Adopted Levels, Gammas

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Balraj Singh and Jun Chen	NDS 158, 1 (2019)	16-May-2019

Q(β^-)=1598.2 *17*; S(n)=9182.4 *19*; S(p)=8843 *3*; Q(α)=−6388.0 *22* 2017Wa10
S(2n)=15702.8 *19*, S(2p)=21566.2 *22*, Q(2β^-)=1253 *4* (2017Wa10).
Mass measurement: 2007Gu09.
Additional information 1.

^{73}Ga Levels

The γ cascades are from 2009St12.

Cross Reference (XREF) Flags

A	^{73}Zn β^- decay (24.5 s)	D	^{74}Ge(d,^{3}He),(pol d,^{3}He)
B	^{70}Zn(α,p)	E	^{238}U(^{76}Ge,Xγ)
C	^{71}Ga(t,p)	F	Coulomb excitation

E(level)[†]	J$^\pi$	T$_{1/2}$[a]	XREF	Comments
0.0[‡#]	1/2$^-$	4.86 h *3*	A EF	%β^-=100 μ=+0.209 *2* (2010Ch16,2014StZZ) δ<r^2>(^{71}Ga,^{73}Ga)=+0.243 fm^2 *4*(stat) *42*(syst) (2012Pr11). Isotope shift $\delta\nu$(^{71}Ga,^{73}Ga)=+15.5 MHz *15*(stat) *40*(syst) (2012Pr11). J$^\pi$: spin from collinear laser spectroscopy (2010Ch16, observation of only three lines in the hyperfine spectrum gives unambiguous 1/2 assignment); parity from allowed β^- decay (log *ft*=5.3 to 1/2$^-$, 1132 level in ^{73}Ge. Considering J$^\pi$(g.s.)=3/2$^-$ for neighboring odd-A Ga isotopes, the anomalous J$^\pi$(g.s.)=1/2$^-$ of ^{73}Ga suggests a changing shell structure from N=42 onwards and strong influence of πf$_{5/2}$ orbital in the g.s. wave function. Previously adopted J$^\pi$(g.s.)=3/2$^-$, based on L-transfers in (t,p) and (d,^{3}He), corresponds to an almost degenerate level (2010Ch16), a conclusion also supported by 2010Di14 in Coulomb excitation. T$_{1/2}$: from 1976Fo07. Others: 4.91 h *5* (1970Wa21), 4.85 h *10* (1958Yt22), 1960Ku04, 1973McZP. μ: from collinear laser spectroscopy (2010Ch16). Note that in 2016St14 evaluation, Q=+0.209 *2* from 2010Ch16 is incorrectly listed.
<0.3[‡#]	3/2$^-$	<200 ms	ABCDEF	%β^-=?; %IT=? E(level): from <0.3 keV, deduced by 2017Ve05 in the study of ^{73}Zn decay. Other estimates: 0.4 keV *4* (2010Di14, Coulomb excitation); 0.075-1 keV (2010Ch16, 0.075 keV limit from assumption of T$_{1/2}$>200 ms based on their experimental conditions, and by assuming same B(M1) as for 3/2$^-$ to 1/2$^-$ transition in ^{71}Ga; 1 keV cited by 2010Ch16 from theoretical estimate in 2009St12, but perusal of 2009St12 suggests a possibility of 1/2$^-$ g.s. and a closely-spaced 3/2$^-$ but does not give the spacing of 1 keV); 9 keV (2011Ji08, shell-model calculations, 1/2$^-$ g.s. is reproduced). T$_{1/2}$: expected to be <200 ms, as a 3/2$^-$ level is not seen in the hyperfine structure study by 2010Ch16 who mention that due to slow release of Ga from their ion source and the accumulation time in the cooler, the half-life of the 3/2$^-$ state would have to be >200 ms to be observed in their study, assuming equal production of 1/2$^-$ and 3/2$^-$ states. J$^\pi$: L(t,p)=0 from 3/2$^-$; L(d,^{3}He)=1 from 0$^+$ together with vector analyzing power.
198.95 *20*	5/2$^-$		AB DEF	J$^\pi$: 5/2$^-$,7/2$^-$ from L(d,^{3}He)=3; 7/2$^-$ is ruled out by population in Coulomb excitation (2010Di14); J=5/2 is also from measured polarization asymmetry in 2008KaZT in (d,^{3}He).

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Adopted Levels, Gammas (continued)

^{73}Ga Levels (continued)

E(level)[†]	Jπ	$T_{1/2}$[a]	XREF	Comments
217.84 *10*	3/2⁻	47 ps *6*	ABCDEF	Jπ: L(t,p)=0 from 3/2⁻ and L(d,^{3}He)=1 from 0⁺.
496.10[b] *18*	5/2⁻,7/2⁻	22 ps *6*	ABCDEF	Jπ: L(d,^{3}He)=3 from 0⁺ and L(t,p)=2 from 3/2⁻. Jπ=7/2⁻ from measured polarization asymmetry in 2008KaZT in (d,^{3}He). Direct population of the 496-keV state via Coulomb excitation from 1/2⁻ ground state, however, limits the spin of this state to be 5/2⁻ (2010Di14).
651.16[d] *20*	(7/2⁻)&		DEF	XREF: D(?).
911.14 *18*	3/2⁻	≤28 ps	ABCD	Jπ: L(t,p)=0 from 3/2⁻ and L(d,^{3}He)=1 from 0⁺.
952.30 *19*	7/2⁻		BCDE	Jπ: L(d,^{3}He)=3 from 0⁺ and polarization asymmetry; L(t,p)=2 from 3/2⁻.
1113.7 *3*	1/2⁻		ABCD	Jπ: L(d,^{3}He)=1 from 0⁺ and polarization asymmetry.
1232.03[c] *23*	9/2⁺		BCDE	Jπ: L(d,^{3}He)=4 from 0⁺ and polarization asymmetry.
1393.17 *21*	(5/2⁻)		A c F	Jπ: proposed by 2010Di14 in Coulomb excitation based on observed population compatible with single-step Coulomb excitation from 1/2⁻ g.s.; L(t,p)=4 from 3/2⁻ for a level at 1396 *3*.
1397.5[b] *3*	(9/2⁻)&		c E	Jπ: L(t,p)=4 from 3/2⁻ for a level at 1396 *3*.
1529 *3*	5/2⁻,7/2⁻@		BCD	E(level): weighted average of 1528 *3* from (t,p) and 1534 *7* from (d,^{3}He). Jπ: L(d,^{3}He)=3 from 0⁺.
1578 *3*	(5/2⁻)		BC	E(level): weighted average of 1578 *3* from (t,p) and 1576 *6* from (α,p). Jπ: from comparisons of measured σ(θ) in ^{70}Zn(α,p) with those for states of known J^π in ^{68}Zn(α,p).
1596.4[d] *3*	(11/2⁻)&		E	
1618 *3*	5/2⁻,7/2⁻		BCD	E(level): weighted average of 1618 *3* from (t,p) and 1620 *7* from (d,^{3}He). Jπ: L(d,^{3}He)=3 from 0⁺.
1692.93 *20*	(1/2⁻,3/2⁻)		A	Jπ: 1475.1γ and 781.7γ to 3/2⁻, 1196.9γ to 5/2⁻,7/2⁻; direct β⁻ feeding from 1/2⁻ parent.
1700 *3*	(1/2 to 7/2)⁻		C	Jπ: L(t,p)=2 from 3/2⁻.
1721.60 *22*	(1/2⁻,3/2⁻)		A D	XREF: D(?). Jπ: L(d,^{3}He)=1 from 0⁺ for an uncertain level at 1716 *10*.
1772 *3*	(5/2,7/2)⁻		CD	E(level): weighted average of 1771 *3* from (t,p) and 1777 *7* from (d,^{3}He). Jπ: L(d,^{3}He)=(3) from 0⁺ and L(t,p)=2 from 3/2⁻.
1800 *3*	(3/2⁻)		BC	XREF: B(1812). E(level): from (t,p). Other: 1812 *8* from (α,p). Jπ: L(t,p)=(0) from 3/2⁻.
1813.4[c] *3*	(13/2⁺)&		E	
1924.70 *21*	1/2⁻,3/2⁻		ABCD	XREF: B(1939). Jπ: L(d,^{3}He)=1 from 0⁺ and L(t,p)=2 from 3/2⁻. But 5/2 preferred from cross section in (α,p) for a level at 1939 *8*.
1952 *3*	(1/2 to 7/2)⁻		C	Jπ: L(t,p)=2 from 3/2⁻.
1980.09 *21*	(1/2⁻,3/2⁻)		A	Jπ: 1761.6γ and 1069.7γ to 3/2⁻, 1483.9γ to 5/2⁻,7/2⁻; direct β⁻ feeding from 1/2⁻ parent.
2001 *3*	(1/2 to 7/2)⁻		C	Jπ: L(t,p)=2 from 3/2⁻.
2067 *3*	(3/2 to 9/2)⁺		C	Jπ: L(t,p)=3 from 3/2⁻.
2067	7/2⁻		D	Jπ: L(d,^{3}He)=3 from 0⁺ and polarization asymmetry.
2109.17 *20*	3/2⁻		A C	Jπ: L(t,p)=0(+2) from 3/2⁻.
2160 *3*	(1/2 to 7/2)⁻		C	Jπ: L(t,p)=2 from 3/2⁻.
2221 *3*	(1/2 to 7/2)⁻		C	Jπ: L(t,p)=2 from 3/2⁻.
2246.3 *3*	(1/2⁻,3/2⁻)		A D	XREF: D(?). Jπ: L(d,^{3}He)=1 from 0⁺ for a level at 2249 *6*.
2277 *3*	(5/2 to 11/2)⁻		C	Jπ: L(t,p)=4 from 3/2⁻.
2380 *3*	(5/2 to 11/2)⁻		C	Jπ: L(t,p)=4 from 3/2⁻.
2380	1/2⁻		D	Jπ: L(d,^{3}He)=1 from 0⁺ and polarization asymmetry.
2411 *3*	(1/2 to 7/2)(⁻)		C	Jπ: L(t,p)=(2) from 3/2⁻.
2466.6 *3*	(3/2⁺)		A CD	Jπ: L(t,p)=(3) from 3/2⁻; direct β⁻ feeding from 1/2⁻ parent.
2498 *3*	(3/2 to 9/2)⁺		C	Jπ: L(t,p)=3 from 3/2⁻.
2527.9[b] *4*	(13/2⁻)&		E	

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Adopted Levels, Gammas (continued)

^{73}Ga Levels (continued)

E(level)[†]	Jπ	XREF	Comments
2582 *6*	(1/2 to 7/2)$^-$	C	Jπ: L(t,p)=2 from 3/2$^-$.
2718.2[c] *4*	(17/2$^+$)[&]	E	
2726 *6*	(5/2$^-$,7/2$^-$)	C	Jπ: L(t,p)=(2+4) from 3/2$^-$.
2761.2[d] *4*	(15/2$^-$)[&]	E	
2770.49 *23*	(1/2$^-$,3/2$^-$)	A	
2814.4 *6*		A	
2986.9 *3*	(1/2,3/2)$^-$	A	Jπ: 2787.9γ to 5/2$^-$, 1873.0γ to 1/2$^-$; allowed β^- feeding from 1/2$^-$ parent.
3099.1 *5*	(1/2$^-$,3/2$^-$)	A	Jπ: direct β^- feeding from 1/2$^-$; 2900.2γ to 5/2$^-$.
3397.2[b] *6*	(17/2$^-$)[&]	E	
3828.3[d] *6*	(19/2$^-$)[&]	E	
3973.3[c] *4*	(21/2$^+$)[&]	E	
5292.5[c] *7*	(25/2$^+$)[&]	E	

[†] From a least-squares fit to γ-ray energies for levels populated in γ-ray studies. Several g.s. transitions could decay to either the g.s. or the level at <0.3 keV. In the fitting procedure final level energy is assumed as 0.15 keV *15* to cover the range up to 0.3 keV.

[‡] Existence of a level near the g.s. is deduced from the observed Doppler-broadening of 199.2γ from the 199.2, 5/2$^-$ level in Coulomb excitation (2010Di14), which restricts the lifetime of the 5/2$^-$ level considerably smaller than 3.5 ns (maximum time-of-flight between target and detector) consistent with the lifetime=3.3 ps from Weisskopf estimate for a pure 199-keV M1 transition but not with 13 ns *2* from measured B(E2)(W.u.)=11 *2* for the assumption of a pure E2 to 1/2$^-$ g.s. Energy of the closely-spaced level near the g.s. is estimated as <0.3 keV from 2017Ve05 in ^{73}Zn β^- decay based on a search for energy differences between γ cascades deexciting the same level but proceeding through distinct paths, and also based on a search for doublets in γ-ray spectra. The energy of this level is also estimated by 2010Di14 as 0.4 keV *4* using the approach based on energy differences between γ cascades.

[#] Based on general systematics of half-lives of ground states and low-lying isomers, longer half-life activity of 4.86-h in ^{73}Ga is associated with the ground state, 1/2$^-$, although, an experimental evidence for an absolute positioning of the 1/2$^-$ and 3/2$^-$ states is lacking.

[@] (7/2) preferred from weak $\sigma(\alpha,p)$ compared with strong $\sigma(d,^3He)$.

[&] Proposed by 2009St12 in ^{238}U(^{76}Ge,Xγ) based on systematics of neighboring odd-A Ga isotopes and band structures.

[a] From $\beta\gamma\gamma$(t) in ^{73}Zn β^- decay (24.5 s) (2017Ve05) using the Advanced Time-Delayed method with an ultrafast plastic scintillator and $LaBr_3$(Ce) detector, unless otherwise noted.

[b] Seq.(A): γ cascade based on 5/2$^-$,7/2.

[c] Seq.(B): γ cascade based on 9/2$^+$.

[d] Seq.(C): γ cascade based on (7/2$^-$).

γ(^{73}Ga)

E_i(level)	J_i^π	E_γ[†]	I_γ[†]	E_f	J_f^π	Comments
198.95	5/2$^-$	198.8[@] *3*	100	<0.3	3/2$^-$	E_γ: weighted average of 198.4 *2* from ^{73}Zn β^- decay (24.5 s), 199.1 *2* from ^{238}U(^{76}Ge,Xγ), and 199.2 *5* from Coulomb excitation.
217.84	3/2$^-$	218.0 *2*	100	0.0	1/2$^-$	E_γ: weighted average of 217.8 *2* from ^{73}Zn β^- decay (24.5 s), 218.2 *2* from ^{238}U(^{76}Ge,Xγ), and 218.4 *6* from Coulomb excitation. The final level is g.s. based on data in Coulomb excitation.
496.10	5/2$^-$,7/2$^-$	278.2 *3*	6.8 *8*	217.84	3/2$^-$	E_γ: weighted average of 278.1 *3* from ^{73}Zn β^- decay (24.5 s) and 279.0 *7* from Coulomb excitation.
		297.3 *2*	0.8 *4*	198.95	5/2$^-$	E_γ: other: 298 *2* from Coulomb excitation (2010Di14).

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Adopted Levels, Gammas (continued)

γ(^{73}Ga) (continued)

E_i(level)	J_i^π	E_γ[†]	I_γ[†]	E_f	J_f^π	Comments
496.10	5/2$^-$,7/2$^-$	495.9[@] *2*	100 *7*	<0.3	3/2$^-$	E_γ: weighted average of 495.7 *2* from ^{73}Zn β^- decay (24.5 s), 496.2 *2* from ^{238}U(^{76}Ge,Xγ), and 495.8 *5* from Coulomb excitation.
651.16	(7/2$^-$)	155.0[‡] *5*	9[‡] *1*	496.10	5/2$^-$,7/2$^-$	
		433.0[‡] *5*	12[‡] *1*	217.84	3/2$^-$	E_γ: other: 434.0 *15* from Coulomb excitation (2010Di14).
		452.1[‡] *2*	100[‡] *4*	198.95	5/2$^-$	E_γ: other: 451.7 *11* from Coulomb excitation (2010Di14).
		651.2[‡@] *2*	57.8[‡] *5*	<0.3	3/2$^-$	E_γ: other: 651 *2* from Coulomb excitation (2010Di14).
911.14	3/2$^-$	415.2 *2*	6.3 *9*	496.10	5/2$^-$,7/2$^-$	
		693.4 *1*	22 *2*	217.84	3/2$^-$	
		910.8[#] *3*	100 *4*	<0.3	3/2$^-$	
952.30	7/2$^-$	456.2[‡] *2*	23.7[‡] *6*	496.10	5/2$^-$,7/2$^-$	
		734.2[‡] *2*	11.6[‡] *4*	217.84	3/2$^-$	
		753.3[‡] *2*	100[‡] *2*	198.95	5/2$^-$	
		952.4[‡] *2*	79.7[‡] *8*	<0.3	3/2$^-$	
1113.7	1/2$^-$	1113.5[#] *3*	100	<0.3	3/2$^-$	
1232.03	9/2$^+$	279.7[‡] *2*	100[‡]	952.30	7/2$^-$	
		580.9[‡] *2*	72.4[‡] *5*	651.16	(7/2$^-$)	
1393.17	(5/2$^-$)	482.2 *2*	11 *11*	911.14	3/2$^-$	
		1194.2 *4*	22 *11*	198.95	5/2$^-$	
		1392.9[#] *3*	100 *11*	<0.3	3/2$^-$	E_γ: other: 1395.1 *12* from Coulomb excitation.
1397.5	(9/2$^-$)	901.4[‡] *2*	100	496.10	5/2$^-$,7/2$^-$	
1596.4	(11/2$^-$)	945.2[‡] *2*	100	651.16	(7/2$^-$)	
1692.93	(1/2$^-$,3/2$^-$)	579.3[&] *3*	2 *2*	1113.7	1/2$^-$	
		781.7 *2*	19 *2*	911.14	3/2$^-$	
		1196.9 *3*	100 *15*	496.10	5/2$^-$,7/2$^-$	
		1475.1 *3*	48 *4*	217.84	3/2$^-$	
		1493.5[&] *6*	2 *2*	198.95	5/2$^-$	
		1692.8[#] *2*	50 *8*	0.0	1/2$^-$	
1721.60	(1/2$^-$,3/2$^-$)	608.4[&] *5*	3 *3*	1113.7	1/2$^-$	
		810.5 *4*	9 *3*	911.14	3/2$^-$	
		1504.0 *3*	19 *3*	217.84	3/2$^-$	
		1721.3[#] *2*	100 *9*	<0.3	3/2$^-$	
1813.4	(13/2$^+$)	581.4[‡] *2*	100	1232.03	9/2$^+$	
1924.70	1/2$^-$,3/2$^-$	1013.4 *4*	3 *1*	911.14	3/2$^-$	
		1428.6 *2*	25 *8*	496.10	5/2$^-$,7/2$^-$	
		1707.0 *4*	3 *1*	217.84	3/2$^-$	
		1726.0[&] *4*	1 *1*	198.95	5/2$^-$	
		1924.5[#] *2*	100 *8*	<0.3	3/2$^-$	
1980.09	(1/2$^-$,3/2$^-$)	586.6[&] *5*	2 *2*	1393.17	(5/2$^-$)	
		1069.7 *3*	3 *2*	911.14	3/2$^-$	
		1483.9 *3*	29 *3*	496.10	5/2$^-$,7/2$^-$	
		1761.6 *5*	10 *3*	217.84	3/2$^-$	
		1979.7[#] *2*	100 *8*	<0.3	3/2$^-$	
2109.17	3/2$^-$	716.1 *2*	5.1 *6*	1393.17	(5/2$^-$)	
		1197.7 *4*	82 *6*	911.14	3/2$^-$	
		1613.1 *2*	100 *6*	496.10	5/2$^-$,7/2$^-$	
		1891.3 *5*	5.1 *6*	217.84	3/2$^-$	
		2108.9[#] *2*	69 *8*	<0.3	3/2$^-$	
2246.3	(1/2$^-$,3/2$^-$)	2028.3 *5*	36 *9*	217.84	3/2$^-$	

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Adopted Levels, Gammas (continued)

γ(^{73}Ga) (continued)

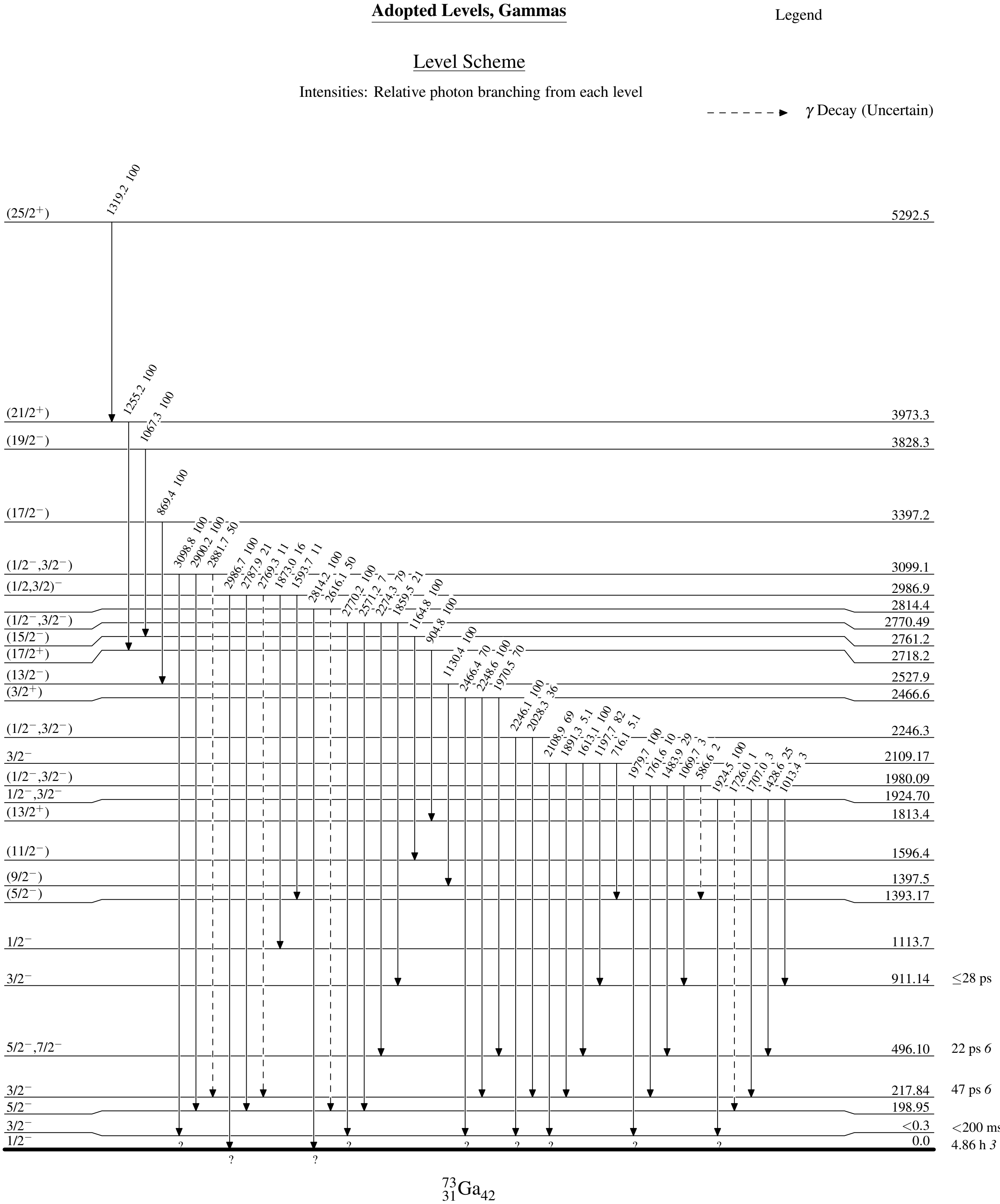
E_i(level)	J_i^π	E_γ[†]	I_γ[†]	E_f	J_f^π
2246.3	(1/2$^-$,3/2$^-$)	2246.1[#] *3*	100 *20*	<0.3	3/2$^-$
2466.6	(3/2$^+$)	1970.5 *7*	70 *30*	496.10	5/2$^-$,7/2$^-$
		2248.6 *5*	100 *30*	217.84	3/2$^-$
		2466.4[#] *3*	70 *30*	<0.3	3/2$^-$
2527.9	(13/2$^-$)	1130.4[‡] *2*	100	1397.5	(9/2$^-$)
2718.2	(17/2$^+$)	904.8[‡] *2*	100	1813.4	(13/2$^+$)
2761.2	(15/2$^-$)	1164.8[‡] *2*	100	1596.4	(11/2$^-$)
2770.49	(1/2$^-$,3/2$^-$)	1859.5 *3*	21 *7*	911.14	3/2$^-$
		2274.3 *3*	79 *7*	496.10	5/2$^-$,7/2$^-$
		2571.2 *7*	7 *7*	198.95	5/2$^-$
		2770.2[#] *3*	100 *20*	<0.3	3/2$^-$
2814.4		2616.1[&] *5*	50 *50*	198.95	5/2$^-$
		2814.2[#] *5*	100 *50*	0.0	1/2$^-$
2986.9	(1/2,3/2)$^-$	1593.7 *5*	11 *5*	1393.17	(5/2$^-$)
		1873.0 *5*	16 *5*	1113.7	1/2$^-$
		2769.3[&] *5*	11 *5*	217.84	3/2$^-$
		2787.9 *4*	21 *5*	198.95	5/2$^-$
		2986.7[#] *3*	100 *10*	0.0	1/2$^-$
3099.1	(1/2$^-$,3/2$^-$)	2881.7[&] *5*	50 *50*	217.84	3/2$^-$
		2900.2 *5*	100 *50*	198.95	5/2$^-$
		3098.8[#] *6*	100 *50*	<0.3	3/2$^-$
3397.2	(17/2$^-$)	869.4[‡] *5*	100	2527.9	(13/2$^-$)
3828.3	(19/2$^-$)	1067.3[‡] *5*	100	2761.2	(15/2$^-$)
3973.3	(21/2$^+$)	1255.2[‡] *2*	100	2718.2	(17/2$^+$)
5292.5	(25/2$^+$)	1319.2[‡] *5*	100	3973.3	(21/2$^+$)

[†] From ^{73}Zn β^- decay (24.5 s), unless otherwise noted.
[‡] From ^{238}U(^{76}Ge,Xγ) (2009St12).
[#] Final level could be the g.s. and/or closely-spaced level at <0.3 keV according to data in ^{73}Zn β^- decay (24.5 s) (2017Ve05). In the least-squares fitting procedure, the final level is assumed to be at 0.15 keV *15* to cover the range up to 0.3 keV.
[@] Final level is <0.3 keV, based on data in Coulomb excitation (2010Di14). In the least-squares fitting procedure, the final level is assumed at 0.15 keV *15*.
[&] Placement of transition in the level scheme is uncertain.

Adopted Levels, Gammas

Level Scheme

Intensities: Relative photon branching from each level



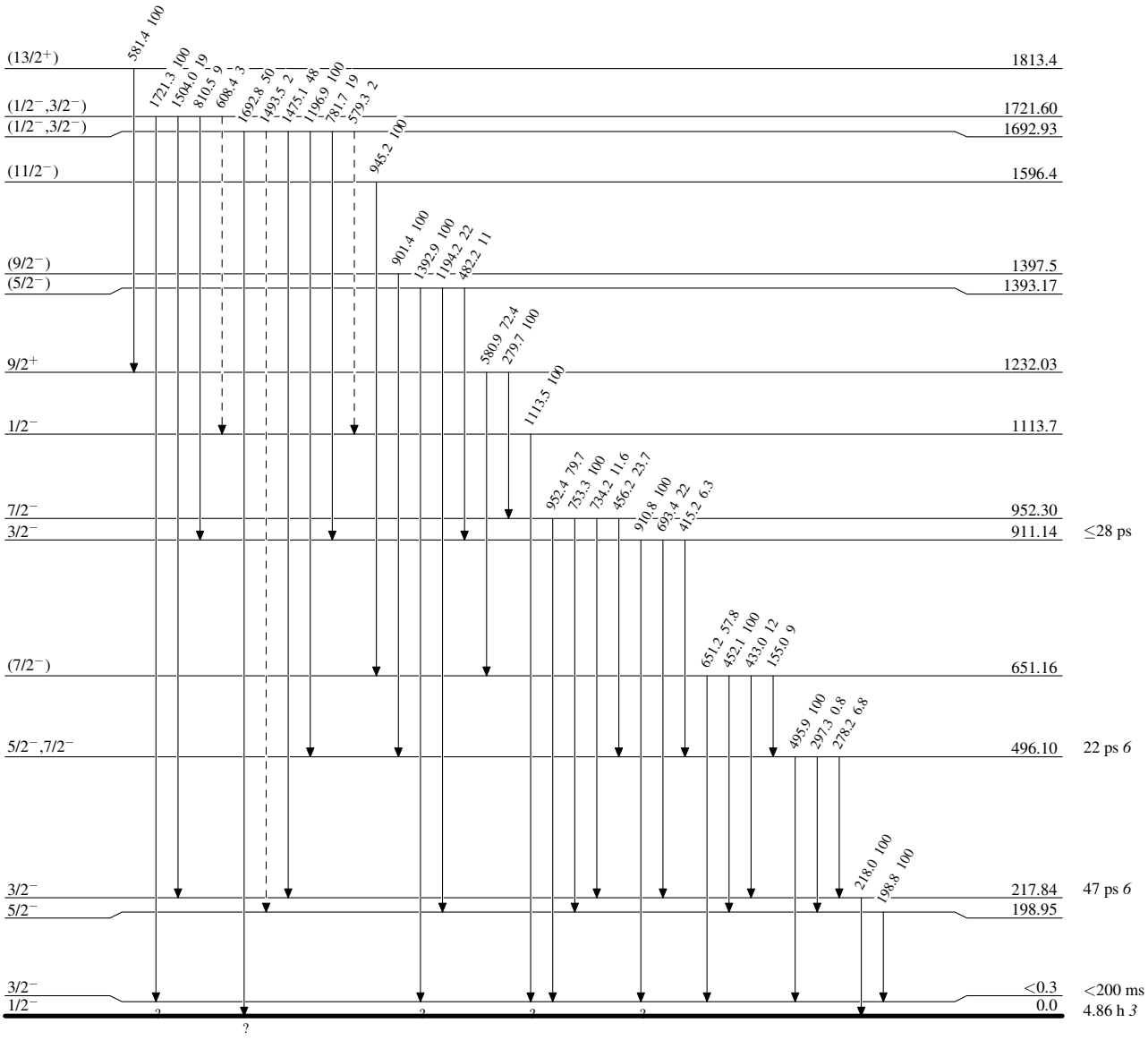
Adopted Levels, Gammas

Legend

Level Scheme (continued)

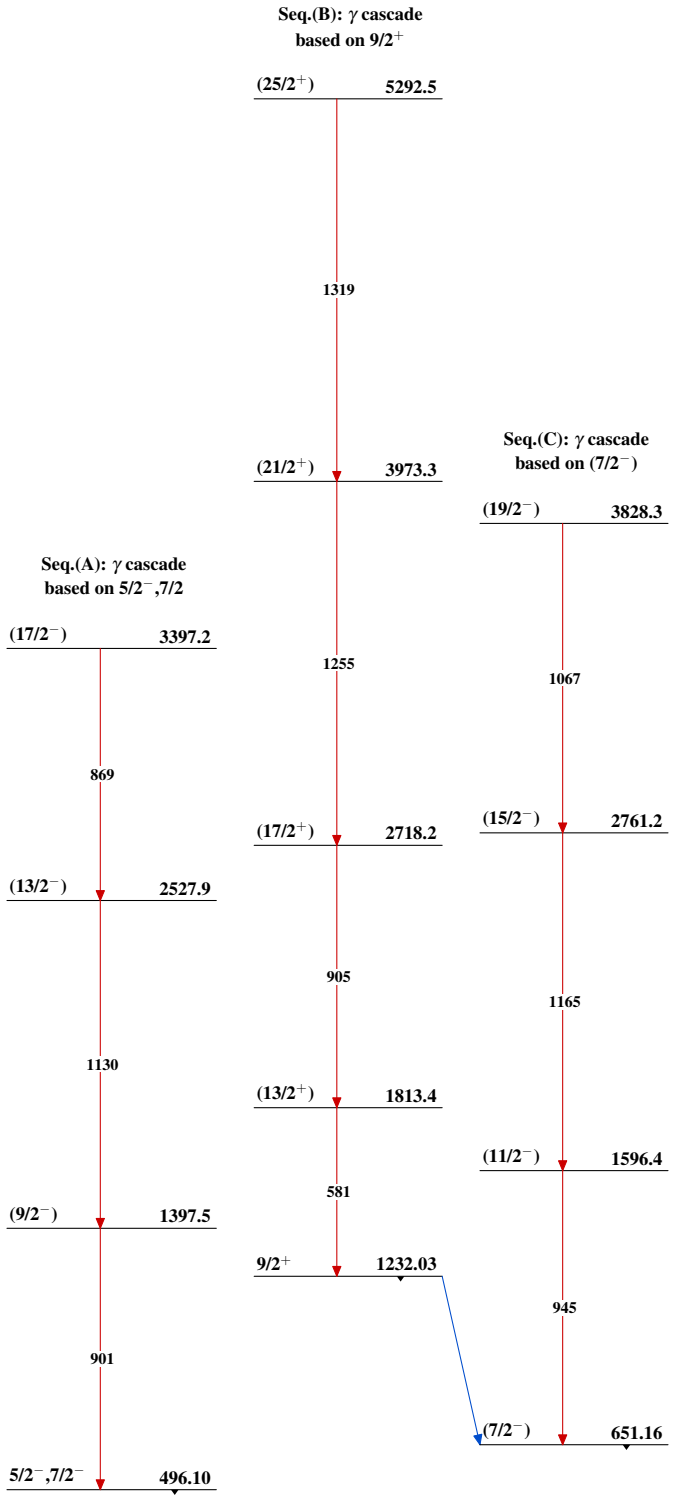
Intensities: Relative photon branching from each level

γ Decay (Uncertain)



$^{73}_{31}Ga_{42}$

Adopted Levels, Gammas



$^{73}_{31}Ga_{42}$