^{97}Zr β^- decay

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	N. Nica	NDS 111, 525 (2010)	19-Nov-2009

Parent: ^{97}Zr: E=0.0; J$^\pi$=1/2$^+$; $T_{1/2}$=16.749 h *8*; Q(β^-)=2659.0 *18*; %β^- decay=100.0
^{97}Zr-ADOPTED values for ^{97}Zr.

^{97}Nb Levels

The level scheme is based on Eγ, Iγ, γγ data of 1968Si02 and modified and refined by subsequent measurements of Eγ, Iγ, γγ, by 1970Ar11, 1970Ho01, 1970Me06, 1970Mi02, 1972TiZS, 1975Co26. The level scheme shown here omits the levels previously suggested at 1547 and 2056 keV. It is felt that the experimental basis for the placement of the 804.52γ deexciting a level at 1547 keV is lacking; if this γ deexcites a 1547-keV level, then the coin spectra of 1970Me06 require that the 218.90γ is a triplet (feeding both the 1547 and 1548-keV levels and also 1433-keV level). The 2056-keV level is omitted because although the coin data (1970Me06) indicate that the 508γ is a doublet, it has not been shown that it feeds the 1548 level directly.

Although seemingly well established, the decay scheme still presents several difficulties: 1) β^- feeding of the 1851.71 keV *5/2*$^+$ level. 1970Me06 measure the Eβ^-(max.)=825 *30* keV in coin with the 1851γ, implying direct β^- feeding to this level, yet strong 1851.61γ to g.s. will not allow J<5/2 or J$^\pi$=5/2$^-$ for this level. The β-group is, therefore, a second forbidden nonunique transition which should have log *ft*>11.0, *i.e.* Iβ^-<10×10^{-3}%. 2) β^- feeding of the 1750.43 keV *5/2*$^+$ level. Again, the log *ft*=8.25 is too low for 1/2$^+$ to 5/2$^+$ β^- transition, but strong decay to 9/2$^+$ g.s. rules out J<5/2 or J$^\pi$=5/2$^-$.

Additional data: 1969Be83: γγ(t); 1970Be86, 1978Kr03: γγ(θ); 1970Ho01, 1970Me06: βγ; 1970Mi02: (ce)γ, βγ; 1971Mu13: I(ce), α(K), γγ(θ); 1976Pr13: βγ(θ); 1979Bo26: Eγ (curved crystal spect.).

E(level)†	J$^\pi$‡	$T_{1/2}$#	Comments
0.0	9/2$^+$	72.1‡ min *7*	%β^-=100 %β^-: from Adopted Levels.
743.35 *3*	1/2$^-$	58.7‡ s *18*	
1147.96 *6*	7/2$^+$	≤0.15 ns	J$^\pi$: not 5/2$^+$ (γγ(θ) 1978Kr03).
1251.01 *7*	3/2$^-$		J$^\pi$: βγ(θ) agrees with J$^\pi$=5/2$^-$, rules out J=1/2 (1976Pr13).
1276.09 *7*	5/2$^+$		
1433.92 *13*	5/2$^-$		
1548.36 *11*	(3/2$^+$,5/2$^-$)		
1652.82 *21*			
1750.43 *9*	5/2$^+$	≤0.2 ns	J$^\pi$: not 7/2$^+$ (γγ(θ) 1978Kr03); J agrees with 7/2 γγ(θ) (1971Mu13).
1764.42 *14*	(3/2$^-$)		
1851.71 *6*	5/2$^+$	≤0.2 ns	J$^\pi$: not 7/2$^+$ (γγ(θ) 1978Kr03).
1958.4 *6*			
2105.91 *6*	(3/2$^+$)	≤0.2 ns	J$^\pi$: J=1/2 ruled out γγ(θ) (1971Mu13).
2203? *2*			
2247.46 *15*	3/2$^-$		

† From least squares fit to Eγ.
‡ From Adopted Levels.
# From γγ(t) (1969Be83).

^{97}Zr β^- decay (continued)

β^- radiations

Iβ calculated from Iγ balance in level scheme.

E(decay)	E(level)	Iβ^- ‡	Log *ft*	Comments
(411.5 *18*)	2247.46	0.38 *3*	7.12 *4*	av Eβ=124.84 *64*
(553.1 *18*)	2105.91	4.95 *17*	6.448 *16*	av Eβ=175.92 *67* E(decay): 560 *30* from B(355γ) (1970Me06); 550 *10* from (1749γ+1851γ)(β^-) (1970Mi02).
(700.6# *19*)	1958.4	0.032 *17*	9.00 *23*	av Eβ=232.18 *74*
(807.3# *18*)	1851.71	0.27 *11*	8.29 *18*	av Eβ=274.44 *73* E(decay): 825 *30* from B(1852γ) (1970Me06).
(894.6 *18*)	1764.42	1.77 *18*	7.64 *5*	av Eβ=309.83 *74*
(908.6# *18*)	1750.43	0.46 *17*	8.25† *16*	av Eβ=315.57 *74* E(decay): 920 *30* from B(1148γ) (1970Me06).
(1006.2# *18*)	1652.82	0.102 *21*	9.07 *9*	av Eβ=356.02 *76*
(1110.6 *18*)	1548.36	0.36 *5*	8.68 *6*	av Eβ=400.08 *77* E(decay): 1050 *50* from B(1276γ) (1970Ho01).
(1382.9# *18*)	1276.09	0.12 *8*	9.5† *3*	av Eβ=517.93 *80*
(1408.0 *18*)	1251.01	3.90 *20*	8.046 *23*	av Eβ=528.97 *80*
(1915.7 *18*)	743.35	87.8 *4*	7.227 *3*	av Eβ=757.30 *83* E(decay): 1840 *50* (1970Ho01).

† log *ft* too low for second forbidden β transition; see comment above.
‡ Absolute intensity per 100 decays.
# Existence of this branch is questionable.

^{97}Zr β^- decay (continued)

γ(^{97}Nb)

The α(K)exp of 1971Mu13 were obtained from measured I(ce(K))/Iγ, normalized to α(K)(743γ M4)=0.0185.

E_γ[†]	I_γ[†a]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[‡]	δ[‡]	α[b]	Comments
111.6 *3*	0.070 *10*	1764.42	(3/2$^-$)	1652.82					
182.9 *5*	0.034 *7*	1433.92	5/2$^-$	1251.01	3/2$^-$				
202.5 *6*	0.031 *9*	1750.43	5/2$^+$	1548.36	(3/2$^+$,5/2$^-$)	D,E2[@]			
218.9 *2*	0.18 *2*	1652.82		1433.92	5/2$^-$				
254.17 *14*	1.23 *8*	2105.91	(3/2$^+$)	1851.71	5/2$^+$	M1+E2		0.030 *11*	α(K)=0.026 *10*; α(L)=0.0032 *14*; α(M)=0.00057 *24*; α(N+..)=9.E−5 *4* α(N)=8.E−5 *4*; α(O)=4.1×10^{-6} *14* α(K)(E2)=0.0351, α(K)(M1)=0.0164. Mult.: from α(K)exp=0.039 *6* (1971Mu13); from α(K)exp<0.02 from γce/$\gamma\beta^-$ (1970Mi02). δ: −0.04 *3* or +3.9 +*5*−*4* (1978Kr03).
272.40 *16*	0.25 *3*	1548.36	(3/2$^+$,5/2$^-$)	1276.09	5/2$^+$				
[x]294.8 *4*	0.09 *3*								Observed by 1970Ar11, 1972TiZS.
297.2 *3*	0.071 *12*	1548.36	(3/2$^+$,5/2$^-$)	1251.01	3/2$^-$				
305.1 *9*	0.03 *2*	1851.71	5/2$^+$	1548.36	(3/2$^+$,5/2$^-$)	D,E2[@]			
330.43 *19*	0.154 *16*	1764.42	(3/2$^-$)	1433.92	5/2$^-$				
355.40 *9*	2.25 *10*	2105.91	(3/2$^+$)	1750.43	5/2$^+$	M1+E2		0.011 *3*	α(K)=0.0092 *22*; α(L)=0.0011 *3*; α(M)=0.00019 *6*; α(N+..)=2.9×10^{-5} *8* α(N)=2.8×10^{-5} *8*; α(O)=1.5×10^{-6} *3* α(K)(E2)=0.0113, α(K)(M1)=0.00707. Mult.: from α(K)exp=0.014 *2* (1971Mu13); α(K)exp=0.0050 *25* from γce/$\gamma\beta^-$ (1970Mi02). δ: −0.04 *3* or +4.0 *5* (1978Kr03).
400.42 *16*	0.263 *17*	1548.36	(3/2$^+$,5/2$^-$)	1147.96	7/2$^+$				
[x]410 *1*	0.07 *5*								Observed by 1970Me06 in coin with 804.52γ.
473.5 *6*	0.08 *4*	1750.43	5/2$^+$	1276.09	5/2$^+$	D,E2[@]			
507.64 *8*	5.4 *2*	1251.01	3/2$^-$	743.35	1/2$^-$				Mult.: α(K)exp=0.0082 *9* (1971Mu13); (theory: α(K)(E2)=0.00432, α(K)(M1)=0.00344).
513.41 *18*	0.59 *5*	1764.42	(3/2$^-$)	1251.01	3/2$^-$				
558 *1*	0.03 *2*	2105.91	(3/2$^+$)	1548.36	(3/2$^+$,5/2$^-$)				
600.6 *6*	<0.2	1851.71	5/2$^+$	1251.01	3/2$^-$				
602.37 *14*	1.48 *8*	1750.43	5/2$^+$	1147.96	7/2$^+$	M1+E2	+0.11 *6*	0.00228	α(K)=0.00201 *3*; α(L)=0.000225 *4*; α(M)=3.96×10^{-5} *6*; α(N+..)=6.14×10^{-6} *9* α(N)=5.80×10^{-6} *9*; α(O)=3.39×10^{-7} *5*
690.52 *16*	0.197 *19*	1433.92	5/2$^-$	743.35	1/2$^-$				
699.2 *3*	0.108 *21*	2247.46	3/2$^-$	1548.36	(3/2$^+$,5/2$^-$)				
703.76 *5*	1.09 *5*	1851.71	5/2$^+$	1147.96	7/2$^+$	M1+E2	+0.19 *8*	1.60×10^{-3}	α(K)=0.001410 *20*; α(L)=0.0001572 *23*; α(M)=2.77×10^{-5} *4*; α(N+..)=4.30×10^{-6} *7* α(N)=4.06×10^{-6} *6*; α(O)=2.37×10^{-7} *4*

γ(^{97}Nb) (continued)

E_γ[†]	I_γ[†a]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[‡]	δ[‡]	α[b]	Comments
707.4 *6*	0.034 *18*	1958.4		1251.01	3/2⁻				
743.36 *3*	100	743.35	1/2⁻	0.0	9/2⁺	[M4]		0.0210	α(K)=0.0181 *3*; α(L)=0.00237 *4*; α(M)=0.000423 *6*; α(N+..)=6.47×10^{-5} *9* α(N)=6.14×10^{-5} *9*; α(O)=3.32×10^{-6} *5* E_γ: from 1979Bo26.
[x]772[#] *3*	0.26[#] *14*								
[x]775.0[#] *8*	0.20[#]								
[x]804.52 *9*	0.66 *8*								
[x]805.6[#] *8*	0.30[#]								
829.79 *9*	0.257 *19*	2105.91	(3/2⁺)	1276.09	5/2⁺				
854.89 *8*	0.383 *24*	2105.91	(3/2⁺)	1251.01	3/2⁻	(E1)[&]		4.21×10^{-4}	α(K)=0.000372 *6*; α(L)=4.08×10^{-5} *6*; α(M)=7.17×10^{-6} *10*; α(N+..)=1.111×10^{-6} *16* α(N)=1.050×10^{-6} *15*; α(O)=6.11×10^{-8} *9*
971.34 *15*	0.299 *18*	2247.46	3/2⁻	1276.09	5/2⁺				
[x]1018.1[#] *8*	0.40[#]								
1021.2 *3*	1.09 *18*	1764.42	(3/2⁻)	743.35	1/2⁻				
[x]1026.7[#] *8*	0.30[#]								
[x]1110.44 *19*	0.10 *2*								E_γ: previously assigned to 1851.71 *6* level. However, weighted average of all Eγ measurements leads to 1110.44+743.35=1853.79, 2.08 keV higher than the E(level) obtained from least squares fit.
1147.97 *8*	2.81 *11*	1147.96	7/2⁺	0.0	9/2⁺	M1+E2	+0.5 *2*	5.47×10^{-4}	α(K)=0.000481 *8*; α(L)=5.31×10^{-5} *8*; α(M)=9.34×10^{-6} *14*; α(N+..)=3.56×10^{-6} *9* α(N)=1.371×10^{-6} *20*; α(O)=8.05×10^{-8} *13*; α(IPF)=2.11×10^{-6} *8*
1276.07 *9*	1.01 *6*	1276.09	5/2⁺	0.0	9/2⁺				
[x]1361.0[#] *8*	0.7[#]								
1362.68 *9*	1.10 *11*	2105.91	(3/2⁺)	743.35	1/2⁻	[E1]		3.22×10^{-4}	α(K)=0.0001559 *22*; α(L)=1.698×10^{-5} *24*; α(M)=2.98×10^{-6} *5*; α(N+..)=0.0001461 *21* α(N)=4.37×10^{-7} *7*; α(O)=2.57×10^{-8} *4*; α(IPF)=0.0001456 *21*
1750.24 *22*	1.17 *11*	1750.43	5/2⁺	0.0	9/2⁺				
1851.61 *9*	0.33 *3*	1851.71	5/2⁺	0.0	9/2⁺				
2203[c] *2*		2203?		0.0	9/2⁺				I_γ: weak.

[†] Weighted average of measurements by 1968Si02, 1970Ar11, 1970Ho01 1970Me06, 1970Mi02, 1972TiZS, unless otherwise noted.
[‡] From γγ(θ) (1978Kr03), unless otherwise noted.
[#] Observed by 1972TiZS only.

$^{97}_{41}$Nb$_{56}$-4

^{97}Zr β^- decay (continued)

$\gamma(^{97}Nb)$ (continued)

[@] Deduced from RUL.
[&] D,E2 deduced from RUL, level scheme limits mult to E1.
[a] For absolute intensity per 100 decays, multiply by 0.9309 *16*.
[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] Placement of transition in the level scheme is uncertain.
[x] γ ray not placed in level scheme.

$^{97}_{41}Nb_{56}$-5

^{97}Zr β^- decay

Decay Scheme

Intensities: $I_{(\gamma+ce)}$ per 100 decays through this branch