^{65}Cu(^{7}Li,2nγ), ^{60}Ni(^{12}C,2pγ) 1977Ro28,2010Su05

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	G. Gürdal, E. A. Mccutchan	NDS 136, 1 (2016)	1-Jul-2016

1977Ro28: ^{60}Ni(^{12}C, 2pγ), E(^{12}C)=30-39 MeV; ^{65}Cu(^{7}Ni, 2nγ), E(^{7}Li)=16-19 MeV. Beams provided by ORNL EN tandem accelerator. Two Ge(Li) detectors used for γ-ray detection. Measured Eγ, Iγ, $\gamma\gamma$ coin (^{60}Ni(^{12}C, 2pγ)), $\gamma(\theta)$, $\gamma\gamma(\theta)$, $T_{1/2}$ by DSAM.

1978RoZS: ^{64}Cu(^{7}Li,2nγ); in-beam measurement of linear polarization of γ rays using a Compton polarimeter.

2010Su05: ^{60}Ni(^{12}C,2pγ), E(^{12}C)=45 MeV beam provided by the tandem accelerator at the Japan Atomic Energy Agency (JAEA). γ-rays were detected with an array of 15 HPGe detectors with BGO shields and three LOAX detectors without shields. The HPGe detectors were placed at angles of 47°, 72°, 90°, 105°, 144° and 147°. The LOAX detectors were placed at 36° and 108° with respect to the beam direction. Measured Eγ, Iγ, $\gamma\gamma$, ADO ratios (Angular Distribution from Oriented nuclei). The γ ray energies in 2010Su05 are consistently $\approx$1 keV lower than those given in 1977Ro28 (and similarly those from other datasets). In order to combine the 2010Su05 Eγ values with the results of other measurements, the evaluators have added 1 keV to all Eγ values given in 2010Su05 and rounded to the nearest keV.

^{70}Ge Levels

Evaluators note: 6506.5 keV 11$^{(-)}$, 7132.5 keV 13$^{(-)}$ and 8404.5 keV 15$^{(-)}$ levels were omitted in the Adopted Levels since the level energies could not be reproduced by the least-squares fit. The energy differences obtained were up to 14 keV.

E(level)[†]	J$^{\pi}$[a]	$T_{1/2}$[b]	Comments
0.0[@]	0^{+}		
1039.6[@] *3*	2^{+}	>5[c] ps	
1215.9[‡#] *6*	0^{+}		
1708.2 *3*	2^{+}	>7[d] ps	J$^{\pi}$: J=2 from $\gamma(\theta)$.
2153.6[@] *4*	4^{+}[e]	4[c] ps *1*	
2156.9[‡#] *4*	2^{+}		
2452.1 *4*	3^{+}		J$^{\pi}$: J=1,2,3 from $\gamma(\theta)$.
2562.6[‡&] *4*	3^{-}	2.3[d] ps *5*	J$^{\pi}$: J=1,2,3 from $\gamma(\theta)$.
2807.4 *4*	4^{+}		J$^{\pi}$: J=1-4 from $\gamma(\theta)$.
3059.6[#] *3*	4^{+}	1.0[d] ps *5*	J$^{\pi}$: J=1-4 from $\gamma(\theta)$.
3298.0[@] *5*	6^{+}[e]	2.6[d] ps *6*	
3417.1[&] *4*	5^{-}[e]	>14[d] ps	
3667.6 *5*	6^{-}[e]		
3754.0 *5*	(6)$^{+}$		J$^{\pi}$: J=2-6 from $\gamma(\theta)$.
3956.0 *5*	7^{-}		J$^{\pi}$: J=5,6,7 from $\gamma(\theta)$.
4104.3[‡#] *6*	6^{+}		
4204.8[@] *6*	8^{+}[e]		
4300.2[&] *5*	6^{-},7^{-},8^{-}		J$^{\pi}$: J=5-9 from $\gamma(\theta)$.
4432.7 *6*	8^{+}		J$^{\pi}$: J=4-8 from $\gamma(\theta)$. J=7-9 from yield function in 1977Ro28.
4852.8 *6*	8$^{(-)}$		J$^{\pi}$: J=6,8 from $\gamma(\theta)$.
5244.8[‡@] *11*	10^{+}		
5300.1 *6*	9$^{(-)}$		J$^{\pi}$: J$^{\pi}$=5,6^{-},7^{-},8^{-} from $\gamma(\theta)$; J=6-8 from yield function in 1977Ro28.
5436.3[‡#] *12*	8^{+}		
5541.0 *7*	9^{+}		
5553.4[‡&] *6*	9$^{(-)}$		
6506.5[‡&] *12*	11$^{(-)}$		
6573.1[‡] *12*	11$^{(-)}$		
6720.9[‡@] *15*	12^{+}		

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^{65}Cu(^{7}Li,2nγ), ^{60}Ni(^{12}C,2pγ) 1977Ro28,2010Su05 (continued)

^{70}Ge Levels (continued)

E(level)[†]	J$^{\pi}$[a]
7132.5[‡&] *16*	13$^{(-)}$
8404.5[‡&] *18*	15$^{(-)}$

[†] From a least-squares fit to Eγ's by evaluators. ΔEγ=1 keV, if not specified.
[‡] Level reported only in 2010Su05.
[#] Band(A): Member of 0^{+} band in 2010Su05.
[@] Band(B): Member of the g.s band in 2010Su05.
[&] Band(C): Member of band based on 3$^{(-)}$ in 2010Su05.
[a] From the Adopted Levels. Additional support from $\gamma(\theta)$ and linear polarization measurements are indicated.
[b] From DSAM in 1977Ro28.
[c] Corrected for precursor γ rays in 1977Ro28.
[d] Not corrected for precursor γ rays in 1977Ro28.
[e] 1978RoZS state J^{π} consistent with $\gamma(\theta)$ of 1977Ro28 and their linear polarization results, however, no details are given.

γ(^{70}Ge)

ADO ratio are for the different combinations of detectors (2010Su05).
γ-ray coincidence intensity ratios (ADO ratios): I(γ1:47°,γ2:all)/I(γ1:105°,γ2:all)=ADO(1), I(γ1:144°,γ2:all)/(γ1:105°,γ2:all)=ADO(2) and (γ1:147°)/(γ1:105°,γ2:all)=ADO(3). Expected ADO ratios are ≈1.3 for stretched quadrupole or ΔJ=0, dipole and 0.8 for stretched pure dipole transitions.

E$_{\gamma}$[†]	I$_{\gamma}$[#]	E$_{i}$(level)	J$^{\pi}_{i}$	E$_{f}$	J$^{\pi}_{f}$	Mult.[a]	δ[@]	Iγ'[&]	Comments
176[‡]		1215.9	0^{+}	1039.6	2^{+}			2.65 *20*	
250[‡]		4204.8	8^{+}	3956.0	7^{-}			0.44 *4*	
250.4 *4*	9.2 *9*	3667.6	6^{-}	3417.1	5^{-}	D+Q	+0.05 *2*	3.0 *3*	Mult.: other: D from ADO(1)=0.85 *4*, ADO(2)=0.69 *4*, ADO(3)=0.70 *4* (2010Su05).
251.9 *4*	0.5 *2*	3059.6	4^{+}	2807.4	4^{+}			2.9 *2*	
288.2 *4*	6.4 *6*	3956.0	7^{-}	3667.6	6^{-}	D+Q	+0.13 *1*	2.65 *22*	Mult.: other: D from ADO(1)=0.97 *5*, ADO(2)=0.83 *4*, ADO(3)=0.84 *4* (2010Su05).
295[‡]		2452.1	3^{+}	2156.9	2^{+}			0.05 *1*	
298[‡]		2452.1	3^{+}	2153.6	4^{+}			0.41 *6*	
344.1 *4*	1.1 *2*	4300.2	6^{-},7^{-},8^{-}	3956.0	7^{-}	D(+Q)	+0.1 *3*	0.72 *6*	Mult.: other: ΔJ=0 D from ADO(1)=1.27 *9*, ADO(2)=1.39 *11*, ADO(3)=1.40 *10* (2010Su05).
357.1 *4*	3.3 *7*	3417.1	5^{-}	3059.6	4^{+}	D(+Q)	+0.00 *4*	1.48 *12*	Mult.: other: D from ADO(1)=0.87 *5*, ADO(2)=0.74 *5*, ADO(3)=0.82 *5* (2010Su05).
405[‡]		2562.6	3^{-}	2156.9	2^{+}			0.17 *2*	
408[‡]		2562.6	3^{-}	2153.6	4^{+}			0.12 *2*	
449[‡]		2156.9	2^{+}	1708.2	2^{+}	D		0.35 *4*	Mult.: ΔJ = 0 dipole transition based on ADO(1)=1.28 *20*, ADO(2)=1.13 *27*, ADO(3)=1.40 *23* (2010Su05).
451[‡]		4204.8	8^{+}	3754.0	(6)$^{+}$			0.16 *1*	
456[‡]		3754.0	(6)$^{+}$	3298.0	6^{+}			0.19 *2*	

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$^{65}Cu(^7Li,2n\gamma)$, $^{60}Ni(^{12}C,2p\gamma)$ 1977Ro28,2010Su05 (continued)

$\gamma(^{70}Ge)$ (continued)

E_γ[†]	I_γ[#]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[a]	δ[@]	$I\gamma'$[&]	Comments
492[‡]		1708.2	2+	1215.9	0+			0.86 7	
496.7 4	0.3 1	3059.6	4+	2562.6	3−	D		2.7 2	Mult.: ADO(1)=0.91 5, ADO(2)=0.74 5, ADO(3)=0.83 5 (2010Su05).
539[‡]		3956.0	7−	3417.1	5−			0.09 2	
607.2 4	0.8 2	3059.6	4+	2452.1	3+	D		4.8 4	Mult.: ADO(1)=1.01 5, ADO(2)=0.89 5, ADO(3)=0.94 5 (2010Su05).
626[‡]		7132.5	13(−)	6506.5	11(−)	Q		0.82 7	Mult.: ADO(1)=1.16 7, ADO(2)=1.30 8, ADO(3)=1.20 7 (2010Su05).
653[‡]		2807.4	4+	2153.6	4+	D		0.98 11	Mult.: ΔJ = 0 dipole transition based on ADO(1)=0.90 6, ADO(2)=0.86 7, ADO(3)=0.86 6 (2010Su05).
658.1 4	1.2 2	3956.0	7−	3298.0	6+	D(+Q)	+0.02 5	0.97 9	Mult.: other: D from ADO(1)=0.78 5, ADO(2)=0.65 6, ADO(3)=0.65 5 (2010Su05).
668.1 4	5.1 5	1708.2	2+	1039.6	2+	Q		26.8 23	Mult.: ΔJ = 0 quadrupole transition based on ADO(1) = 1.01 5, ADO(2)=0.84 4, ADO(3) =0.93 5 (2010Su05).
679		4432.7	8+	3754.0	(6)+			0.12 2	
688[‡]		4104.3	6+	3417.1	5−			0.24 2	
743.8 4	4.5 4	2452.1	3+	1708.2	2+	D(+Q)	+0.04 8	22.3 18	Mult.: other: D from ADO(1)=1.01 5, ADO(2)=0.85 4, ADO(3)=0.91 5 (2010Su05).
854[‡]		2562.6	3−	1708.2	2+			0.25 3	
854.6 4	6.7 7	3417.1	5−	2562.6	3−	Q		2.76 22	Mult.: ADO(1)=1.25 7, ADO(2)=1.33 8, ADO(3)=1.30 8 (2010Su05).
883[‡]		4300.2	6−,7−,8−	3417.1	5−	Q		0.77 6	Mult.: ADO(1)=1.28 14, ADO(2)=1.15 16, ADO(3)=1.34 15 (2010Su05).
896.8 4	1.2 2	4852.8	8(−)	3956.0	7−	D+Q	+1.1 3	1.16 10	Mult.: other: D from ADO(1)=0.69 7, ADO(2)=0.75 10, ADO(3)=0.86 9 (2010Su05).
902[‡]		3059.6	4+	2156.9	2+			1.47 12	
906.0 4	1.6 3	3059.6	4+	2153.6	4+	D		7.5 7	Mult.: ΔJ = 0 dipole transition based on ADO(1)=1.22 6, ADO(2)=1.10 6, ADO(3)=1.14 6 (2010Su05).
906.6 4	5.9 6	4204.8	8+	3298.0	6+	E2		8.2 7	Mult.: other: Q from ADO(1)=1.27 6, ADO(2)=1.17 6, ADO(3)=1.24 6 (2010Su05).
941[‡]		2156.9	2+	1215.9	0+			1.52 12	
946.7 4	1.7 3	3754.0	(6)+	2807.4	4+	Q		1.04 9	Mult.: other: Q from ADO(1)=1.46 17, ADO(2)=1.67 23, ADO(3)=1.81 21 (2010Su05). Other: D+Q from 1977Ro28 based on δ=+0.38 8.
953[‡]		6506.5	11(−)	5553.4	9(−)	Q		1.02 9	Mult.: ADO(1) =1.25 8, ADO(2)=1.69 12, ADO(3)=1.45 10 in 2010Su05.
1002.4 4	1.5 3	4300.2	6−,7−,8−	3298.0	6+	D+Q	+0.11 2	0.98 9	Mult.: other: D from ADO(1)=0.86 6, ADO(2)=0.90 8, ADO(3)=0.76 6 (2010Su05).

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^{65}Cu(^{7}Li,2nγ), ^{60}Ni(^{12}C,2pγ) 1977Ro28,2010Su05 (continued)

γ(^{70}Ge) (continued)

E_γ[†]	I_γ[#]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[a]	δ[@]	Iγ′[&]	Comments
1039.6 4	100	1039.6	2+	0.0	0+	E2		100 10	
1040[‡]		5244.8	10+	4204.8	8+	Q		5.8 6	Mult.: ADO(1) = 1.21 6, ADO(2)=1.16 6, ADO(3)=1.16 6 (2010Su05).
1045[‡]		4104.3	6+	3059.6	4+			3.3 3	
1098.8 4	4.2 4	2807.4	4+	1708.2	2+	Q		5.0 5	Mult.: ADO(1)=1.37 8, ADO(2)=1.29 8, ADO(3)=1.32 8 (2010Su05).
1108.3 4	1.7 3	5541.0	9+	4432.7	8+	D		1.54 16	Mult.: ADO(1)=0.81 5, ADO(2)=0.57 5, ADO(3)=0.47 3 (2010Su05).
1114.0 4	39 4	2153.6	4+	1039.6	2+	Q		35 3	Mult.: ADO(1) = 1.30 7, ADO(2)=1.16 6, ADO(3) =1.20 6 (2010Su05).
1117[‡]		2156.9	2+	1039.6	2+			4.8 4	
1134.6 4	5.4 5	4432.7	8+	3298.0	6+	Q		2.9 3	Mult.: ADO(1)=1.07 6, ADO(2)=1.13 7, ADO(3)=1.15 6 (2010Su05).
1144.5 4	18.0 18	3298.0	6+	2153.6	4+	E2		9.4 9	Mult.: other: Q from ADO(1)=1.40 7, ADO(2)=1.53 8, ADO(3)=1.48 8 (2010Su05).
1253.2[‡] 4	0.4 1	5553.4	9(−)	4300.2	6−,7−,8−	Q		1.16 10	E_γ: placement from 2010Su05. 1253γ is placed from a 4551-keV, J=(8) level in 1977Ro28. Mult.: ADO(1)=1.21 7, ADO(2)=1.52 10, ADO(3)=1.35 8 (2010Su05).
1263.9 4	8.1 8	3417.1	5−	2153.6	4+	E1(+M2)	+0.02 2	2.85 24	Mult.: other: D from ADO(1)=0.91 5, ADO(2)=0.89 5, ADO(3)=0.81 4 (2010Su05).
1272[‡]		8404.5	15(−)	7132.5	13(−)			0.24 4	ADO(1)=1.39 8, ADO(2)=1.26 10, ADO(3)=1.17 8 for 1273 + 1273 unresolved doublet (2010Su05).
1273[‡]		6573.1	11(−)	5300.1	9(−)	Q		0.42 4	Mult.: ADO(1)=1.39 8, ADO(2)=1.26 10, ADO(3)=1.17 8 for 1273 + 1273 unresolved doublet (2010Su05).
1295[‡]		4104.3	6+	2807.4	4+	Q		0.49 4	Mult.: ADO(1)=1.27 12, ADO(2)=1.78 23, ADO(3)=1.28 14 (2010Su05).
1332[‡]		5436.3	8+	4104.3	6+	Q		0.47 5	Mult.: ADO(1) =1.39 10, ADO(2)=1.91 15, ADO(3)=1.45 11 (2010Su05).
1344.1 4	0.6 2	5300.1	9(−)	3956.0	7−	Q		0.88 8	Mult.: ADO(1)=1.25 20, ADO(2)=1.72 33, ADO(3)=1.89 25 (2010Su05).
1351[‡]		3059.6	4+	1708.2	2+			0.47 4	
1412.6 4	1.4 3	2452.1	3+	1039.6	2+	D+Q		10.6 9	Mult.: ADO(1)=1.19 6, ADO(2)=1.07 6, ADO(3)=1.06 5 (2010Su05).

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^{65}Cu(^{7}Li,2nγ), ^{60}Ni(^{12}C,2pγ) 1977Ro28,2010Su05 (continued)

γ(^{70}Ge) (continued)

E_γ [†]	I_γ [#]	E_i(level)	J^π_i	E_f	J^π_f	Mult. [a]	δ [@]	Iγ′ [&]	Comments
1476 [‡]		6720.9	12^+	5244.8	10^+	Q		0.26 *2*	Mult.: ADO(1) =1.39 *9*, ADO(2)=1.90 *14*, ADO(3)=1.66 *11* (2010Su05).
1523.1 *4*	11 *1*	2562.6	3^-	1039.6	2^+	D(+Q)	+0.02 *5*	8.7 *8*	Mult.: other: D from ADO(1)=0.98 *5*, ADO(2)=0.99 *5*, ADO(3)=0.97 *5* (2010Su05).
1708.3 *4*	5.7 *6*	1708.2	2^+	0.0	0^+	E2		16.4 *13*	
1948 [‡]		4104.3	6^+	2156.9	2^+			0.18 *2*	E_γ: 1948γ populates 2156.9 keV 2^+ state according to level scheme. Placement of 1948γ is questionable due to ΔJ.
2020.5 *4*	2.2 *4*	3059.6	4^+	1039.6	2^+	Q		11.9 *10*	Mult.: ADO(1)=1.32 *7*, ADO(2)=1.34 *7*, ADO(3)=1.39 *7* (2010Su05).
2156 [‡]		2156.9	2^+	0.0	0^+			0.60 *6*	

† From 1977Ro28, except where noted.

‡ From 2010Su05 with a 1 keV offset added by the evaluators. The results of 2010Su05 are consistently ≈1 keV lower than the Eγ values reported by 1977Ro28 (and similarly those from other datasets) suggesting a problem with the energy calibration in 2010Su05. ΔE=1 keV assumed for least-squares fitting.

\# Relative photon intensity at E(^{7}Li)=18 MeV with Iγ(1040γ)=100 (1977Ro28).

@ From γ(θ) in 1977Ro28.

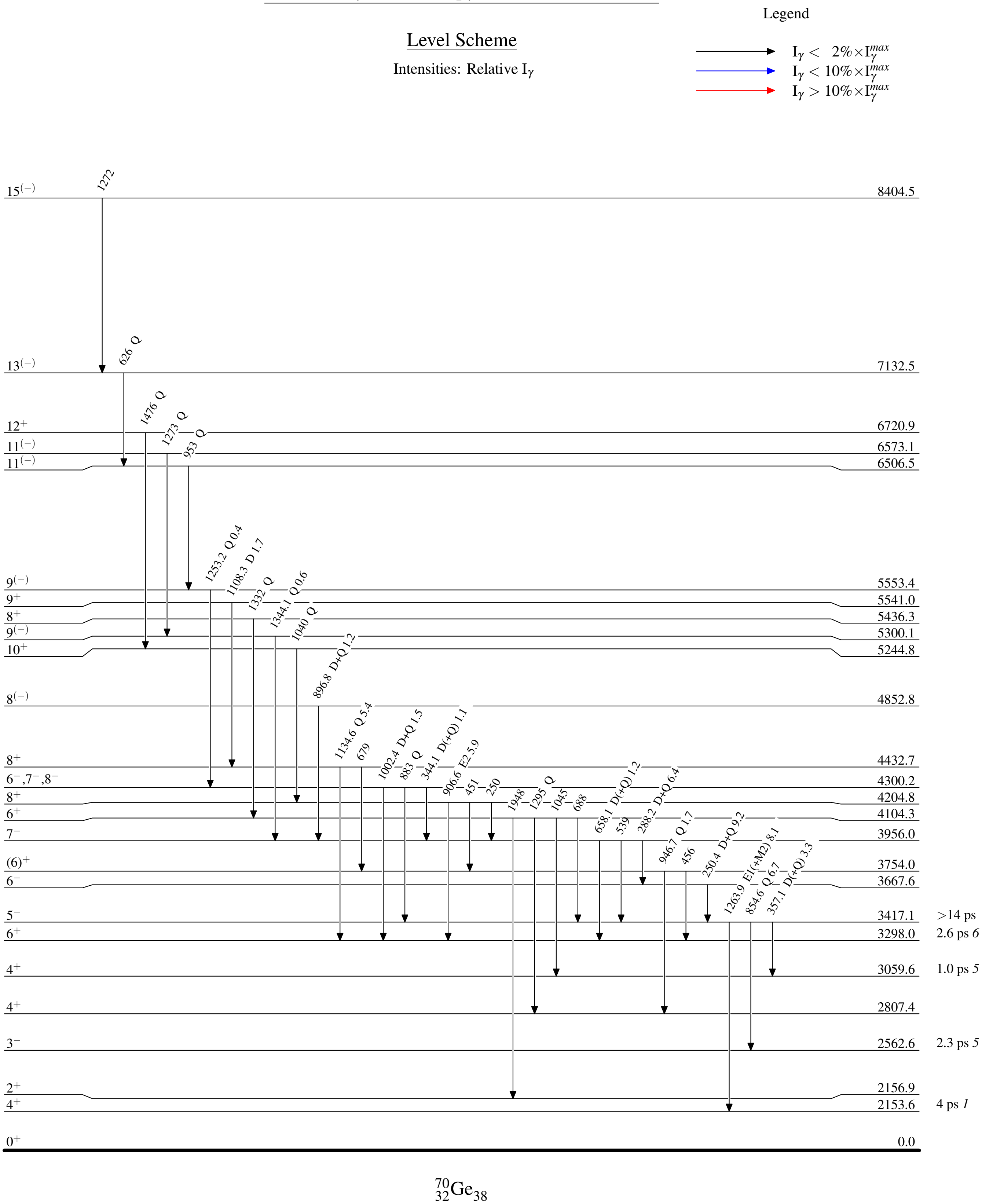
& From 2010Su05, normalized to Iγ(1040γ)=100.

a From γ(θ) (1977Ro28) and linear polarization data (1978RoZS), except where noted.

$^{65}Cu(^{7}Li,2n\gamma)$, $^{60}Ni(^{12}C,2p\gamma)$ 1977Ro28,2010Su05

Level Scheme

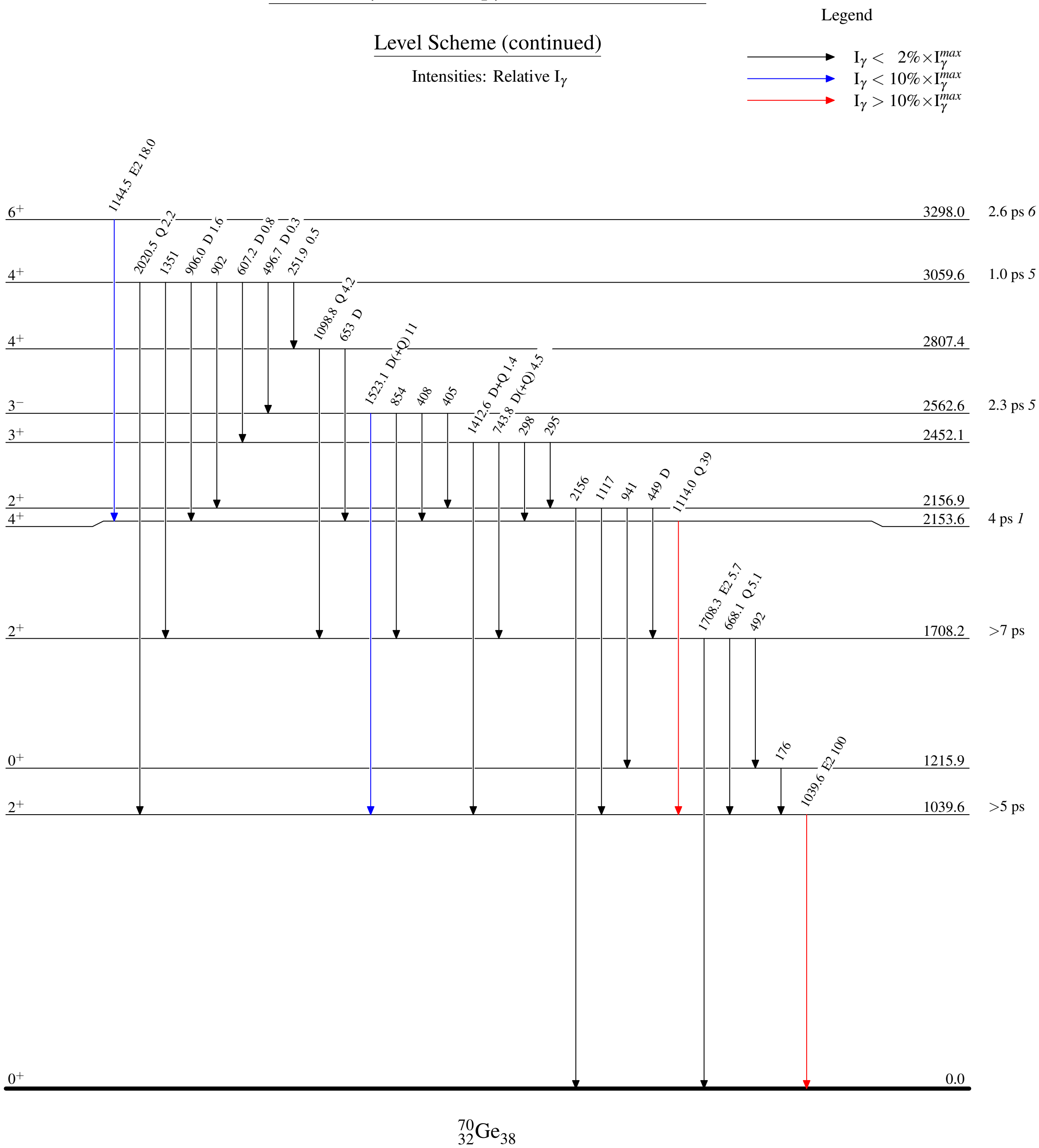
Intensities: Relative I_γ



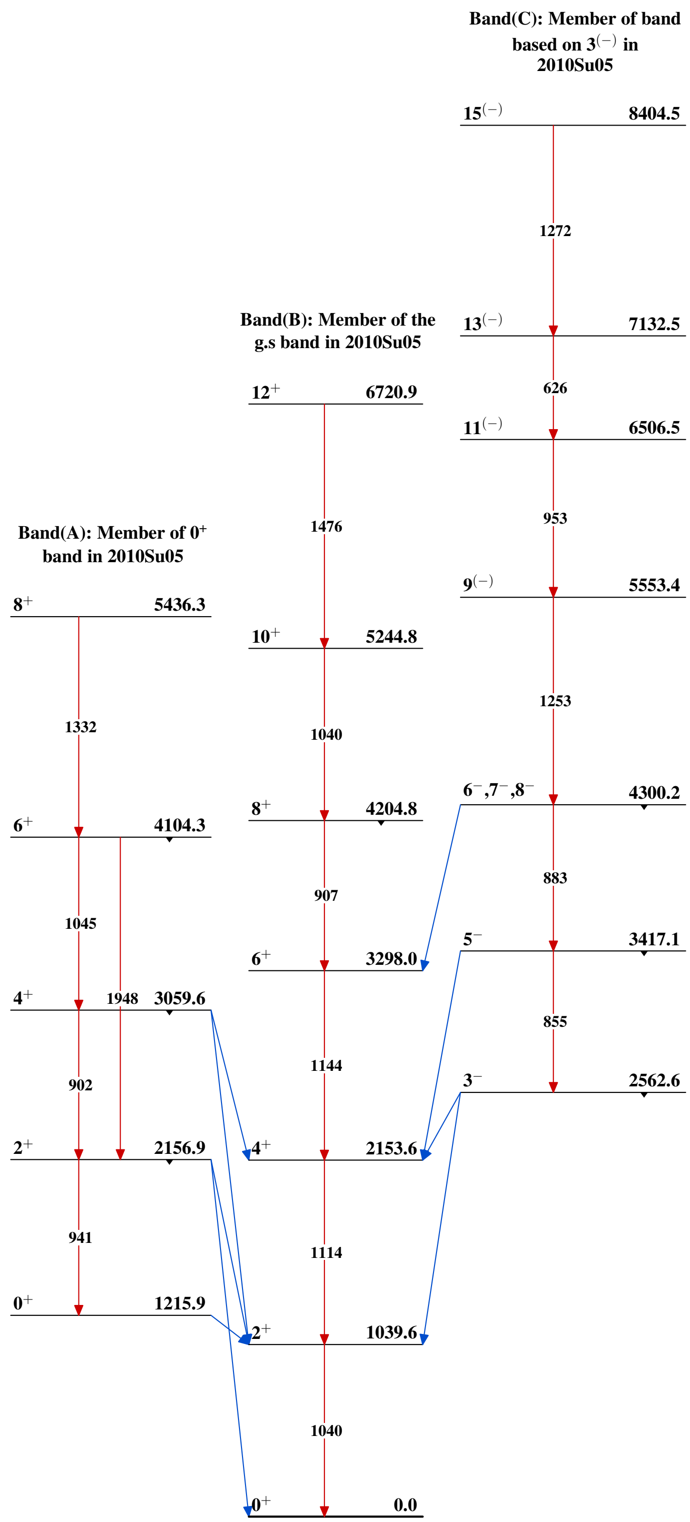
^{65}Cu(^{7}Li,2nγ), ^{60}Ni(^{12}C,2pγ) 1977Ro28,2010Su05

Level Scheme (continued)

Intensities: Relative I_γ



^{65}Cu(^{7}Li,2nγ), ^{60}Ni(^{12}C,2pγ) 1977Ro28,2010Su05



$^{70}_{32}Ge_{38}$