper from authors of 1973Is04) reported 15 levels at 129,1, 182.3, 202.3, 214.3, 419.8, 595.9, 641.3, 683.8, 748.6, 962.6, 985.3, 1248.7, 1640.8, 1674.5, 1805.2. In their later paper 1971Is02, first excited state was indicates at 6.5 keV. Thus all level energies in in 1970Is04 should be increased upwards by 6.5 keV. A total of 49 transitions were placed amongst these levels.

In a composite level scheme for g.s. and isomer decay, 1972Ta02 report 31 levels at 6.48, 135.6, 188.8, 208.8, 220.8, 426.8, 554.4, 603.6, 648.4, 690.5, 755.3, 969.6, 992.4, 1165.0, 1208.4, 1256.1, 1299.4, 1450.8, 1459.1, 1487.3, 1648.2, 1681.5, 1682.7, 1812.5, 1830.5, 1922.8, 1954.0, 2076.0, 2143.8, 2178.8, 2422.2. Nine of these at 1208.4, 1299.4, 1450.8, 1459.1, 1487.3, 1682.7, 2143.8, 2178.8 and 2422.3 have been omitted here since these are not confirmed in 1983TaZI and 1973Is04. The gamma rays from these levels have either not been confirmed or placed elsewhere in the level schemes based on γγ coin data with two Ge detectors in 1983TaZI and 1973Is04.

In a composite level scheme for g.s. and isomer decay, 1973Is04 report 24 levels at 6.54, 135.5, 188.9, 209.1, 220.8, 426.5, 551.6, 554.9, 575.4, 603.4, 648.4, 690.3, 755.2, 879.1, 969.2, 991.9, 1156.2, 1255.6, 1647.9, 1681.4, 1812.5, 1940.4, 1953.8, 2018.9. All The level scheme for the isomer decay is essentially the same as in 1983TaZI.

1983TaZI report 16 levels populated in the decay of g.s. of ^{129}Ba and 23 levels from the decay of isomer in ^{129}Ba; five low-lying levels amongst these are populated in the decay of both the activities. A 2308.6 level reported in 1983TaZI is discarded due to poor fit of of the two γ rays 2105.8 and 2086.2 from this level. Their level scheme for isomer decay is almost identical to that given in 1973Is04.

E(level)[†]	Jπ[@]	$T_{1/2}$	Comments
0.0	$1/2^+$	32.06 h *6*	$T_{1/2}$: from Adopted Levels.
6.5450 *10*	$5/2^+$	72 ns *6*	$T_{1/2}$: from (129.1-214.3 keV γ)(6.54 ce(M)+ce(N))(t) (1976Be11).
135.69 *8*	$3/2^+$		
208.87 *10*	$(5/2)^+$		
220.74 *7*	$3/2^+$		
554.09[‡] *13*	$(1/2,3/2)^+$		
1164.66[‡] *17*	$(1/2,3/2)^+$		
1609.67[‡] *22*	(1/2,3/2)		
1648.64 *22*	$(1/2^+,3/2)$		
1694.25[‡] *23*	(1/2,3/2)		
1700.93[#] *22*	$(1/2^+,3/2)$		
1830.52[‡] *16*	(1/2,3/2)		
1922.87[‡] *16*	$(1/2^+,3/2)$		
1954.03 *14*	$(1/2^+,3/2^+)$		
2077.67 *22*	$(1/2^+,3/2)$		E(level): level in 1983TaZI and 1972Ta02, not in 1973Si04. But different γ rays are assigned in 1972Ta02 from this level.
2254.8[#] *3*			

[†] From least-squares fit to Eγ data.
[‡] Level from 1983TaZI and 1972Ta02; not reported in 1973Is04.
[#] Level from 1983TaZI, not reported in 1972Ta02 and 1973Is04.
[@] From Adopted Levels.

^{129}Ba ε decay (2.23 h) 1983TaZI,1973Is04,1972Ta02 (continued)

ε,β⁺ radiations

Total measured positron intensity=6% (1961Ar05).

E(decay)	E(level)	Iβ⁺ #	Iε†#	Log *ft*‡	I(ε+β⁺)†#	Comments
(181@ *11*)	2254.8					
(358 *11*)	2077.67		0.0022 *2*	8.23 *6*	0.0022 *2*	εK=0.8313 *9*; εL=0.1316 *7*; εM+=0.03712 *22*
(482 *11*)	1954.03		1.11 *7*	5.80 *4*	1.11 *7*	εK=0.8382 *5*; εL=0.1264 *4*; εM+=0.03543 *11*
(513 *11*)	1922.87		0.16 *1*	6.70 *4*	0.16 *1*	εK=0.8393 *4*; εL=0.1255 *3*; εM+=0.03514 *10*
(605 *11*)	1830.52		1.18 *8*	5.99 *4*	1.18 *8*	εK=0.8420 *3*; εL=0.12350 *21*; εM+=0.03448 *7*
(735 *11*)	1700.93		0.17 *1*	7.01 *4*	0.17 *1*	εK=0.8446 *2*; εL=0.12157 *14*; εM+=0.03385 *5*
(742 *11*)	1694.25		0.046 *4*	7.58 *5*	0.046 *4*	εK=0.8447 *2*; εL=0.12149 *14*; εM+=0.03383 *5*
(787 *11*)	1648.64		0.047 *5*	7.63 *6*	0.047 *5*	εK=0.8454 *2*; εL=0.1210 *2*; εM+=0.03366 *4*
(826 *11*)	1609.67		0.25 *2*	6.95 *5*	0.25 *2*	εK=0.8459 *2*; εL=0.1206 *1*; εM+=0.03354 *4*
(1271 *11*)	1164.66		1.21 *11*	6.65 *5*	1.21 *11*	εK=0.8491; εL=0.11786 *6*; εM+=0.03265 *2*
(1882 *11*)	554.09	0.15 *2*	3.0 *3*	6.59 *5*	3.2 *3*	av Eβ=390.0 *49*; εK=0.8110 *18*; εL=0.1108 *3*; εM+=0.03062 *8* E(decay): 975 *60* (β⁺ end-point energy), relative β⁺ intensity=60 (measured in 1961Ar05).
(2215 *11*)	220.74	3.14 *15*	20.4 *8*	5.91 *3*	23.5 *9*	av Eβ=536.8 *49*; εK=0.738 *3*; εL=0.1004 *5*; εM+=0.02772 *12* E(decay): 1243 *35* (β⁺ end-point energy), relative β⁺ intensity=240 (measured in 1961Ar05).
(2227@ *11*)	208.87	<0.04	<0.20	>8.0	<0.24	av Eβ=542.0 *49*; εK=0.735 *3*; εL=0.0999 *5*; εM+=0.02759 *12*
(2300 *11*)	135.69	1.4 *1*	7.4 *4*	6.39 *4*	8.8 *5*	av Eβ=574.5 *49*; εK=0.714 *4*; εL=0.0969 *5*; εM+=0.02677 *13*
(2436 *11*)	0.0	13 *1*	47 *1*	5.63 *3*	60 *1*	av Eβ=634.9 *50*; εK=0.671 *4*; εL=0.0910 *5*; εM+=0.02512 *14* E(decay): 1425 *15* (β⁺ end-point energy), relative β⁺ intensity=780 (measured in 1961Ar05). I(ε+β⁺): from intensity balance. 1983TaZI give 69 *6*.

† From γ-ray intensity balance. Weak feedings (<2% or so) are considered as tentative since there still remain many unplaced γ rays.

‡ For weak (<2% or so) ε feedings, values are considered as approximate.

Absolute intensity per 100 decays.

@ Existence of this branch is questionable.

γ(^{129}Cs)

Iγ normalization: Absolute intensities per 100 decays of ^{129}Ba are given by 1983TaZI.
All the unplaced γ rays are listed with the decay of the isomer.

E_γ ‡	I_γ #a	E_i(level)	J_i^π	E_f	J_f^π	Mult. @	δ	α †	$I_{(\gamma+ce)}$ a	Comments
6.545 *1*		6.5450	5/2$^+$	0.0	1/2$^+$	E2		3.98×10^5 *6*	23.6 *9*	α(L)=3.15×10^5 *5*; α(M)=6.82×10^4 *10*; α(N)=1.355×10^4 *19*; α(O)=1498 *21*; α(P)=0.373 *6* E_γ: from ce(L2), ce(L3) measurements (1973Is04) relative to the ce(K) line of 182.32 *5* G. Other: 6.48 *15* from differences of pairs γ-ray transitions feeding g.s. and 6.54-keV isomer (1972Ta02). $I_{(\gamma+ce)}$: from total Iγ+ce feeding this level from higher levels, no direct ε or β feeding is expected due to J^π difference.
85.1 *3*	0.054 *5*	220.74	3/2$^+$	135.69	3/2$^+$	[M1,E2]		2.4 *10*		Mult.: L3/L2=1.79 *28*. α(K)=1.6 *4*; α(L)=0.6 *5*; α(M)=0.13 *10* α(N)=0.027 *20*; α(O)=0.0032 *23*; α(P)=5.1×10^{-5} *3* Additional information 4.
129.14 *10*	5.51 *28*	135.69	3/2$^+$	6.5450	5/2$^+$	M1+E2	0.20 *5*	0.449 *10*		α(K)=0.381 *7*; α(L)=0.054 *3*; α(M)=0.0112 *6* α(N)=0.00236 *12*; α(O)=0.000322 *13*; α(P)=1.477×10^{-5} *21* Additional information 1. Mult.: L1:L2:L3::100.0 *26*:13.4 *13*:5.4 *11*. Other: K/ΣL>5.6 (1961Ar05) gives δ(E2/M1)<0.5.
135.61 *20*	1.00 *10*	135.69	3/2$^+$	0.0	1/2$^+$	M1(+E2)	<0.4	0.399 *19*		α(K)=0.336 *11*; α(L)=0.050 *7*; α(M)=0.0103 *15* α(N)=0.0022 *3*; α(O)=0.00029 *4*; α(P)=1.290×10^{-5} *20* Additional information 2.
202.3 *1*	0.30 *3*	208.87	(5/2)$^+$	6.5450	5/2$^+$	M1(+E2)	0.2 *2*	0.128 *4*		Mult.,δ: from K/ΣL>6.1 (1961Ar05). α(K)=0.1095 *23*; α(L)=0.0148 *14*; α(M)=0.0030 *3* α(N)=0.00064 *6*; α(O)=8.9×10^{-5} *7*; α(P)=4.25×10^{-6} *7* E_γ: uncertainty based on γ intensity in isomer decay. Additional information 3.
214.30 *10*	13.4 *7*	220.74	3/2$^+$	6.5450	5/2$^+$	M1(+E2)	0.5 *5*	0.113 *8*		Mult.: L1:L2:L3::100.0 *44*:7.0 *19*:4.5 *16*. α(K)=0.095 *4*; α(L)=0.014 *3*; α(M)=0.0029 *7*

$^{129}_{55}Cs_{74}$-4

^{129}Ba ε decay (2.23 h) 1983TaZI,1973Is04,1972Ta02 (continued)

γ(^{129}Cs) (continued)

E_γ[‡]	I_γ[#a]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[@]	δ	α[†]	Comments
									α(N)=0.00061 *13*; α(O)=8.3×10^{-5} *14*; α(P)=3.59×10^{-6} *11* Additional information 5.
220.83 *10*	8.5 *4*	220.74	3/2$^+$	0.0	1/2$^+$	M1(+E2)	<0.9	0.104 *5*	Mult.: α(K)exp=0.097 *3*. Other: K/ΣL=6.9 (1961Ar05) gives δ(E2/M1)<0.75. α(K)=0.0879 *23*; α(L)=0.0131 *19*; α(M)=0.0027 *4* α(N)=0.00057 *8*; α(O)=7.7×10^{-5} *9*; α(P)=3.30×10^{-6} *9* Mult.,δ: from EKC AND K/ΣL=6.7 (1961Ar05). Additional information 6.
333.9 *3*	0.44 *4*	554.09	(1/2,3/2)$^+$	220.74	3/2$^+$	M1,E2		0.0323 *14*	α(K)=0.0273 *18*; α(L)=0.0040 *3*; α(M)=0.00083 *7* α(N)=0.000174 *13*; α(O)=2.35×10^{-5} *10*; α(P)=1.00×10^{-6} *13* Mult.: from α(K)exp=0.035 (1961Ar05). Additional information 7.
554.0 *2*	2.94 *29*	554.09	(1/2,3/2)$^+$	0.0	1/2$^+$	(M1,E2)		0.0083 *12*	α(K)=0.0071 *11*; α(L)=0.00095 *9*; α(M)=0.000194 *16* α(N)=4.1×10^{-5} *4*; α(O)=5.6×10^{-6} *6*; α(P)=2.7×10^{-7} *5* Mult.: from α(K)exp=0.016 (1961Ar05). Additional information 8.
944.5 *3*	0.112 *11*	1164.66	(1/2,3/2)$^+$	220.74	3/2$^+$				Additional information 9.
1140.3 *3*	0.0176 *18*	1694.25	(1/2,3/2)	554.09	(1/2,3/2)$^+$				Additional information 15.
1164.4 *2*	1.10 *11*	1164.66	(1/2,3/2)$^+$	0.0	1/2$^+$	(M1,E2)			Mult.: from α(K)exp=0.0024 (1961Ar05). Additional information 10.
1276.6 *3*	0.118 *12*	1830.52	(1/2,3/2)	554.09	(1/2,3/2)$^+$				Additional information 19.
1368.6 *3*	0.055 *6*	1922.87	(1/2$^+$,3/2)	554.09	(1/2,3/2)$^+$				Additional information 23.
1389.3 *3*	0.051 *5*	1609.67	(1/2,3/2)	220.74	3/2$^+$				Additional information 11.
1400.1 *3*	0.0121 *12*	1954.03	(1/2$^+$,3/2$^+$)	554.09	(1/2,3/2)$^+$				Additional information 27.
1439.8 *3*	0.047 *5*	1648.64	(1/2$^+$,3/2)	208.87	(5/2)$^+$				Additional information 13.
1473.6 *3*	0.198 *20*	1609.67	(1/2,3/2)	135.69	3/2$^+$				Additional information 12.
1512.9 *3*		1648.64	(1/2$^+$,3/2)	135.69	3/2$^+$				Additional information 14.
1558.4 *3*	0.028 *3*	1694.25	(1/2,3/2)	135.69	3/2$^+$				Additional information 16.
1610.3 *3*	0.33 *3*	1830.52	(1/2,3/2)	220.74	3/2$^+$				Additional information 20.
1693.8 *3*	0.080 *8*	1700.93	(1/2$^+$,3/2)	6.5450	5/2$^+$				Additional information 17.
1694.3 *3*	0.080 *8*	1830.52	(1/2,3/2)	135.69	3/2$^+$				Additional information 21.
1701.5 *3*	0.086 *9*	1700.93	(1/2$^+$,3/2)	0.0	1/2$^+$				Additional information 18.
1744.7 *3*	0.086 *9*	1954.03	(1/2$^+$,3/2$^+$)	208.87	(5/2)$^+$				Additional information 28.
1787.5 *3*	0.022 *2*	1922.87	(1/2$^+$,3/2)	135.69	3/2$^+$				Additional information 24.
1818.8 *3*	0.080 *8*	1954.03	(1/2$^+$,3/2$^+$)	135.69	3/2$^+$				Additional information 29.
1830.3 *3*	0.65 *7*	1830.52	(1/2,3/2)	0.0	1/2$^+$				Additional information 22.
1856.7 *3*	0.0011 *1*	2077.67	(1/2$^+$,3/2)	220.74	3/2$^+$				Additional information 32.
1869.0 *3*	0.0011 *1*	2077.67	(1/2$^+$,3/2)	208.87	(5/2)$^+$				Additional information 33.
1916.4 *3*	0.0132 *13*	1922.87	(1/2$^+$,3/2)	6.5450	5/2$^+$				Additional information 25.
1922.6 *3*	0.066 *7*	1922.87	(1/2$^+$,3/2)	0.0	1/2$^+$				Additional information 26.
1947.5 *3*	0.29 *3*	1954.03	(1/2$^+$,3/2$^+$)	6.5450	5/2$^+$				Additional information 30.

$^{129}_{55}Cs_{74}$-5

^{129}Ba ε decay (2.23 h) 1983TaZI,1973Is04,1972Ta02 (continued)

γ(^{129}Cs) (continued)

E_γ ‡	I_γ #a	E_i(level)	J_i^π	E_f	J_f^π	Comments
1953.8 *3*	0.64 *6*	1954.03	(1/2$^+$,3/2$^+$)	0.0	1/2$^+$	Additional information 31.
2034.0 *3*		2254.8		220.74	3/2$^+$	Additional information 34.
^{x}2086.2&						
^{x}2105.8&						

† Overlaps M1 and E2 values for M1+E2, or M1,E2 transitions.

‡ From unweighted average of values from 1972Ta02 and 1973Is04 (or 1983TaZI). Uncertainties are provided only by 1972Ta02. In 1983TaZI, most energies are the same as in 1973Is04. Based on comparison of values in three studies, evaluators assign the uncertainties as follows: Δ(Eγ)=0.10 keV for Iγ≥3%, 0.20 keV for Iγ=0.5-3%, and 0.3 keV or Iγ<0.5%. Document records in the ENSDF database provide compiled Eγ values from 1973Is04, 1972Ta02, and 1961Ar05.

From 1983TaZI, unless otherwise noted. Uncertainties are not given by 1983TaZI. The evaluators assign the uncertainties as follows: Δ(Iγ)=5% for Iγ≥5%, 10% for Iγ<5% Document records in the ENSDF database provide compiled Iγ, Ice(K), K/L ratios from 1973Is04, 1972Ta02, and 1961Ar05.

@ From 1973Is04, unless otherwise noted. Values α(K)exp, K/L and L-subshell ratios are from private communication to 1996Te01 from 1973Is04. Other multipolarities are deduced by evaluators of current evaluation using Iγ values from 1973Is04 and Ice(K) and/or K/L ratios from 1961Ar05. For γ rays above 350 keV or so, such assignments are tentative since the agreement between deduced α(K)exp values and theoretical values from BrIcc code is poor.

& γ from 1983TaZI only. 2105.8γ and 2086.2γ placed from a 2308.6 level, but the energy fit is poor, thus the evaluators have kept these as unplaced. None of the two γ rays was reported in 1973Is04 and 1972Ta02.

a Absolute intensity per 100 decays.

x γ ray not placed in level scheme.

$^{129}_{55}Cs_{74}$-6

^{129}Ba ε decay (2.23 h) 1983TaZI,1973Is04,1972Ta02

Decay Scheme

Intensities: $I_{(\gamma+ce)}$ per 100 parent decays

Legend
- $I_\gamma < 2\% \times I_\gamma^{max}$
- $I_\gamma < 10\% \times I_\gamma^{max}$
- $I_\gamma > 10\% \times I_\gamma^{max}$
- Coincidence