(HI,xnγ)

History

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

1978Ar19: ^{86}Sr(α,3nγ), E_α=21 MeV and 51 MeV. Measured $\gamma\gamma$ coincidences and γ angular distribution; levels to 5100 keV. Level lifetimes measured by γ(t) between beam pulses.
1978Ki06: ^{84}Sr(α,nγ), E_α=16.8 MeV. Measured $\gamma\gamma$ coincidences and γ angular distribution.
1986Wa25: ^{74}Ge(^{18}O,5nγ), E(^{18}O)=60 MeV, measured lifetimes using recoil-distance method.
1999Zh18: ^{59}Co(^{32}S,3pnγ), E(^{32}S)=118 MeV. Measured γ singles, $\gamma\gamma$ coincidences, $\gamma\gamma(\theta)$ DCO with array of seven Ge detectors each with Compton suppression.

^{87}Zr Levels

E(level)	J^π †	$T_{1/2}$ ‡	Comments
0.0	$9/2^+$ &		
200.8 *2*	$7/2^+$ &	2.44 [a] ns *10*	
335.6 *2*	$1/2^-$ &		
470.7 *2*	$(7/2^+)$		
801.4 *2*	$(7/2^+)$		
931.6 [@] *3*			
1069.4 *2*	$(13/2)^+$	<49 ps	$T_{1/2}$: also, 2.73 ns (1978Ar19), but probably from decay of 2312 level.
1087.3 *2*	$(9/2^+)$		
1124.88 *20*	$(11/2^+)$		
1657 *1*	$(11/2^+)$		
1691.3 *3*	$(13/2^+)$		
2073.7 *3*	$(13/2^-)$	2.97 [a] ns *20*	
2201.9 *3*	$(17/2)^+$	<35 ps	$T_{1/2}$: also 2.73 ns (1978Ar19), but probably from decay of 2312 level.
2312.5 *4*	$(17/2^-)$	2.74 ns *9*	$T_{1/2}$: average of 2.73 ns 7 and 2.94 ns 20 from 1978Ar19 and 2.1 ns 4 from 1986Wa25.
2467.2 *4*	$(17/2^-)$	11 ps *3*	
2617?			
2894.1 *11*	$(21/2^+)$	71 ps *7*	
2988.8 *7*	$(19/2^-)$		
3237.3 *9*	$(19/2^-)$	3.0 ps *6*	
3367.1 *8*	$(21/2^-)$	<3 ps	
3380.4 *13*	$(23/2^+)$	<0.2 [a] ps	
3942.7 *13*	$(25/2^+)$	0.15 [a] ps *5*	
4056.8 [#] *15*	$(25/2^+)$		
4128.7 *15*	$(25/2^+)$	0.80 [a] ps *20*	
4334.3 *13*	$(25/2^-)$	6.9 ps *14*	
4530.2 *14*	$(27/2^+)$	0.44 [a] ps *10*	
4619.7 [#] *15*	$(27/2^-)$		
5054.8 [#] *15*	$(29/2^+)$		
5075.4 *15*	$(27/2^-)$	0.5 [a] ps *2*	
5507.6 [#] *15*	$(29/2^+)$		
5530.4 [#] *15*	$(29/2^-)$		
5691.0 [#] *17*	$(29/2^-)$		
5803.2 [#] *16*	$(31/2^+)$		
6213.7 [#] *17*	$(31/2^-)$		
6234.3 [#] *16*	$(33/2^+)$		
6269.9 [#] *19*	$(31/2^-)$		
6573.6 [#] *19*	$(35/2^+)$		
6841.2 [#] *19*	$(33/2^-)$		

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(HI,xnγ) (continued)

^{87}Zr Levels (continued)

E(level)	Jπ†
7453.0# *19*	(35/2⁻)
7476.8?# *18*	(37/2⁺)
8778.7# *22*	(39/2⁻)
10092.7# *24*	(43/2⁻)

† For levels reported by 1978Ar19, deduced on the basis of excitation functions and $\gamma(\theta)$ and, for quadrupole transitions, from RUL. From 1999Zh18 for other levels, unless noted as "From Adopted Levels".
‡ From 1986Wa25, unless indicated otherwise.
# Reported only by 1999Zh18.
@ Reported only by 1978Ki06.
& From Adopted Levels.
a From 1978Ar19, γ(t) between beam pulses.

γ(^{87}Zr)

coin: from 1978Ki06 and 1978Ar19.

Eγ†	Iγ‡	Ei(level)	J_i^π	Ef	J_f^π	Mult.#	δ	αb	Comments
110.6 *10*	15	2312.5	(17/2⁻)	2201.9	(17/2)⁺	(D)			Mult.: A_2=+0.42 *2*, A_4=+0.03 *3* (1978Ar19). Mult.: From $\gamma(\theta)$. Tentative J^π assignment is consistent with E1.
129.7		3367.1	(21/2⁻)	3237.3	(19/2⁻)	(D+Q)			
134.8 *2*	1.3	335.6	1/2⁻	200.8	7/2⁺				
154.7 *2*	15	2467.2	(17/2⁻)	2312.5	(17/2⁻)	(M1+E2)		0.09 *4*	α(K)=0.08 *3*; α(L)=0.011 *5*; α(M)=0.0018 *8* α(N)=0.00025 *10*; α(O)=1.5×10⁻⁵ *5* Mult.: A_2=+0.42 *1*, A_4=+0.02 *2* (1978Ar19).
x169.7									Eγ: From 1978Ar19; states that this is a doublet partly belonging to ^{87}Y.
200.9 *2*	12.9	200.8	7/2⁺	0.0	9/2⁺	M1+E2&	−0.35	0.0371	α(K)=0.0325 *5*; α(L)=0.00387 *6*; α(M)=0.000674 *10* α(N)=9.45×10⁻⁵ *14*; α(O)=6.20×10⁻⁶ *9* Mult.: A_2=+0.17 *2*, A_4=−0.02 *4* (1978Ar19). δ: −0.35 or −2.6 from (HI,xnγ) (1978Ar19), but α(exp) determined in isomeric decay deviates from α for δ=−2.6 by more than one standard deviation.
238.8 *2*	26	2312.5	(17/2⁻)	2073.7	(13/2⁻)	E2		0.0478	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* Mult.: A_2=+0.30 *2*, A_4=−0.14 *3* (1978Ar19).
285.6		4619.7	(27/2⁻)	4334.3	(25/2⁻)				
295.4		5803.2	(31/2⁺)	5507.6	(29/2⁺)				

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(HI,xnγ) (continued)

γ(^{87}Zr) (continued)

E_γ[†]	I_γ[‡]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[#]	α[b]	Comments
339.3		6573.6	(35/2$^+$)	6234.3	(33/2$^+$)			
378.2	7	3367.1	(21/2$^-$)	2988.8	(19/2$^-$)	(D+Q)		Mult.: A_2=−0.30 *2*, A_4=0 (1978Ar19).
401.8	3	4530.2	(27/2$^+$)	4128.7	(25/2$^+$)			
415[c]	9	2617?		2201.9	(17/2)$^+$			E_γ,I_γ: reported only by 1978Ar19. A_2=+0.2 *1*, A_4=0 (1978Ar19).
416.8 *2*	15	2073.7	(13/2$^-$)	1657	(11/2$^+$)	D		Mult.: A_2=−0.34 *12*, A_4=0 (1978Ar19). Mult.: from γ(θ), mult is definitely not Q. From tentative JPI likely E1.
431.0		6234.3	(33/2$^+$)	5803.2	(31/2$^+$)			
455.0		5530.4	(29/2$^-$)	5075.4	(27/2$^-$)			
460.9 *2*		931.6		470.7	(7/2$^+$)			E_γ: observed only by 1978Ki06.
470.7 *2*	3	470.7	(7/2$^+$)	0.0	9/2$^+$	(D+Q)		Mult.: A_2=−0.06 *2*, A_4=0 (1978Ar19). δ: δ(E2/M1)=−0.04 or −8 (1978Ar19).
486.4	26	3380.4	(23/2$^+$)	2894.1	(21/2$^+$)	(D)		Mult.: A_2=−0.34 *4*, A_4=0 (1978Ar19) But possible doublet with γ from ^{87}Y.
521.9	3	2988.8	(19/2$^-$)	2467.2	(17/2$^-$)	(D)		Mult.: A_2=−0.35 *20*, A_4=0 (1978Ar19).
524.5		5054.8	(29/2$^+$)	4530.2	(27/2$^+$)			
562.4	11	3942.7	(25/2$^+$)	3380.4	(23/2$^+$)	(D)		Mult.: A_2=−0.15 *11*, A_4=0 (1978Ar19).
567	4	1691.3	(13/2$^+$)	1124.88	(11/2$^+$)			
569 *1*	6	1657	(11/2$^+$)	1087.3	(9/2$^+$)			
578.8		6269.9	(31/2$^-$)	5691.0	(29/2$^-$)			
587.3	9	4530.2	(27/2$^+$)	3942.7	(25/2$^+$)	(D)		
600.9 *2*	3	801.4	(7/2$^+$)	200.8	7/2$^+$			A_2=+0.08 *13*, A_4=0 (1978Ar19).
611.9		7453.0	(35/2$^-$)	6841.2	(33/2$^-$)			
615.6		5691.0	(29/2$^-$)	5075.4	(27/2$^-$)			
621.9 *2*	3	1691.3	(13/2$^+$)	1069.4	(13/2)$^+$	(D)[@]		Mult.: A_2=+0.45 *5*, A_4=0 (1978Ar19).
627.5		6841.2	(33/2$^-$)	6213.7	(31/2$^-$)			
675.8	10	2988.8	(19/2$^-$)	2312.5	(17/2$^-$)	(D)		E_γ: Used the unweighted average of 1978Ar19 and 1999Zh18 as the 673.4γ from 1978Ki06 is not only discrepant, but unplaced by the authors. Mult.: A_2=−0.16 *10*, A_4=0 (1978Ar19).
683.4		6213.7	(31/2$^-$)	5530.4	(29/2$^-$)			
692.2	34	2894.1	(21/2$^+$)	2201.9	(17/2)$^+$	E2	1.67×10^{-3}	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* Mult.: A_2=+0.34 *3*, A_4=−0.11 *5* (1978Ar19).
741.0	8	5075.4	(27/2$^-$)	4334.3	(25/2$^-$)	(D)		Mult.: A_2=−0.4 *1*, A_4=0 (1978Ar19).
748.4	7	4128.7	(25/2$^+$)	3380.4	(23/2$^+$)	(D)		Mult.: A_2=−0.5 *2*, A_4=0 (1978Ar19).
770.6[c]	4	3237.3	(19/2$^-$)	2467.2	(17/2$^-$)	(D)		Mult.: A_2=−0.9 *2*, A_4=0 (1978Ar19).
801.2 *2*	1.6	801.4	(7/2$^+$)	0.0	9/2$^+$	(D)		I_γ: from I_γ(801)=6 and I_γ(601)=11 from 1978Ki06, 1978Ar19 give I_γ(600) <4. Mult.: A_2=−0.2 *2*, A_4=0 (1978Ar19).
886.4 *2*	12	1087.3	(9/2$^+$)	200.8	7/2$^+$			A_2=−0.36 *9*, A_4=0 (1978Ar19).
900.0	8	3367.1	(21/2$^-$)	2467.2	(17/2$^-$)	(E2)[&]	8.60×10^{-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* Mult.: A_2=+0.4 *2*, A_4=−0.2 *3* (1978Ar19).
903.0[c]		7476.8?	(37/2$^+$)	6573.6	(35/2$^+$)			
910.8		5530.4	(29/2$^-$)	4619.7	(27/2$^-$)			
924.8	8	3237.3	(19/2$^-$)	2312.5	(17/2$^-$)	(M1+E2)[&]	7.98×10^{-4}	α(K)=0.000705 *10*; α(L)=7.76×10^{-5} *12*; α(M)=1.345×10^{-5} *21* α(N)=1.91×10^{-6} *3*; α(O)=1.359×10^{-7} *19* Mult.: A_2=+0.34 *10*, A_4=0 (1978Ar19).

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(HI,xnγ) (continued)

γ(^{87}Zr) (continued)

E_γ[†]	I_γ[‡]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[#]	α[b]	Comments
949.0	3	2073.7	(13/2⁻)	1124.88	(11/2⁺)	[D]		Mult.: A_2=−0.6 *4*, A_4=0 (1978Ar19).
967.2	12	4334.3	(25/2⁻)	3367.1	(21/2⁻)	(E2)	7.25×10^{-4}	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* Mult.: A_2=+0.26 *10*, A_4=−0.35 *15* (1978Ar19).
977.4		5507.6	(29/2⁺)	4530.2	(27/2⁺)			
1004.3 *2*	19	2073.7	(13/2⁻)	1069.4	(13/2)⁺	(D)		
1048.5		3942.7	(25/2⁺)	2894.1	(21/2⁺)			
1069.4 *2*	100	1069.4	(13/2)⁺	0.0	9/2⁺	E2[&]	5.76×10^{-4}	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* Mult.: A_2=+0.38 *3*, A_4=−0.04 *5* (1978Ar19). Mult.: Stretched Q from angular distribution and M2 excluded by RUL.
1087.4 *2*	2	1087.3	(9/2⁺)	0.0	9/2⁺			
1112.3		5054.8	(29/2⁺)	3942.7	(25/2⁺)			
1124.9 *2*	7	1124.88	(11/2⁺)	0.0	9/2⁺	D+Q[a]		Mult.: A_2=−0.65 *22*, A_4=+0.44 *21* (1978Ar19).
1132.5 *2*	67	2201.9	(17/2)⁺	1069.4	(13/2)⁺	E2	5.09×10^{-4}	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* Mult.: A_2=+0.28 *3*, A_4=−0.11 *5* (1978Ar19).
1149.7		4530.2	(27/2⁺)	3380.4	(23/2⁺)			
1162.7		4056.8	(25/2⁺)	2894.1	(21/2⁺)			
1179.5		6234.3	(33/2⁺)	5054.8	(29/2⁺)			
1183.0		7453.0	(35/2⁻)	6269.9	(31/2⁻)			
1196.1		5530.4	(29/2⁻)	4334.3	(25/2⁻)			
1242.7[c]		7476.8?	(37/2⁺)	6234.3	(33/2⁺)			
1273.0		5803.2	(31/2⁺)	4530.2	(27/2⁺)			
1314.0		10092.7	(43/2⁻)	8778.7	(39/2⁻)			
1325.7		8778.7	(39/2⁻)	7453.0	(35/2⁻)			
1378.7		5507.6	(29/2⁺)	4128.7	(25/2⁺)			
1456 *1*	4	1657	(11/2⁺)	200.8	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* Mult.: A_2=+0.19 *18*, A_4=0 (1978Ar19).
1657 *1*	8	1657	(11/2⁺)	0.0	9/2⁺	(M1+E2)[a]	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* Mult.: A_2=−0.56 *22*, A_4=0 (1978Ar19).

[†] From 1978Ki06 if an uncertainty is given; otherwise from an unweighted average of the values from 1978Ar19 and 1999Zh18, neither of whom give uncertainties.
[‡] From 1978Ar19, measured in ^{86}Sr(α,3nγ) at E_α=51 MeV.
[#] From γ(θ) (1978Ar19).
[@] γ(θ) allows a small δ.
[&] From γ(θ) and RUL.

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(HI,xnγ) (continued)

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

[a] $\gamma(\theta)$ gives $\Delta J=-1$ with large δ.
[b] Additional information 1.
[c] Placement of transition in the level scheme is uncertain.
[x] γ ray not placed in level scheme.

(HI,xnγ)

Level Scheme

Intensities: Type not specified

Legend

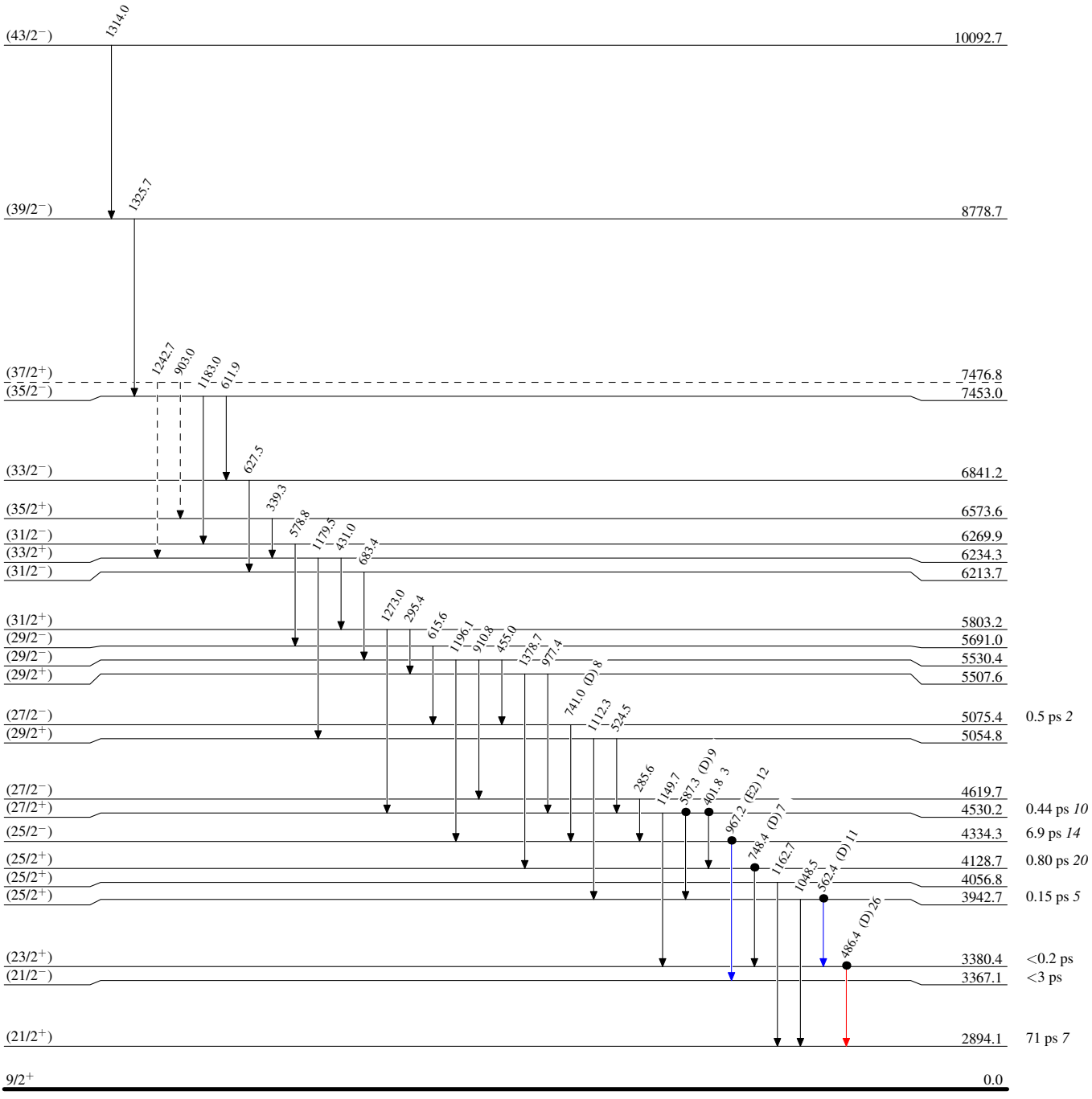
$I_\gamma < 2\% \times I_\gamma^{max}$

$I_\gamma < 10\% \times I_\gamma^{max}$

$I_\gamma > 10\% \times I_\gamma^{max}$

γ Decay (Uncertain)

Coincidence

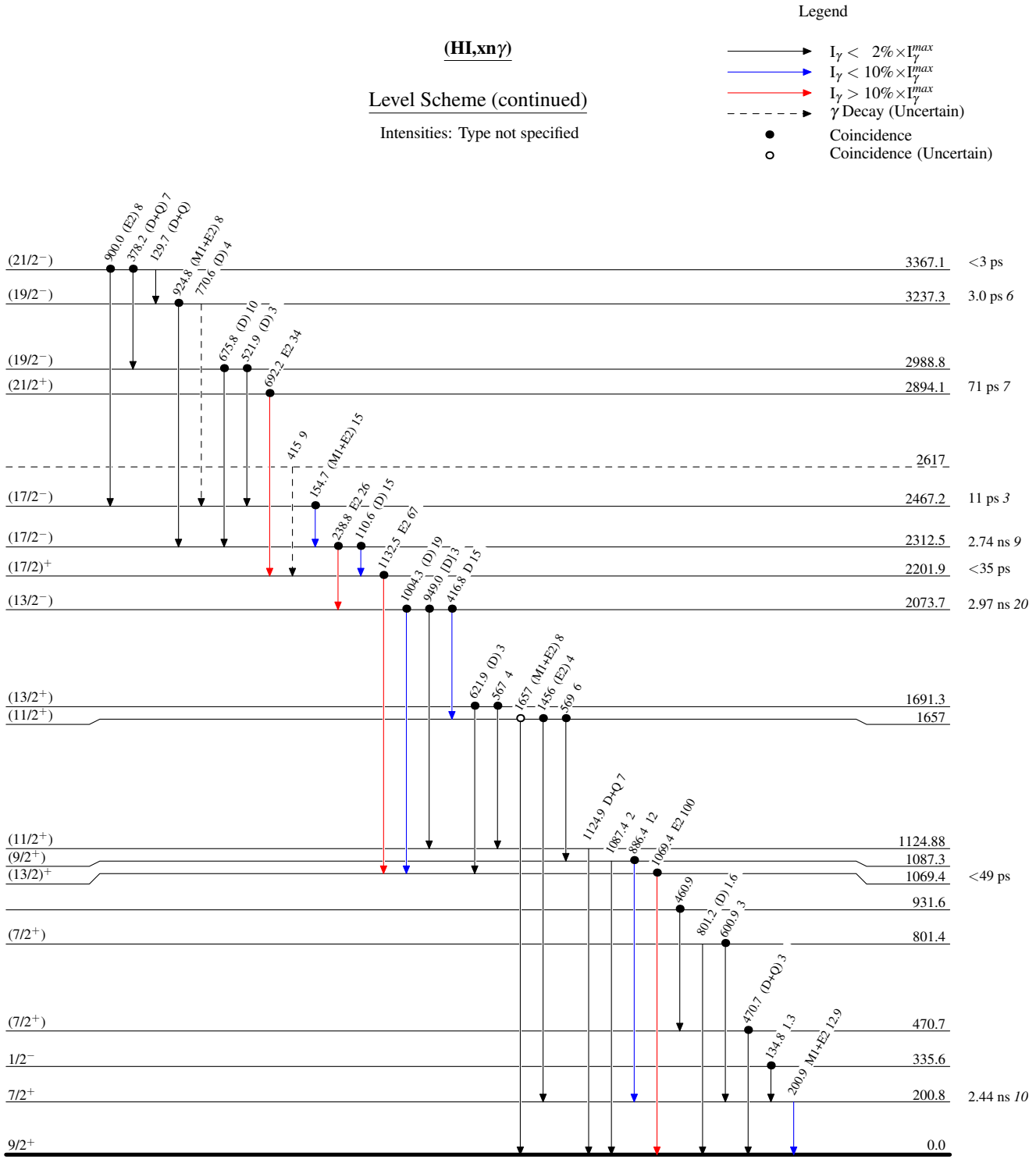


$^{87}_{40}Zr_{47}$

(HI,xnγ)

Level Scheme (continued)

Intensities: Type not specified



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