^{90}Nb ε decay 1990Me15,1982Wa24

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	S. K. Basu, E. A. Mccutchan	NDS 165,1 (2020)	1-Mar-2020

Parent: ^{90}Nb: E=0.0; J$^\pi$=8$^+$; $T_{1/2}$=14.60 h *5*; Q(ε)=6111.0 *30*; %ε+%β^+ decay=100

1990Me15: Measured precision Eγ and Iγ with carefully calibrated Ge(Li) detector systems.

1982Wa24: Measured precision Eγ, γ(t), $\gamma\gamma$ and delayed $\gamma\gamma$ coin with Ge(Li)-NaI escape-suppression spectrometer and Ge(Li).

1968Pe01: Measured γ singles and ce(t) spectra with chemically separated sources.

1987Be12: $\gamma\gamma(\theta)$ with NaI-Ge(Li) detectors.

1964Lo02: Delayed $\beta\gamma$ coin with anthracene and NaI.

Others: 1954On06, 1955Ma31, 1957Sh32, 1958La12, 1959Bj39, 1960Ha06, 1966Pe10, 1970Tu04, 1971Za03, 1975Pa07, 1980Iw03, 2001Ba06.

Decay scheme is based on $\gamma\gamma$ coin and energy sums (1982Wa24).

Total energy release in the decay is 6040 keV *60* as computed by the code Radlist, compared to the Q value of 6111 *3*.

α: Additional information 1.

^{90}Zr Levels

E(level)[†]	J$^\pi$[‡]	$T_{1/2}$	Comments
0	0$^+$	stable	
1760.74 *15*	0$^+$		
2186.265 *19*	2$^+$		
2318.991 *19*	5$^-$	809.2 ms *20*	g=1.250 *26* (1987Ed02) g: From nuclear magnetic resonance on oriented nuclei.
2739.29 *5*	(4)$^-$		
2747.867 *21*	3$^-$		
3076.917 *21*	4$^+$		
3448.221 *21*	6$^+$		
3589.409 *22*	8$^+$	125 ns *6*	$T_{1/2}$: From delayed $\beta\gamma$ coin (1964Lo02).
4232.21 *3*	6$^-$,7$^-$		
4319.02? *10*			
4375.06 *7*	7$^-$		
4541.36 *4*	6$^+$		
4640.94 *5*			
5059.97 *3*	7$^+$		
5164.48 *3*	(8)$^+$		
5247.52 *5*	9$^+$		
5432.78 *3*	7$^+$,8$^+$,9$^+$		
5589.46? *10*			

† From a least-squares fit to Eγ, by evaluators.

‡ From the Adopted Levels.

ε,β^+ radiations

$\varepsilon+\beta^+$ branches are obtained from Iγ+ce imbalance at each level.

E(decay)	E(level)	Iε[†]	Log *ft*	I($\varepsilon+\beta^+$)[†]	Comments
(521.5[‡] *30*)	5589.46?	0.07 *1*	7.35 *7*	0.07 *1*	εK=0.8669; εL=0.10857 *4*; εM+=0.024520 *9*
(678.2 *30*)	5432.78	1.40 *3*	6.281 *11*	1.40 *3*	εK=0.8686; εL=0.10725 *2*; εM+=0.024176 *5*
(863.5 *30*)	5247.52	0.335 *15*	7.116 *20*	0.335 *15*	εK=0.8697; εL=0.10632 *2*; εM+=0.023934 *3*
(946.5 *30*)	5164.48	1.017 *24*	6.715 *11*	1.017 *24*	εK=0.8701; εL=0.1060; εM+=0.023857 *3*
(1051.0 *30*)	5059.97	4.64 *9*	6.148 *9*	4.64 *9*	εK=0.8705; εL=0.1057; εM+=0.02378

Continued on next page (footnotes at end of table)

^{90}Nb ε decay 1990Me15,1982Wa24 (continued)

ϵ,β^+ radiations (continued)

E(decay)	E(level)	Iβ^+ †	Iε†	Log *ft*	I($\varepsilon+\beta^+$)†	Comments
(1470.1 *30*)	4640.94	0.00466 *23*	0.214 *9*	7.779 *18*	0.219 *9*	av Eβ=200.5 *13*; εK=0.8529 *5*; εL=0.10271 *6*; εM+=0.02307 *2*
(1735.9 *30*)	4375.06	0.010 *1*	0.088 *9*	8.31 *5*	0.098 *10*	av Eβ=314.7 *13*; εK=0.7793 *13*; εL=0.09353 *15*; εM+=0.02100 *4*
(1792.0‡ *30*)	4319.02?	0.009 *1*	0.06 *1*	8.50 *7*	0.07 *1*	av Eβ=339.0 *13*; εK=0.7550 *14*; εL=0.09057 *17*; εM+=0.02034 *4*
(1878.8 *30*)	4232.21	0.031 *4*	0.141 *20*	8.18 *6*	0.172 *24*	av Eβ=376.8 *13*; εK=0.7125 *16*; εL=0.08539 *19*; εM+=0.01917 *5*
(2521.6 *30*)	3589.409	51 *2*	36 *1*	6.028 *16*	87 *3*	av Eβ=662.2 *14*; εK=0.3600 *14*; εL=0.04296 *17*; εM+=0.00964 *4*
(2662.8 *30*)	3448.221	<4	<2	>7.3	<6	av Eβ=726.1 *14*; εK=0.3014 *12*; εL=0.03595 *14*; εM+=0.00807 *3*

† Absolute intensity per 100 decays.
‡ Existence of this branch is questionable.

γ(^{90}Zr)

For adjusted Eγ and Iγ (based on energy sums and intensity balance) see 1982Wa24.
For a search for the 2319 to 1761 E5 transition with mini-orange detectors, see 1985HaZI.

E_γ[‡]	I_γ[‡@]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[#]	δ[#]	α	Comments
132.716 *18*	50.4 *5*	2318.991	5⁻	2186.265	2⁺	E3(+M4)	<0.07	2.97 *11*	α(K)=2.20 *8*; α(L)=0.644 *23*; α(M)=0.115 *5*; α(N)=0.0146 *6*; α(O)=0.000359 *24* Mult.: α(K)exp=2.11 *15*; K/L=3.22 *16* (1968Pe01). Mult.: (132.7γ)(2186.3γ)(θ): A_2=+0.187 *38*, A_4=−0.063 *36* (1978Be12). δ: +0.06 *10* from γγ(θ); 0.00 *7* from ce measurements.
141.178 *15*	814 *8*	3589.409	8⁺	3448.221	6⁺	E2		0.316	α(K)=0.268 *4*; α(L)=0.0402 *6*; α(M)=0.00701 *10*; α(N)=0.000940 *14*; α(O)=4.52×10^{-5} *7* Mult.: α(K)exp=0.268 *19*; K/L=6.25 *33* (1968Pe01). Mult.: (141.3γ)(1129.2γ)(θ): A_2=−0.070 *12*, A_4=−0.003 *10* (1978Be12). δ: −0.02 *+11−5* from γγ(θ); 0.05 *4* from ce measurements; both consistent with no M3 admixture.
222[a]	<0.08[†]	4541.36	6⁺	4319.02?					
268[a]	<0.05[†]	5432.78	7⁺,8⁺,9⁺	5164.48	(8)⁺				
309[a]	<0.11[†]	4541.36	6⁺	4232.21	6⁻,7⁻				
329.058 *16*	1.50 *5*	3076.917	4⁺	2747.867	3⁻				
337.50 *15*	0.3 *1*	3076.917	4⁺	2739.29	(4)⁻				
371.307 *8*	22.0 *8*	3448.221	6⁺	3076.917	4⁺	E2		0.01064	α(K)=0.00929 *13*; α(L)=0.001119 *16*; α(M)=0.000194 *3*; α(N)=2.71×10^{-5} *4*; α(O)=1.712×10^{-6} *24* Mult.: α(K)exp=0.088 *6*.
409[a]	<0.11[†]	4640.94		4232.21	6⁻,7⁻				
420.28 *5*	0.33 *3*	2739.29	(4)⁻	2318.991	5⁻				
425.5 *2*	0.06 *1*	2186.265	2⁺	1760.74	0⁺	E2		0.00688	α(K)=0.00602 *9*; α(L)=0.000713 *10*; α(M)=0.0001239 *18*; α(N)=1.732×10^{-5} *25* α(O)=1.117×10^{-6} *16*
429[a]	<0.06[†]	2747.867	3⁻	2318.991	5⁻				
518.60 *6*	8.4 *6*	5059.97	7⁺	4541.36	6⁺				α(K)exp=0.00195 *17*.
524[a]	<0.23[†]	5164.48	(8)⁺	4640.94					
561.604 *11*	1.46 *4*	2747.867	3⁻	2186.265	2⁺				
623[a]	<0.23[†]	5164.48	(8)⁺	4541.36	6⁺				
643[a]	<0.23[†]	4232.21	6⁻,7⁻	3589.409	8⁺				
757.95 *5*	0.49 *5*	3076.917	4⁺	2318.991	5⁻				
784[a]	<0.08[†]	4232.21	6⁻,7⁻	3448.221	6⁺				

$^{90}_{40}Zr_{50}$-3

γ(^{90}Zr) (continued)

E_γ[‡]	I_γ[‡@]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[#]	α	Comments
792.05 *19*	0.13 *4*	5432.78	$7^+,8^+,9^+$	4640.94				
827.74 *4*	13.5 *2*	5059.97	7^+	4232.21	$6^-,7^-$	E1	4.19×10^{-4}	α(K)=0.000371 *6*; α(L)=4.04×10^{-5} *6*; α(M)=6.99×10^{-6} *10*; α(N)=9.93×10^{-7} *14*; α(O)=7.02×10^{-8} *10* Mult.: α(K)exp=0.00033 *4*. Mult.: (827.7γ)(1913.2γ)(θ): A_2=+0.164 *40*, A_4=+0.062 *35* (1978Be12).
890.64 *5*	22.0 *5*	3076.917	4^+	2186.265	2^+	(E2)	8.82×10^{-4}	α(K)=0.000777 *11*; α(L)=8.69×10^{-5} *13*; α(M)=1.507×10^{-5} *22*; α(N)=2.13×10^{-6} *3* α(O)=1.479×10^{-7} *21* Mult.: α(K)exp=0.00076 *6*. Mult.: (890.6γ)(2186.3γ)(θ): A_2=+0.132 *51*, A_4=−0.023 *48* (1978Be12). δ: +0.05 *7* from $\gamma\gamma(\theta)$; 0.0 *1* from ce measurements; both consistent with no M3 admixture.
891[a]	<0.70[†]	5432.78	$7^+,8^+,9^+$	4541.36	6^+			
932[a]	<1.4[†]	5164.48	$(8)^+$	4232.21	$6^-,7^-$			
952[a]	<0.11[†]	4541.36	6^+	3589.409	8^+			
1051.53 *4*	2.6 *1*	4640.94		3589.409	8^+			
1057.8 *1*	0.21 *6*	5432.78	$7^+,8^+,9^+$	4375.06	7^-			
1093.14 *9*	1.2 *1*	4541.36	6^+	3448.221	6^+			
1129.224 *15*	1130 *5*	3448.221	6^+	2318.991	5^-	E1	2.41×10^{-4}	α(K)=0.000203 *3*; α(L)=2.20×10^{-5} *3*; α(M)=3.81×10^{-6} *6*; α(N)=5.42×10^{-7} *8*; α(O)=3.85×10^{-8} *6* Mult.: α(K)exp=0.000197 *11*. Mult.: (141.3γ)(1129.2γ)(θ): A_2=−0.070 *12*, A_4=−0.003 *10* (1978Be12). δ: −0.02 *7* from $\gamma\gamma(\theta)$; 0.000 *14* from ce measurements; both consistent with no M2 admixture.
1155[a]	<0.06[†]	4232.21	$6^-,7^-$	3076.917	4^+			
1192.7 *1*	0.20 *2*	4640.94		3448.221	6^+			
1201[a]	<0.23[†]	5432.78	$7^+,8^+,9^+$	4232.21	$6^-,7^-$			
1270.396 *18*	15.8 *3*	3589.409	8^+	2318.991	5^-	(E3)	7.63×10^{-4}	α(K)=0.000667 *10*; α(L)=7.56×10^{-5} *11*; α(M)=1.313×10^{-5} *19*; α(N)=1.86×10^{-6} *3* α(O)=1.285×10^{-7} *18* Mult.: α(K)exp=0.00068 *7*.
1464[a]	<0.28[†]	4541.36	6^+	3076.917	4^+			
1470.528 *24*	5.6 *2*	5059.97	7^+	3589.409	8^+			
1493[a]	<0.11[†]	4232.21	$6^-,7^-$	2739.29	$(4)^-$			
1575.035 *23*	6.3 *2*	5164.48	$(8)^+$	3589.409	8^+	M1,E2	3.64×10^{-4} *8*	α(K)=0.000230 *5*; α(L)=2.50×10^{-5} *5*; α(M)=4.34×10^{-6} *9*;

From ENSDF

γ(^{90}Zr) (continued)

E_γ[‡]	I_γ[‡@]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[#]	α	$I_{(\gamma+ce)}$[@]	Comments
									α(N)=6.17×10^{-7} *13*; α(O)=4.41×10^{-8} *11* Mult.: α(K)exp=0.00023 *6*.
1611.76 *3*	29.0 *8*	5059.97	7$^+$	3448.221	6$^+$	M1,E2	3.67×10^{-4} *9*		α(K)=0.000220 *5*; α(L)=2.39×10^{-5} *5*; α(M)=4.14×10^{-6} *9*; α(N)=5.90×10^{-7} *13*; α(O)=4.21×10^{-8} *11* Mult.: α(K)exp=0.000240 *22*. Mult.: (1611.8γ)(1129.2γ)(θ): A_2=−0.088 *20*, A_4=+0.013 *18* (1978Be12). δ: +0.35 *7* or +2.4 *5* from $\gamma\gamma$ correlation.
1658.10 *4*	4.08 *18*	5247.52	9$^+$	3589.409	8$^+$				
1716.27 *3*	6.1 *2*	5164.48	(8)$^+$	3448.221	6$^+$	(E2)	3.91×10^{-4}		α(K)=0.000191 *3*; α(L)=2.08×10^{-5} *3*; α(M)=3.61×10^{-6} *5*; α(N)=5.14×10^{-7} *8*; α(O)=3.66×10^{-8} *6* Mult.: α(K)exp=0.00021 *7*. Mult.: (1716.2γ)(1129.2γ)(θ): A_2=−0.011 *75*, A_4=+0.041 *60* (1978Be12).
1760.70 *20*		1760.74	0$^+$	0	0$^+$	E0		0.060 *10*	E_γ: Conversion electrons observed by 1968Pe01. $I_{(\gamma+ce)}$: From intensity balance, assuming no ε feeding. Mult.: α(K)exp > 4.8.
1843.342 *22*	8.4 *2*	5432.78	7$^+$,8$^+$,9$^+$	3589.409	8$^+$	M1,E2	4.08×10^{-4} *14*		α(K)=0.000170 *4*; α(L)=1.84×10^{-5} *4*; α(M)=3.19×10^{-6} *6*; α(N)=4.54×10^{-7} *9*; α(O)=3.25×10^{-8} *8* Mult.: α(K)exp=0.000166 *23*.
1913.194 *25*	15.6 *2*	4232.21	6$^-$,7$^-$	2318.991	5$^-$	M1,E2	4.27×10^{-4} *16*		α(K)=0.000158 *3*; α(L)=1.71×10^{-5} *4*; α(M)=2.97×10^{-6} *6*; α(N)=4.23×10^{-7} *8*; α(O)=3.03×10^{-8} *7* Mult.: α(K)exp=0.000144 *17*.
1984.54 *3*	8.3 *3*	5432.78	7$^+$,8$^+$,9$^+$	3448.221	6$^+$				(1984.5γ)(1129.2γ)(θ): A_2=−0.006 *54*, A_4=−0.036 *50* (1978Be12).
2000.2[&a] *3*	0.8[&] *1*	4319.02?		2318.991	5$^-$				
2000.2[&a] *3*	0.8[&] *1*	5589.46?		3589.409	8$^+$				
2056.10 *8*	1.4 *1*	4375.06	7$^-$	2318.991	5$^-$				
2186.242 *25*	219 *2*	2186.265	2$^+$	0	0$^+$	E2	5.36×10^{-4}		α(K)=0.0001223 *18*; α(L)=1.325×10^{-5} *19*; α(M)=2.29×10^{-6} *4*; α(N)=3.27×10^{-7} *5*; α(O)=2.34×10^{-8} *4* Mult.: α(K)exp=0.000123 *10*.
2222.34 *3*	7.6 *3*	4541.36	6$^+$	2318.991	5$^-$				α(K)exp=0.00010 *3*.
2318.959 *25*	1000 *2*	2318.991	5$^-$	0	0$^+$	E5	4.64×10^{-4}		α(K)=0.000408 *6*; α(L)=4.63×10^{-5} *7*; α(M)=8.04×10^{-6} *12*; α(N)=1.141×10^{-6} *16*; α(O)=7.97×10^{-8} *12* Mult.: α(K)exp=0.000385 *30* (1984HaZC).
[x]2321.9 *2*	9 *2*								
2322[a]	<0.10[†]	4640.94		2318.991	5$^-$				
2741.0 *3*	0.09 *3*	5059.97	7$^+$	2318.991	5$^-$	E3	5.86×10^{-4}		α(K)=0.0001277 *18*; α(L)=1.391×10^{-5} *20*;

$^{90}_{40}$Zr$_{50}$-5

γ(^{90}Zr) (continued)

E_γ[‡]	I_γ[‡@]	E_i(level)	J_i^π	E_f	J_f^π	Comments
						α(M)=2.41×10^{-6} *4*; α(N)=3.43×10^{-7} *5*; α(O)=2.46×10^{-8} *4*
2747.8 *3*	0.06 *2*	2747.867	3$^-$	0	0$^+$	
2845[a]	<0.02[†]	5164.48	(8)$^+$	2318.991	5$^-$	
3114[a]	<0.02[†]	5432.78	7$^+$,8$^+$,9$^+$	2318.991	5$^-$	

† Upper limits from 1982Wa24 renormalized to current normalization.
‡ From 1990Me15, except as noted.
# From the Adopted Gammas. For cases where values originate from this dataset, supported evidence is included in the comments.
@ For absolute intensity per 100 decays, multiply by 0.08203 *20*.
& Multiply placed with undivided intensity.
a Placement of transition in the level scheme is uncertain.
x γ ray not placed in level scheme.

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