^{91}Zr(n,n′γ) 1979Av02,2013Pe16

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Coral M. Baglin	NDS 114, 1293 (2013)	1-Sep-2013

1979Av02: fast reactor neutrons. 63.6% ^{91}Zr target. Ge(Li), FWHM=5 keV at 1.2 MeV. Measured Eγ, Iγ, γ(θ).

1974Gl06: E=1.27-2.37 MeV (from ^{3}H(p,n)^{3}He) and E=3.43-6.19 MeV (from ^{2}H(d,n)^{3}He). 89% ^{91}Zr target. Ge(Li), NaI(Tl) anti-Compton spectrometer. Measured γ production cross sections.

2013Pe16: E(n)=2.0, 2.5, 2.8, 3.5 MeV; naturally-occurring Zr metal (99.2% purity) and oxide (99.978% pure ZrO_2 In polyethylene vial) targets; high-purity Ge detector; measured γ(θ), θ(lab)=40° *150*50°; deduced level lifetimes using DSAM. Demonstrated 2041-level lifetime dependence on crystal domain size In ZrO_2 samples, the larger domain sizes giving best agreement with results from amorphous samples.

^{91}Zr Levels

E(level)[†]	Jπ[‡]	$T_{1/2}$[#]	Comments
0	5/2+		
1204.93 *10*	1/2+		Jπ: 1/2+ from γ excit (1974Gl06).
1466.5 *4*	5/2+	344 fs *+42−33*	Jπ: 5/2+ from γ excit (1974Gl06). $T_{1/2}$: 344 fs *+58−42* (metal), 344 fs *+68−48* (oxide) (2013Pe16); 1466γ and E(n)=2.0 MeV.
1882.21 *18*	7/2+	73 fs *+5−4*	Jπ: 7/2+,9/2+ from γ excit (1974Gl06). $T_{1/2}$: 76 fs *6* (metal), 69 fs *+6−5* (oxide) (2013Pe16); 1882γ and E(n)=2.0 MeV.
2042.38 *20*	3/2+	11.8 fs *14*	Jπ: 3/2+ from γ excit (1974Gl06). $T_{1/2}$: 11.1 fs *21* (metal), 11.8 fs *+21−14* (oxide) (2013Pe16); 2042γ and E(n)=2.5 MeV.
2131.63 *20*	(9/2)+	114 fs *+12−10*	Jπ: (9/2+) from γ excit (1974Gl06). $T_{1/2}$: 115 fs *+17−13* (metal), 112 fs *+17−13* (oxide) (2013Pe16); 2132γ and E(n)=2.5 MeV.
2170.03 *20*	(11/2)−	333 fs *+90−55*	Jπ: (11/2−) from γ excit (1974Gl06).
2189.6 *7*	(5/2)−		
2200.5 *3*	7/2+	0.33 ps *+9−6*	Jπ: 5/2+ preferred over 7/2+ in γ excit (1974Gl06). $T_{1/2}$: 344 fs *+58−42* (metal), 344 fs *+68−48* (oxide) (2013Pe16). 2201γ and E(n)=2.5 MeV.
2321.3 *6*	(11/2)−		
2356.6 *7*	(1/2)−		
2366.53 *20*		105 fs *+18−14*	$T_{1/2}$: for metal target (2013Pe16); 2367γ and E(n)=2.8 MeV.
2534.71 *22*	(3/2+,5/2+)	78 fs *+19−15*	$T_{1/2}$: for metal target (2013Pe16); 652γ and E(n)=2.8 MeV.
2558.0 *5*	1/2+		
2578.0 *5*	(3/2)−	73 fs *+25−17*	$T_{1/2}$: for metal target (2013Pe16); 2578γ and E(n)=2.8 MeV.
2640.0 *4*	(3/2)−	92 fs *+32−21*	$T_{1/2}$: for metal target (2013Pe16); 2640γ and E(n)=3.5 MeV.
2693.6 *5*	(3/2)−	22 fs *+6−5*	$T_{1/2}$: for metal target (2013Pe16); 2694γ and E(n)=3.5 MeV.
2764.9 *8*	(13/2)−		
2775.2 *5*	(5/2)−	129 fs *+50−31*	$T_{1/2}$: for metal target (2013Pe16); 2775γ and E(n)=3.5 MeV.
2791.6 *3*			
2811.9 *8*	(7/2+)	24 fs *+5−4*	$T_{1/2}$: for metal target (2013Pe16); 2811γ and E(n)=3.5 MeV.
2835.7? *5*	(3/2,5/2,7/2)−		
2871.0 *8*	3/2+		
2895.8? *6*			Level not adopted; the 726γ tentatively deexciting it in (n,n′γ) probably deexcites the adopted 2857 level, absent in 1979Av02.
2902.4 *8*	(7/2)+		
2914.3 *5*	(9/2+)		
2928.4 *10*	(3/2,5/2)+	61 fs *+15−11*	$T_{1/2}$: for metal target (2013Pe16); 2928γ and E(n)=3.5 MeV.
2992.1 *7*			
3007.7 *8*	5/2−,7/2−	94 fs *+43−26*	$T_{1/2}$: for metal target (2013Pe16); 3008γ and E(n)=3.5 MeV.
3083.1 *8*	3/2+	17 fs *+6−4*	$T_{1/2}$: for metal target (2013Pe16); 3083γ and E(n)=3.5 MeV.
3107.9 *8*	7/2+,9/2+	38 fs *+8−6*	$T_{1/2}$: for metal target (2013Pe16); 3108γ and E(n)=3.5 MeV.
3234.8 *10*	(3/2)−	27 fs *+6−8*	$T_{1/2}$: for metal target (2013Pe16); 3235γ and E(n)=3.5 MeV.

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^{91}Zr(n,n′γ) 1979Av02,2013Pe16 (continued)

^{91}Zr Levels (continued)

E(level)[†]	J$^\pi$[‡]
3276.6? *6*	
3290.4? *5*	3/2$^+$
3331.1 *15*	1/2$^+$

[†] From least-squares fit to Eγ.
[‡] From Adopted Levels. J$^\pi$ from Hauser-Feshbach calculations (Moldauer formulation) (1974Gl06) are given under comments.
[#] From DSAM (2013Pe16). uncertainties are statistical only.

γ(^{91}Zr)

Eγ[†]	Iγ[†]	E$_i$(level)	J$^\pi_i$	E$_f$	J$^\pi_f$	Mult.[‡]	δ[‡]	Comments
151.3 *5*	1.1 *3*	2321.3	(11/2)$^-$	2170.03	(11/2)$^-$			
[x]214.2[#] *3*	3 *1*							
[x]434.7 *4*	0.6 *2*							
443.6 *6*	1.7 *6*	2764.9	(13/2)$^-$	2321.3	(11/2)$^-$			
[x]637.9 *5*	0.4 *2*							
652.5 *2*	3.4 *9*	2534.71	(3/2$^+$,5/2$^+$)	1882.21	7/2$^+$			
660.0 *2*	2.7 *8*	2791.6		2131.63	(9/2)$^+$			
712.6 *5*	1.0 *3*	2902.4	(7/2)$^+$	2189.6	(5/2)$^-$			
725.8[&] *5*	4.1 *12*	2895.8?		2170.03	(11/2)$^-$			Probably misplaced; see comment on 2896 level.
732.4[&] *5*	2.4 *7*	2775.2	(5/2)$^-$	2042.38	3/2$^+$			
770.5 *10*	0.8 *3*	2811.9	(7/2$^+$)	2042.38	3/2$^+$			
782.7 *4*	5.4 *16*	2914.3	(9/2$^+$)	2131.63	(9/2)$^+$			
791.6 *6*	1.9 *7*	2992.1		2200.5	7/2$^+$			
[x]795.9 *8*	1.3 *5*							
[x]902.7 *2*	3.8 *12*							
1068.0 *5*	2.1 *4*	2534.71	(3/2$^+$,5/2$^+$)	1466.5	5/2$^+$			
1151.7 *7*	2.5 *6*	2356.6	(1/2)$^-$	1204.93	1/2$^+$			
1204.92 *10*	50 *5*	1204.93	1/2$^+$	0	5/2$^+$			
1248.0[&] *4*	1.8 *7*	3290.4?	3/2$^+$	2042.38	3/2$^+$			
1369.2[&] *3*	4 *1*	2835.7?	(3/2,5/2,7/2)$^-$	1466.5	5/2$^+$			
1466.2[@] *5*	100	1466.5	5/2$^+$	0	5/2$^+$			A_2=+0.02 *7* (1979Av02).
[x]1619.7 *2*	1.8 *4*							
[x]1689.3 *5*	1.4 *5*							
[x]1752.6 *3*	4.1 *13*							
1810.1[&] *4*	1.4 *5*	3276.6?		1466.5	5/2$^+$			
1882.2 *2*	55 *5*	1882.21	7/2$^+$	0	5/2$^+$	(M1+E2)	+1.0 *+27−4*	A_2=+0.21 *9* (1979Av02).
2042.4 *2*	20 *2*	2042.38	3/2$^+$	0	5/2$^+$	(M1(+E2))		A_2=−0.03 *4* (1979Av02). δ: −10<δ<+0.1 (1979Av02).
2131.6 *2*	46 *4*	2131.63	(9/2)$^+$	0	5/2$^+$	(E2)		A_2=+0.21 *6* (1979Av02) (+0.21 expected for stretched Q).
2170.0 *2*	43 *4*	2170.03	(11/2)$^-$	0	5/2$^+$	(E3)		A_2=+0.50 *10* (1979Av02) (0.48 expected for octupole transition).
2189.0 *9*	12 *5*	2189.6	(5/2)$^-$	0	5/2$^+$			
2200.5 *3*	23 *2*	2200.5	7/2$^+$	0	5/2$^+$	(M1+E2)		A_2=−0.16 *10* (1979Av02). δ: −0.20 *+25−80* or −2.3 *+13−37* (1979Av02).

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^{91}Zr(n,n′γ) 1979Av02,2013Pe16 (continued)

γ(^{91}Zr) (continued)

E_γ †	I_γ †	E_i(level)	J^π_i	E_f	J^π_f	Mult.‡	δ‡	Comments
2366.5 *2*	12 *2*	2366.53		0	5/2+			
2534.8 *4*	4.4 *8*	2534.71	(3/2+,5/2+)	0	5/2+			
2558.0 *5*	2.4 *4*	2558.0	1/2+	0	5/2+			
2578.0 *5*	4 *1*	2578.0	(3/2)−	0	5/2+			
2640.0 *4*	3.2 *6*	2640.0	(3/2)−	0	5/2+			
2693.6 *5*	4.5 *9*	2693.6	(3/2)−	0	5/2+	(E1(+M2))	−0.3 *+3−7*	δ: other solution, δ=−1.8 *+9−52*, is improbable for E1+M2. A_2=−0.18 *12* (1979Av02).
x2724.4 *8*	0.6 *2*							
x2747.9 *9*	0.7 *3*							
2775.2 *5*	2.8 *7*	2775.2	(5/2)−	0	5/2+			
2810.8 *10*	4.3 *9*	2811.9	(7/2+)	0	5/2+			
2871.0 *8*	1.4 *4*	2871.0	3/2+	0	5/2+			
2903.1 *10*	0.8 *3*	2902.4	(7/2)+	0	5/2+			
2928.3 *10*	3.0 *10*	2928.4	(3/2,5/2)+	0	5/2+			
3007.6 *8*	1.9 *5*	3007.7	5/2−,7/2−	0	5/2+			
3083.0 *8*	1.4 *5*	3083.1	3/2+	0	5/2+			
3107.8 *8*	2.0 *6*	3107.9	7/2+,9/2+	0	5/2+			
3234.7 *10*	0.9 *4*	3234.8	(3/2)−	0	5/2+			
3331.0 *15*	1.2 *5*	3331.1	1/2+	0	5/2+			

† From 1979Av02. Eγ data from 1974Gl06 are in excellent agreement with those of 1979Av02, but are less precise.
‡ From γ(θ) (1979Av02); A_2 from γ(θ) is given in comments, A_4 (not given explicitly by authors) is small in all cases. Δπ is assumed from adopted level scheme.
# Possibly an impurity line.
@ From 1974Gl06. 1979Av02 used Eγ=1466.24 as calibration energy.
& Placement of transition in the level scheme is uncertain.
x γ ray not placed in level scheme.

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Level Scheme

Intensities: Relative I_γ