Adopted Levels, Gammas

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	T. D. Johnson and W. D. Kulp(a)	NDS 129, 1 (2015)	27-Jul-2015

Q(β^-)=−5473 *8*; S(n)=9449 *6*; S(p)=7352 *15*; Q(α)=−4974 *8* 2012Wa38
Q(β^-n)=−18285 *7*, Q(εcp)=−2112 *4*.
Mass excess from 2008We10: −79341.4 *53* keV, from 2012Ka13: −79343.9 *50* keV, using ^{97}Mo as reference (jyfltrap).
For model calculations of level energies and configurations, see 1985Ox01.
; Systematics of 1-qp configurations, 2010Ro27.
Other recent theory and calcuations:2010Ro27,2006Es02.

^{87}Zr Levels

Cross Reference (XREF) Flags

A	(HI,xnγ)	D	^{87}Zr IT decay (14.0 s)
B	^{87}Nb β^+ decay (2.6 min)	E	^{90}Zr(^{3}He,^{6}He)
C	^{87}Nb β^+ decay (3.75 min)		

E(level)†	Jπ‡	$T_{1/2}$#	XREF	Comments
0.0	9/2$^+$	1.68 h *1*	ABCDE	%ε+%β^+=100 μ=−0.895 *9*; Q=+0.423 *48* (2002Fo12,2003Th03) Jπ: from log*ft*=5.7 allows J^π=9/2$^+$, 7/2$^+$, or 11/2$^+$. A log*ft*=8.10 to a 5/2$^-$ level rules out 11/2$^+$. log*ft*=6.77 to the 11/2$^+$ 1591.3 level rules out 7/2$^+$. Collinear laser spectroscopy of cool bunched ion beams was performed on ^{87}Zr providing information on mean-square charge radii, magnetic moments, and extracted quadrupole moments for the ground state. In addition, these measurements provide additional arguments for the 9/2$^+$ assignment for the ground state based on Zr systematics of strong prolate deformations for N < 50 (2002Fo12). $T_{1/2}$: from 1984Pr01. However, their measured results of 1.684 *1* and 1.667 *6* would give an average of about 1.682 *3*. So, the authors seem to have chosen to increase their final uncertainty. Other: 1.69 h *2* (1989Sh39). μ,Q: from collinear LASER spectroscopy. β_2=0.10 *1* from 2002Fo12. Mean square charge radius around 18.7 fm^2 corresponding to β_2 between 0.1 and 0.2 (2002Ca47) from LASER spectroscopy. The 9/2, as opposed to 7/2, spin assignment is consistent with the larger quadrupole moment. See 2002Fo12 for more detail.
200.91 *12*	7/2$^+$	2.44 ns *10*	ABCDE	Jπ: See 335 level.
335.84 *19*	1/2$^-$	14.0 s *2*	A CDE	%IT=100 μ=+0.642 *7* (2002Fo12) μ: from collinear LASER spectroscopy. Jπ: Uniquely established using collinear laser spectroscopy, see 2002Fo12. E3γ from the 335 level to the 200 level and M1+E2γ from the 200 level to the gs, establishes π(335 level)=− and J^π(200 level)=7/2$^+$. $T_{1/2}$: from isomeric decay. %IT: no ε decay from this level has been observed.
470.63 *12*	(7/2$^+$)		AB	Jπ: from log*ft*=5.8 from (9/2$^+$) and Δ J=1 transition to 9/2$^+$ based on angular distribution measurement.
523.7 *23*			B	
589.3 *17*			B	
801.50 *15*	(7/2)		AB	
817.45 *22*			B E	
931.53 *24*			A	
1061 *15*			E	

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Adopted Levels, Gammas (continued)

^{87}Zr Levels (continued)

E(level)[†]	Jπ[‡]	$T_{1/2}$[#]	XREF	Comments
1069.42 *19*	(13/2)$^+$	<49 ps	A	
1087.37 *15*	(9/2)		AB	
1124.88 *20*	(11/2$^+$)		A	
1284.0 *23*			B	
1287.5 *23*			B	
1505.5 *23*			B	
1656.9 *3*	(11/2$^+$)		A	
1669 *4*			B	
1691.3 *3*	(13/2)		A	
1749 *4*			B	
1884.4 *3*	(7/2$^+$,9/2$^+$,11/2$^+$)		B	Jπ: from log*ft*=4.6 for ε decay from (9/2$^+$) ^{87}Nb.
1911. *4*			B	
1919.6 *23*			B	
1949 *3*			B	
2059.2 *23*			B	
2069.3 *23*			B	
2073.72 *25*	(13/2$^-$)	2.97 ns *20*	A	
2125 *15*			E	
2201.9 *3*	(17/2)$^+$	<35 ps	A	
2245.3 *23*			B	
2287 *15*			E	
2312.5 *4*	(17/2$^-$)	2.74 ns *9*	A	
2354.3 *7*			B	
2467.1 *4*	(17/2$^-$)	11 ps *3*	A	
2598.2 *23*			B	
2894.1	(21/2)$^+$	71 ps *7*	A	
2986.1 *4*	(19/2$^-$)		A	
3053.3 *23*			B	
3236.8	(19/2$^-$)	3.0 ps *6*	A	
3365.9 *8*	(21/2$^-$)	<3 ps	A	
3380.4 *15*	(23/2)	<0.2 ps	A	
3447.0 *23*			B	
3942.7	(25/2)	0.15 ps *5*	A	
4056.8	(25/2$^+$)		A	
4128.7	(25/2)	0.80 ps *20*	A	
4333.1	(25/2$^-$)	6.9 ps *14*	A	
4530.2	(27/2)	0.44 ps *10*	A	
4618.6	(27/2$^-$)		A	
5054.8	(29/2$^+$)		A	
5074.3 *16*	(27/2$^-$)	0.5 ps *2*	A	
5507.6	(29/2$^+$)		A	
5529.3	(29/2$^-$)		A	
5689.9	(29/2$^-$)		A	
5803.2	(31/2$^+$)		A	
6212.6	(31/2$^-$)		A	
6234.3	(33/2$^+$)		A	
6268.8	(31/2$^-$)		A	
6573.7	(35/2$^+$)		A	
6840.1	(33/2$^-$)		A	
7451.9	(35/2$^-$)		A	
7476.8	(37/2$^+$)		A	
8777.6	(39/2$^-$)		A	
10091.6	(43/2$^+$)		A	

Continued on next page (footnotes at end of table)

Adopted Levels, Gammas (continued)

^{87}Zr Levels (continued)

† From least-squares fit to γ-ray energies.
‡ From (HI,xnγ), unless indicated otherwise. Based on excitation functions, $\gamma(\theta)$, and, for quadrupole transitions, RUL.
# From (HI,xnγ) using Doppler shift attenutation, or recoil distance techniques.

Adopted Levels, Gammas (continued)

γ(^{87}Zr)

E_i(level)	J_i^π	E_γ[†]	I_γ[†]	E_f	J_f^π	Mult.[‡]	δ	α[#a]	Comments
200.91	7/2$^+$	201.02[@] *14*	100	0.0	9/2$^+$	M1+E2	−0.35	0.0370	B(M1)(W.u.)=0.00095 *4*; B(E2)(W.u.)=3.25 *14* α(K)=0.0324 *5*; α(L)=0.00387 *6*; α(M)=0.000673 *10* α(N)=9.43×10^{-5} *14*; α(O)=6.19×10^{-6} *9* δ: δ=−0.35 or −2.6 from (HI,xnγ), but α(exp) determined in isomeric decay deviates from α for δ=−2.6 by more than one standard deviation.
335.84	1/2$^-$	134.93[@] *15*	100	200.91	7/2$^+$	E3		2.67	B(E3)(W.u.)=0.0646 *13* α(K)=1.98 *3*; α(L)=0.571 *9*; α(M)=0.1020 *16* α(N)=0.01292 *20*; α(O)=0.000314 *5* Mult.: from α(exp) deduced in isomeric decay.
470.63	(7/2$^+$)	470.63[@] *12*	100	0.0	9/2$^+$	(D+Q)			δ: δ=−0.04 or δ=−8 from (HI,xnγ).
523.7		322.8 *23*	100	200.91	7/2$^+$				
589.3		388.7 *23*	100	200.91	7/2$^+$				
801.50	(7/2)	600.9 *2*	100[&] *16*	200.91	7/2$^+$				
		801.2 *2*	42[&] *13*	0.0	9/2$^+$	(D)			
817.45		616.5[&] *2*	100	200.91	7/2$^+$				
931.53		460.9 *2*	100	470.63	(7/2$^+$)				
1069.42	(13/2)$^+$	1069.4 *2*	100	0.0	9/2$^+$	E2		5.76×10^{-4}	B(E2)(W.u.)>0.36 α(K)=0.000508 *8*; α(L)=5.63×10^{-5} *8*; α(M)=9.76×10^{-6} *14* α(N)=1.385×10^{-6} *20*; α(O)=9.70×10^{-8} *14*
1087.37	(9/2)	886.4[&] *2*	100	200.91	7/2$^+$				
		1087.4 *2*	17	0.0	9/2$^+$				
1124.88	(11/2$^+$)	1124.9 *2*	100	0.0	9/2$^+$	D+Q			
1284.0		466.5[&] *23*	100	817.45					
1287.5		470.0[&] *23*	100	817.45					
1505.5		1304.6[&] *23*	100	200.91	7/2$^+$				
1656.9	(11/2$^+$)	569 *1*	75	1087.37	(9/2)				
		1456 *1*	50	200.91	7/2$^+$	(E2)		3.67×10^{-4}	α(K)=0.000264 *4*; α(L)=2.89×10^{-5} *4*; α(M)=5.01×10^{-6} *7* α(N)=7.12×10^{-7} *10*; α(O)=5.05×10^{-8} *8*; α(IPF)=6.84×10^{-5} *11*
		1657 *1*	100	0.0	9/2$^+$	(M1+E2)		3.68×10^{-4}	α(K)=0.000210 *4*; α(L)=2.28×10^{-5} *4*; α(M)=3.95×10^{-6} *6* α(N)=5.63×10^{-7} *9*; α(O)=4.04×10^{-8} *7*; α(IPF)=0.000130 *5*
1669		381.3[&] *23*	100	1287.5					
1691.3	(13/2)	567	100	1124.88	(11/2$^+$)				
		621.9 *2*	75	1069.42	(13/2)$^+$	(D)			
1749		461.7[&] *23*	100	1287.5					

$^{87}_{40}Zr_{47}$-4

Adopted Levels, Gammas (continued)

γ(^{87}Zr) (continued)

E_i(level)	J_i^π	E_γ[†]	I_γ[†]	E_f	J_f^π	Mult.[‡]	δ	α[#a]	Comments
1884.4	(7/2$^+$,9/2$^+$,11/2$^+$)	797.0[&] *23*	14	1087.37	(9/2)				
		1066.8[&] *3*	100 *11*	817.45					
		1083.0[&] *7*	6 *3*	801.50	(7/2)				
		1295.4[&] *23*	5	589.3					
		1683.6[&] *7*	41 *4*	200.91	7/2$^+$				
		1884.5[&] *7*	89 *8*	0.0	9/2$^+$				
1911.		242.4[&] *23*	100	1669					
1919.6		1718.7[&] *23*	100	200.91	7/2$^+$				
1949		1360.1[&] *23*	100	589.3					
2059.2		1858.3[&] *23*	100	200.91	7/2$^+$				
2069.3		1868.4[&] *23*	100	200.91	7/2$^+$				
2073.72	(13/2$^-$)	416.8 *2*	79	1656.9	(11/2$^+$)	D			
		949.0	16	1124.88	(11/2$^+$)	[D]			
		1004.3 *2*	100	1069.42	(13/2)$^+$	(D)			
2201.9	(17/2)$^+$	1132.5 *2*	100	1069.42	(13/2)$^+$	E2		5.09×10^{-4}	B(E2)(W.u.)>0.38 α(K)=0.000448 *7*; α(L)=4.95×10^{-5} *7*; α(M)=8.58×10^{-6} *12* α(N)=1.217×10^{-6} *17*; α(O)=8.54×10^{-8} *12*; α(IPF)=1.72×10^{-6} *3*
2245.3		2044.4[&] *23*	100	200.91	7/2$^+$				
2312.5	(17/2$^-$)	110.6 *10*	58	2201.9	(17/2)$^+$	(D)			
		238.8 *2*	100	2073.72	(13/2$^-$)	E2		0.0478	B(E2)(W.u.)=7.0 *3* α(K)=0.0414 *6*; α(L)=0.00534 *8*; α(M)=0.000929 *14* α(N)=0.0001276 *19*; α(O)=7.37×10^{-6} *11*
2354.3		2153.4[&] *7*	100	200.91	7/2$^+$				
2467.1	(17/2$^-$)	154.7 *2*	100	2312.5	(17/2$^-$)	(M1+E2)	0.5 *25*	0.09 *12*	α(K)=0.08 *10*; α(L)=0.011 *16*; α(M)=0.002 *3* α(N)=0.0003 *4*; α(O)=1.5×10^{-5} *16*
2598.2		2397.3[&] *23*	100	200.91	7/2$^+$				
2894.1	(21/2)$^+$	692.2	100	2201.9	(17/2)$^+$	E2		1.67×10^{-3}	B(E2)(W.u.)=2.19 *22* α(K)=0.001469 *21*; α(L)=0.0001670 *24*; α(M)=2.90×10^{-5} *4* α(N)=4.09×10^{-6} *6*; α(O)=2.78×10^{-7} *4*
2986.1	(19/2$^-$)	521.9	30	2467.1	(17/2$^-$)	(D)			
		675.8 *2*	100	2312.5	(17/2$^-$)	(D)			
3053.3		2852.3[&] *23*	100	200.91	7/2$^+$				
3236.8	(19/2$^-$)	924.8	100	2312.5	(17/2$^-$)	(M1+E2)	0.50 *25*	7.98×10^{-4}	B(M1)(W.u.)=(0.0074 *21*); B(E2)(W.u.)=(2.4 *20*) α(K)=0.000705 *10*; α(L)=7.76×10^{-5} *12*;

$^{87}_{40}Zr_{47}$-5

Adopted Levels, Gammas (continued)

γ(^{87}Zr) (continued)

E_i(level)	J_i^π	E_γ[†]	I_γ[†]	E_f	J_f^π	Mult.[‡]	α[#a]	Comments
								α(M)=1.345×10^{-5} *20* α(N)=1.91×10^{-6} *3*; α(O)=1.359×10^{-7} *19*
3365.9	(21/2$^-$)	129.7		3236.8	(19/2$^-$)	(D+Q)		
		378.2	88	2986.1	(19/2$^-$)	(D+Q)		
		900.0	100	2467.1	(17/2$^-$)	(E2)	8.60×10^{-4}	B(E2)(W.u.)>7.4 α(K)=0.000758 *11*; α(L)=8.47×10^{-5} *12*; α(M)=1.469×10^{-5} *21* α(N)=2.08×10^{-6} *3*; α(O)=1.442×10^{-7} *21*
3380.4	(23/2)	486.4	100	2894.1	(21/2)$^+$			
3447.0		3246.0 *23*		200.91	7/2$^+$			
3942.7	(25/2)	562.4	100	3380.4	(23/2)	(D)		
		1048.5		2894.1	(21/2)$^+$			
4056.8	(25/2$^+$)	1162.7	100	2894.1	(21/2)$^+$			
4128.7	(25/2)	748.4	100	3380.4	(23/2)	(D)		
4333.1	(25/2$^-$)	967.2	100	3365.9	(21/2$^-$)	(E2)	7.25×10^{-4}	B(E2)(W.u.)=4.2 *9* α(K)=0.000640 *9*; α(L)=7.12×10^{-5} *10*; α(M)=1.235×10^{-5} *18* α(N)=1.749×10^{-6} *25*; α(O)=1.218×10^{-7} *17*
4530.2	(27/2)	401.8	33	4128.7	(25/2)			
		587.3	100	3942.7	(25/2)	(D)		
		1149.7		3380.4	(23/2)			
4618.6	(27/2$^-$)	285.6	100	4333.1	(25/2$^-$)			
5054.8	(29/2$^+$)	524.5		4530.2	(27/2)			
		1112.3		3942.7	(25/2)			
5074.3	(27/2$^-$)	741.0	100	4333.1	(25/2$^-$)	(D)		
5507.6	(29/2$^+$)	977.4		4530.2	(27/2)			
		1378.7		4128.7	(25/2)			
5529.3	(29/2$^-$)	455.0		5074.3	(27/2$^-$)			
		910.8		4618.6	(27/2$^-$)			
		1196.1		4333.1	(25/2$^-$)			
5689.9	(29/2$^-$)	615.6	100	5074.3	(27/2$^-$)			
5803.2	(31/2$^+$)	295.4		5507.6	(29/2$^+$)			
		1273.0		4530.2	(27/2)			
6212.6	(31/2$^-$)	683.4	100	5529.3	(29/2$^-$)			
6234.3	(33/2$^+$)	431.0		5803.2	(31/2$^+$)			
		1179.5		5054.8	(29/2$^+$)			
6268.8	(31/2$^-$)	578.8	100	5689.9	(29/2$^-$)			
6573.7	(35/2$^+$)	339.3	100	6234.3	(33/2$^+$)			
6840.1	(33/2$^-$)	627.5	100	6212.6	(31/2$^-$)			
7451.9	(35/2$^-$)	611.9		6840.1	(33/2$^-$)			
		1183.0		6268.8	(31/2$^-$)			
7476.8	(37/2$^+$)	903.0		6573.7	(35/2$^+$)			
		1242.7		6234.3	(33/2$^+$)			
8777.6	(39/2$^-$)	1325.7	100	7451.9	(35/2$^-$)			
10091.6	(43/2$^+$)	1314.0	100	8777.6	(39/2$^-$)			

$^{87}_{40}Zr_{47}$-6

Adopted Levels, Gammas (continued)

$\gamma(^{87}Zr)$ (continued)

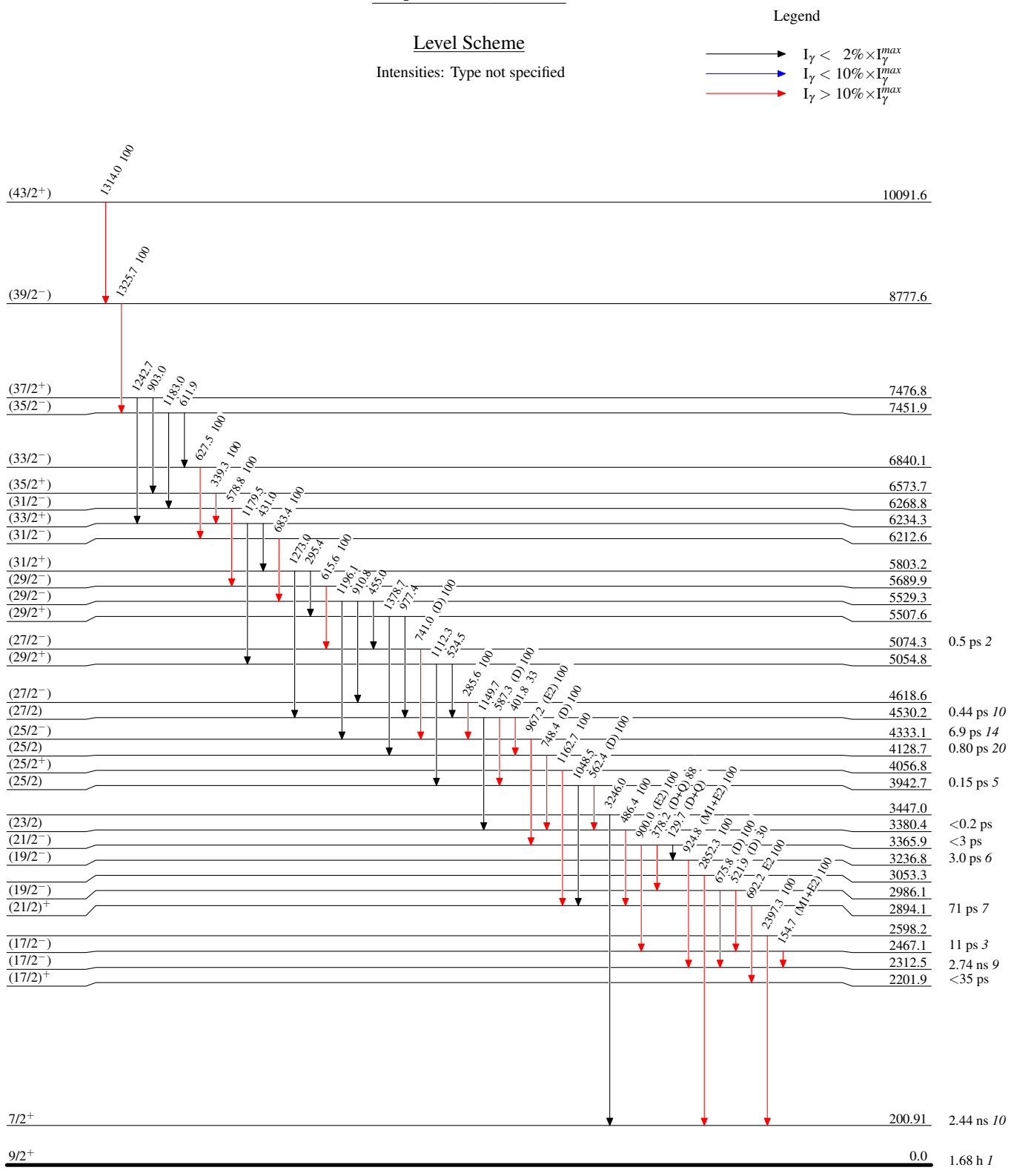
† From (HI,xnγ), unless indicated otherwise.
‡ From (HI,xnγ) and adopted parities, unless indicated otherwise.
# Value is given only where needed for B(E2)(W.u.) or B(M1)(W.u.) calculation.
@ Weighted average from (HI,xnγ) and $\varepsilon+\beta^+$ decay (2.6 m).
& From $\varepsilon+\beta^+$ decay (2.6 m).
a Additional information 1.

$^{87}_{40}Zr_{47}$-7

Adopted Levels, Gammas

Level Scheme

Intensities: Type not specified

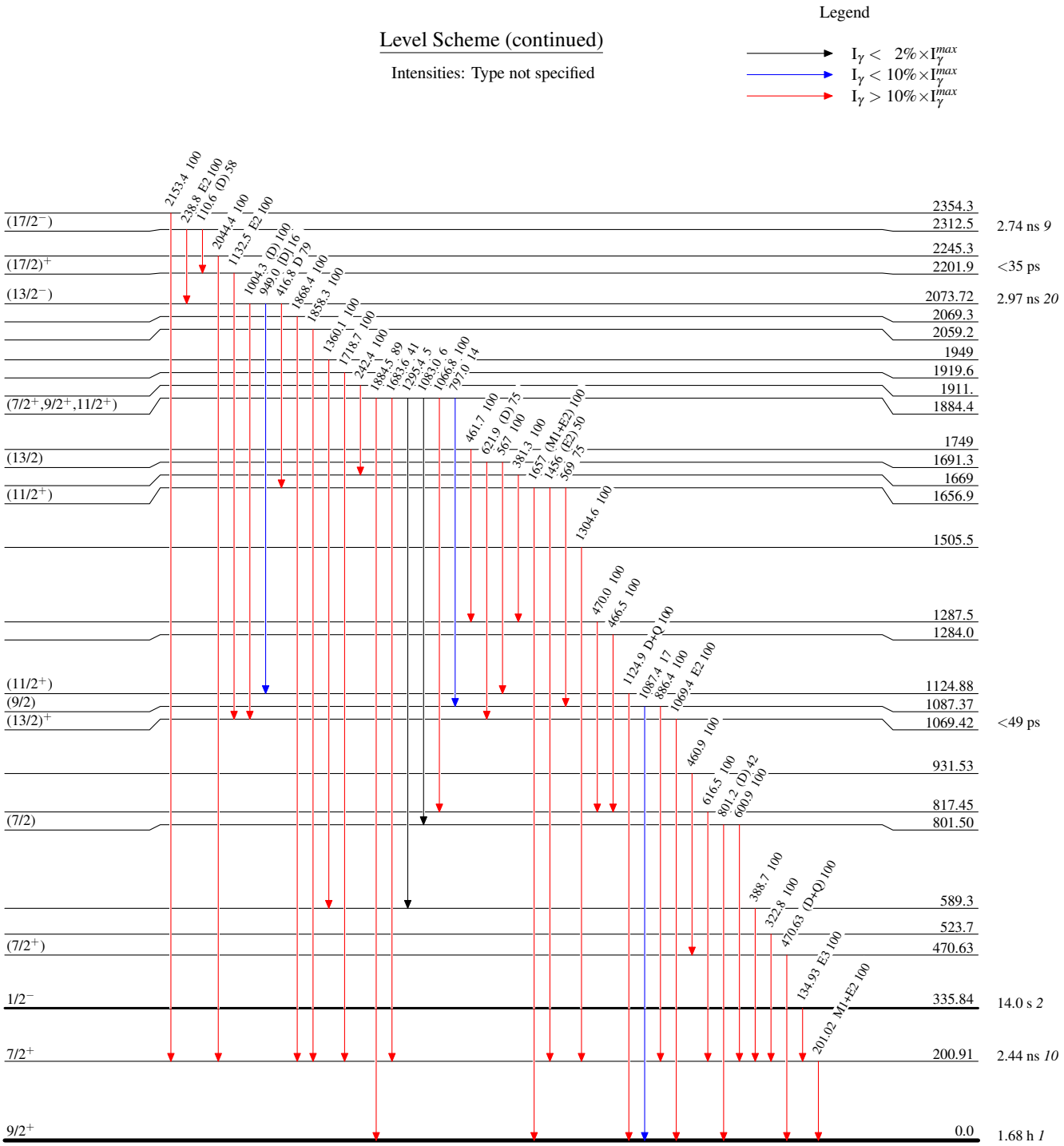


$^{87}_{40}Zr_{47}$

Adopted Levels, Gammas

Level Scheme (continued)

Intensities: Type not specified



$^{87}_{40}Zr_{47}$