^{44}Ca(γ,γ′),(pol γ,γ′) 2011Is01,1986Be30

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Jun Chen and Balraj Singh	NDS 190,1 (2023)	20-Jun-2023

2011Is01: two experiments: the first one performed at the Darmstadt High Intensity Photon Setup (DHIPS) with the E=6.3 and 9.9 MeV polarized photons produced via bremsstrahlung by stopping completely the intense electron beam from the injector of the electron accelerator S-DALINAC in a thick copper radiator. HPGe detectors at 90° and 130° for detecting γ-rays with BGO Compton-suppression shields. Targets of 97.1% enriched CaO_3; the second performed at the High Intensity γ-ray Source (HIγS) facility at Duke University with the polarized photon beam produced via intercavity laser Compton backscattering (LCB) of a free-electron laser (FEL) beam with relativistic electrons in a storage ring. Four HPGe clover detectors for detecting γ-rays. Target of 95.8 enriched CaO_3. Measured Eγ, Iγ, γ polarization asymmetry. Deduced levels, J^π, γ-widths, transition strengths.

1986Be30: Eγ=4-7 MeV γ-rays produced by the V(n,γ) reaction. Target of 4.86 g/cm^2 natural Ca. A 40 cm^3 Ge(Li) detector for detecting scattered γ-rays. Measured Eγ, Iγ, γ(θ), γ(pol). Deduced levels, J^π, widths, γ-branchings, mixing ratio.

2016De05: The quasi-monochromatic, linearly polarized and intense beam of real photons, Eγ=5.9 MeV were provided at the High Intensity γ-ray Source (HIγS) facility at TUNL. The target was 11.2 g natural calcium-carbonate. De-exciting rays were detected with four $LaBr_3$:Ce scintillation detectors and four HPGe detectors. Measured singles and coincidence γ-ray spectra, γ(pol,θ). Deduced J^π for 5806 and 5875 levels.

2004Ha51: Eγ=9.9 MeV γ-rays source produced at the nuclear resonance fluorescence (NRF) setup at the Darmstadt superconducting electron linear accelerator S-DALINAC. Measured Eγ, Iγ. Deduced electric dipole strength distribution, pygmy dipole resonance features.

Other: 2007Kl05.

All data above 3301 keV level (except 5210 keV level) are from 2011Is01; others including 5210 keV level are from 1986Be30, unless otherwise noted.

^{44}Ca Levels

B(E1)↑ and B(M1)↑ given under comments are from 2011Is01 for level parity π=− and +, respectively, unless otherwise noted.

E(level)[†]	J^π[‡]	$T_{1/2}$[&]	Comments
0.0	0^+[#]		
1157.06 *16*	2^+[#]		
1883.49 *15*	0^+[#]		
2656.7 *5*	2^+[#]		
3301.1 *6*	2^+		
3307.8 *3*	3^-[#]		
3661.50 *15*	1	5.8 fs *+12−9*	B(E1)↑=3.16×10^{-5} *76*; B(M1)↑=0.29 *7*
3691.7 *4*	1	46 fs *+30−13*	B(E1)↑=0.57×10^{-5} *21*; B(M1)↑=0.05 *2*
4196.3 *3*	1	30 fs *+8−5*	B(E1)↑=0.58×10^{-5} *12*; B(M1)↑=0.05 *1* E(level),J^π: probably the same level as 4196.10, 2^+ in the Adopted Levels.
4649.46 *10*	1	7.4 fs *+16−11*	B(E1)↑=1.77×10^{-5} *32*; B(M1)↑=0.16 *3*
4848.39 *20*	1	17 fs *+5−3*	B(E1)↑=0.68×10^{-5} *15*; B(M1)↑=0.06 *1*
4865.9 *3*	1	4.3 fs *+14−9*	B(E1)↑=1.47×10^{-5} *41*; B(M1)↑=0.13 *4*
5161.0 *3*	1	2.6 fs *3*	B(E1)↑=3.71×10^{-5} *41*; B(M1)↑=0.34 *4*
5210.0 *5*	1^+	2.0 fs *+4−3*	B(M1)↑=0.15 *6* (1986Be30) J^π: from γ(θ) and γ(pol) in 1986Be30. $T_{1/2}$: from Γ=0.228 eV *40* (1986Be30).
5611.6 *3*	1	1.4 fs *+7−4*	B(E1)↑=1.67×10^{-5} *32*; B(M1)↑=0.15 *3*
5800.61 *20*	1	11 fs *+5−3*	B(E1)↑=0.59×10^{-5} *17*; B(M1)↑=0.05 *2*
5806.31 *10*	1^-	2.3 fs *3*	B(E1)↑=2.90×10^{-5} *36*; B(M1)↑=0.26 *3*
5875.82 *20*	1^-	4.2 fs *+8−5*	B(E1)↑=1.55×10^{-5} *21* J^π: from γ(pol) in 2016De05.

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^{44}Ca(γ,γ′),(pol γ,γ′) 2011Is01,1986Be30 (continued)

^{44}Ca Levels (continued)

E(level)[†]	Jπ[‡]	$T_{1/2}$[&]	Comments
5911.13 *20*	1	1.9 fs *+6−4*	B(E1)↑=3.35×10^{-5} *82*; B(M1)↑=0.30 *7*
6082.8 *5*	1$^+$	2.1 fs *+4−3*	B(M1)↑=0.13 *5*
6136.6 *3*	1$^-$	1.27 fs *+20−15*	B(E1)↑=3.03×10^{-5} *65*
6245.5 *3*	1	9 fs *+3−2*	B(E1)↑=0.62×10^{-5} *14*; B(M1)↑=0.06 *1*
6422.12 *10*	1$^-$	0.21 fs *2*	B(E1)↑=21.6×10^{-5} *32*
6446.6 *8*	1$^+$	5.9 fs *+16−11*	B(M1)↑=0.05 *2*
6507.1 *5*	1	3.3 fs *+9−6*	B(E1)↑=1.43×10^{-5} *31*; B(M1)↑=0.13 *3*
6675.44 *20*	1	4.5 fs *+9−6*	B(E1)↑=0.98×10^{-5} *17*; B(M1)↑=0.09 *2*
6960.7 *6*	1	5.6 fs *+13−9*	B(E1)↑=0.70×10^{-5} *13*; B(M1)↑=0.06 *1*
6972.14 *19*	1	0.47 fs *+14−9*	B(E1)↑=2.81×10^{-5} *47*; B(M1)↑=1.17 *20*
7065.9 *9*	1	2.7 fs *+6−4*	B(E1)↑=1.38×10^{-5} *24*; B(M1)↑=0.13 *2*
7226.0 *3*	1	2.8 fs *+6−4*	B(E1)↑=1.22×10^{-5} *21*; B(M1)↑=0.11 *2*
7275.1 *9*	1	1.9 fs *+4−3*	B(E1)↑=1.82×10^{-5} *30*; B(M1)↑=0.17 *3*
7403.0 *8*	1	3.7 fs *+9−6*	B(E1)↑=0.87×10^{-5} *16*; B(M1)↑=0.08 *2*
7572.0 *5*	1$^{(+)}$[@]	2.6 fs *+8−5*	B(M1)↑=0.10 *2*
7578.9 *3*	1$^-$[@]	0.51 fs *+7−6*	B(E1)↑=5.90×10^{-5} *75*
7662.1 *6*	1$^-$	4.7 fs *+21−11*	B(E1)↑=0.62×10^{-5} *19*
7783.3 *10*	1$^-$	4.2 fs *+19−11*	B(E1)↑=0.66×10^{-5} *20*
7808.9 *16*	1$^-$	8 fs *+4−2*	B(E1)↑=0.34×10^{-5} *11*
7828.8 *12*	1	6 fs *+3−2*	B(E1)↑=0.44×10^{-5} *15*; B(M1)↑=0.04 *1*
7834.7 *8*	1$^-$	3.0 fs *+9−6*	B(E1)↑=0.89×10^{-5} *21*
7953.1 *5*	1	1.7 fs *+7−4*	B(E1)↑=0.78×10^{-5} *26*; B(M1)↑=0.07 *2*
8070.2 *7*	1	2.2 fs *+5−3*	B(E1)↑=1.15×10^{-5} *21*; B(M1)↑=0.10 *2*
8086.0 *7*	1	2.1 fs *+5−3*	B(E1)↑=1.17×10^{-5} *21*; B(M1)↑=0.11 *2*
8321.5 *16*	1	9.5 fs *+7−3*	B(E1)↑=0.24×10^{-5} *11*; B(M1)↑=0.02 *1*
8395.3 *4*	1	1.6 fs *+5−3*	B(E1)↑=1.35×10^{-5} *32*; B(M1)↑=0.12 *3*
8405.4 *17*	1	0.42 fs *+7−5*	B(E1)↑=5.26×10^{-5} *77*; B(M1)↑=0.48 *7*
8556.7 *8*	1$^-$	2.4 fs *+16−7*	B(E1)↑=0.88×10^{-5} *36*
8615.2 *12*	1$^-$	2.3 fs *+10−5*	B(E1)↑=0.88×10^{-5} *27*
8802 *3*	1$^-$	11 fs *+13−4*	B(E1)↑=0.17×10^{-5} *9*
8828.0 *11*	1$^-$	0.8 fs *+3−2*	B(E1)↑=1.13×10^{-5} *62*
8851.5 *7*	1$^-$	0.70 fs *+17−12*	B(E1)↑=2.27×10^{-5} *66*
8908.8 *7*	1$^-$	0.33 fs *+7−5*	B(E1)↑=5.57×10^{-5} *93*
9024.1 *20*	1$^-$		
9148.4 *24*	1$^-$		
9273.5 *8*	1$^-$	1.1 fs *+3−2*	B(E1)↑=3.62×10^{-5} *81*
9317.2 *10*	1$^-$		
9664.9 *7*	1$^-$		
9814.1 *11*	1$^-$		
9898.2 *10*	1$^-$		

[†] From a least-squares fit to γ-ray energies.

[‡] From γ polarization asymmetry, unless otherwise noted.

[#] From the Adopted Levels.

[@] The pol value of −0.65 *2* is combined for unresolved 7572.0γ+7578.2γ. 2011Is01 estimated pol=−0.61 *6* if the stronger state at 7578 keV is assumed as 1$^-$ and weaker state at 7572 keV as 1$^+$, consistent with the measured pol value, which is likely dominated by contribution from the 7578.2γ. On this basis, evaluators keep the negative-parity assignment for the 7578.9 level as in 2011Is01, but assign tentative positive parity for the 7572.0 level, whereas firm positive parity was assigned by 2011Is01.

[&] Deduced from Γ_γ by evaluators, assuming the listed γ decay is the only mode as Γ_0/Γ=1 assumed in 2011Is01. Actual $T_{1/2}$

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^{44}Ca(γ,γ′),(pol γ,γ′) 2011Is01,1986Be30 (continued)

^{44}Ca Levels (continued)

could be smaller for levels from which only the g.s. transitions are reported, with the possibility that competing transitions to the low-lying 2^+ and 0^+ excited states in ^{44}Ca might have missed observation, making Γ_γ underestimated, thus $T_{1/2}$ overestimated.

γ(^{44}Ca)

E_i(level)	J^π_i	E_γ	I_γ	E_f	J^π_f	Mult.#	δ	Comments
1157.06	2^+	1157		0.0	0^+			
1883.49	0^+	726†		1157.06	2^+			
2656.7	2^+	1499†		1157.06	2^+			
		2656†		0.0	0^+			
3301.1	2^+	2144		1157.06	2^+			
		3301		0.0	0^+			
3661.50	1	353.67 *25*		3307.8	3^-			Γ_γ=0.0002 eV *1*.
		1005.0 *9*		2656.7	2^+			Γ_γ=0.00026 eV *7*.
		1777.973 *20*		1883.49	0^+			Γ_γ=0.0188 eV *46*.
		2504.39 *6*		1157.06	2^+			Γ_γ=0.0058 eV *15*.
		3661.3 *2*		0.0	0^+			Γ_γ=0.054 eV *13*.
3691.7	1	3691.5 *4*	100	0.0	0^+			Γ_γ=0.010 eV *4*.
4196.3	1	4196.1 *3*	100	0.0	0^+			Γ_γ=0.015 eV *3*.
4649.46	1	4649.2 *1*	100	0.0	0^+			Γ_γ=0.062 eV *11*.
4848.39	1	4848.1 *2*	100	0.0	0^+			Γ_γ=0.027 eV *6*.
4865.9	1	2982.3 *3*	79 *27*	1883.49	0^+			Γ_γ=0.047 eV *21*.
		4865.7 *4*	100 *27*	0.0	0^+			Γ_γ=0.059 eV *16*.
5161.0	1	5160.7 *3*	100	0.0	0^+			Γ_γ=0.178 eV *19*.
5210.0	1^+	1909	33‡ *15*	3301.1	2^+			
		2553	4‡ *4*	2656.7	2^+			
		3326	80‡ *2*	1883.49	0^+	M1		A_2=+0.43 *10* (1986Be30) Mult.: from γ(θ).
		4053	65‡ *2*	1157.06	2^+	M1+E2	+0.27 *8*	A_2=−0.11 *4* (1986Be30) Mult.,δ: from γ(θ). Γ(E2)=0.0038 eV (1986Be30) which corresponds to B(E2)↓=0.00042 e^2b^2 *8*.
		5210	100‡ *1*	0.0	0^+	M1		A_2=+0.47 *4*; pol=+0.84 *13* (1986Be30)
5611.6	1	4454.1 *8*	100 *21*	1157.06	2^+			Γ_γ=0.22 eV *11*.
		5611.2 *3*	47 *21*	0.0	0^+			Γ_γ=0.103 eV *20*.
5800.61	1	5800.2 *2*	100	0.0	0^+			Γ_γ=0.040 eV *12*.
5806.31	1^-	5805.9 *1*	100	0.0	0^+	E1		pol=−0.31 *4* (2016De05) Γ_γ=0.198 eV *25*.
5875.82	1^-	5875.4 *2*	100	0.0	0^+	E1		pol=−0.33 *6* (2016De05) Γ_γ=0.110 eV *15*.
5911.13	1	5910.7 *2*	100	0.0	0^+			Γ_γ=0.241 eV *59*.
6082.8	1^+	4199.5 *5*	62 *12*	1883.49	0^+	M1		pol=+1.16 *30* Γ_γ=0.068 eV *22*.
		4925.3 *8*	41 *7*	1157.06	2^+			pol=+0.06 *17* Γ_γ=0.045 eV *15*.
		6080.1 *14*	100 *7*	0.0	0^+	M1		pol=+0.88 *7* Γ_γ=0.109 eV *29*.
6136.6	1^-	4978.5 *5*	46 *7*	1157.06	2^+			pol=−0.05 *8* Γ_γ=0.113 eV *29*.
		6136.4 *3*	100 *5*	0.0	0^+	E1		pol=−0.83 *3* Γ_γ=0.245 eV *39*.
6245.5	1	6245.0 *3*	100	0.0	0^+			Γ_γ=0.053 eV *12*.
6422.12	1^-	4539.9 *7*	5.2 *7*	1883.49	0^+	E1		pol=−1.24 *25* Γ_γ=0.104 eV *18*.

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^{44}Ca(γ,γ′),(pol γ,γ′) 2011Is01,1986Be30 (continued)

γ(^{44}Ca) (continued)

E_i(level)	J^π_i	E_γ	I_γ	E_f	J^π_f	Mult.[#]	Comments
6422.12	1^-	5263.8 *7*	5.5 *7*	1157.06	2^+	E1	pol=−0.14 *7* Γ_γ=0.110 eV *18*.
		6421.6 *1*	100 *1*	0.0	0^+	E1	pol=−0.89 *1* Γ_γ=1.99 eV *21*.
6446.6	1^+	5288.0 *17*	50 *14*	1157.06	2^+		pol=+0.08 *37* Γ_γ=0.026 eV *10*.
		6446.3 *8*	100 *10*	0.0	0^+	M1	pol=+0.75 *22* Γ_γ=0.052 eV *14*.
6507.1	1	6506.6 *5*	100	0.0	0^+		Γ_γ=0.137 eV *30*.
6675.44	1	6674.9 *2*	100	0.0	0^+		Γ_γ=0.102 eV *17*.
6960.7	1	6960.1 *6*	100	0.0	0^+		Γ_γ=0.082 eV *16*.
6972.14	1	5815.0 *5*	100 *15*	1157.06	2^+		Γ_γ=0.64 eV *21*.
		6971.5 *2*	52 *15*	0.0	0^+		Γ_γ=0.332 eV *56*.
7065.9	1	7065.3 *9*	100	0.0	0^+		Γ_γ=0.170 eV *29*.
7226.0	1	7225.4 *3*	100	0.0	0^+		Γ_γ=0.161 eV *27*.
7275.1	1	7274.5 *9*	100	0.0	0^+		Γ_γ=0.245 eV *40*.
7403.0	1	7402.3 *8*	100	0.0	0^+		Γ_γ=0.123 eV *23*.
7572.0	$1^{(+)}$	7571.3 *5*	100	0.0	0^+	(M1)[@]	Γ_γ=0.173 eV *39*.
7578.9	1^-	7578.2 *3*	100	0.0	0^+	E1[@]	pol=−0.65 *2* Γ_γ=0.90 eV *11*.
7662.1	1^-	7661.4 *6*	100	0.0	0^+		pol=−0.85 *10* Γ_γ=0.098 eV *30*.
7783.3	1^-	7782.6 *10*	100	0.0	0^+	E1	pol=−0.74 *14* Γ_γ=0.108 eV *33*.
7808.9	1^-	7808.2 *16*	100	0.0	0^+	E1	pol=−1.00 *13* Γ_γ=0.057 eV *18*.
7828.8	1	7828.1 *12*	100	0.0	0^+		Γ_γ=0.074 eV *24*.
7834.7	1^-	7834.0 *8*	100	0.0	0^+	E1	pol=−1.11 *7* Γ_γ=0.150 eV *35*.
7953.1	1	5293.8 *14*	100	2656.7	2^+		Γ_γ=0.136 eV *65*.
		7952.6 *5*	100	0.0	0^+		Γ_γ=0.136 eV *45*.
8070.2	1	8069.4 *7*	100	0.0	0^+		Γ_γ=0.210 eV *39*.
8086.0	1	8085.2 *7*	100	0.0	0^+		Γ_γ=0.215 eV *39*.
8321.5	1	8320.7 *16*	100	0.0	0^+		Γ_γ=0.048 eV *21*.
8395.3	1	8394.4 *4*	100	0.0	0^+		Γ_γ=0.278 eV *65*.
8405.4	1	8404.5 *17*	100	0.0	0^+		Γ_γ=1.09 eV *16*.
8556.7	1^-	8555.8 *8*	100	0.0	0^+	E1	pol=−0.97 *4* Γ_γ=0.193 eV *79*.
8615.2	1^-	8614.3 *12*	100	0.0	0^+	E1	pol=−0.87 *6* Γ_γ=0.197 eV *60*.
8802	1^-	8800.9 *29*	100	0.0	0^+	E1	pol=−1.34 *81* Γ_γ=0.041 eV *22*.
8828.0	1^-	6944.6 *18*	100 *14*	1883.49	0^+	E1	pol=−1.24 *20* Γ_γ=0.31 eV *14*.
		8826.6 *14*	89 *23*	0.0	0^+	E1	pol=−1.40 *18* Γ_γ=0.27 eV *11*.
8851.5	1^-	7692.9 *18*	19 *8*	1157.06	2^+	E1	pol=−0.79 *29* Γ_γ=0.105 eV *49*.
		8850.7 *7*	100 *6*	0.0	0^+	E1	pol=−0.98 *4* Γ_γ=0.55 eV *12*.
8908.8	1^-	8907.8 *7*	100	0.0	0^+	E1	pol=−0.93 *4* Γ_γ=1.37 eV *23*.
9024.1	1^-	9023.1 *20*	100	0.0	0^+	E1	pol=−1.05 *22*
9148.4	1^-	9147.4 *24*	100	0.0	0^+	E1	pol=−0.91 *22*

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^{44}Ca(γ,γ'),(pol γ,γ') 2011Is01,1986Be30 (continued)

γ(^{44}Ca) (continued)

E_i(level)	J^{π}_i	E_γ	I_γ	E_f	J^{π}_f	Mult.#	Comments
9273.5	1−	9272.5 *8*	100	0.0	0+	E1	pol=−0.95 *4* Γ_γ=0.433 eV *96*.
9317.2	1−	9316.1 *10*	100	0.0	0+	E1	pol=−0.96 *5*
9664.9	1−	8508.5 *33*	17 *8*	1157.06	2+		pol=+0.13 *23*
		9663.7 *7*	100 *6*	0.0	0+	E1	pol=−0.99 *3*
9814.1	1−	9812.9 *11*	100	0.0	0+	E1	pol=−0.89 *6*
9898.2	1−	9897.0 *10*	100	0.0	0+	E1	pol=−0.88 *6*

† Rounded-off value from the Adopted Gammas.

‡ From 1986Be30.

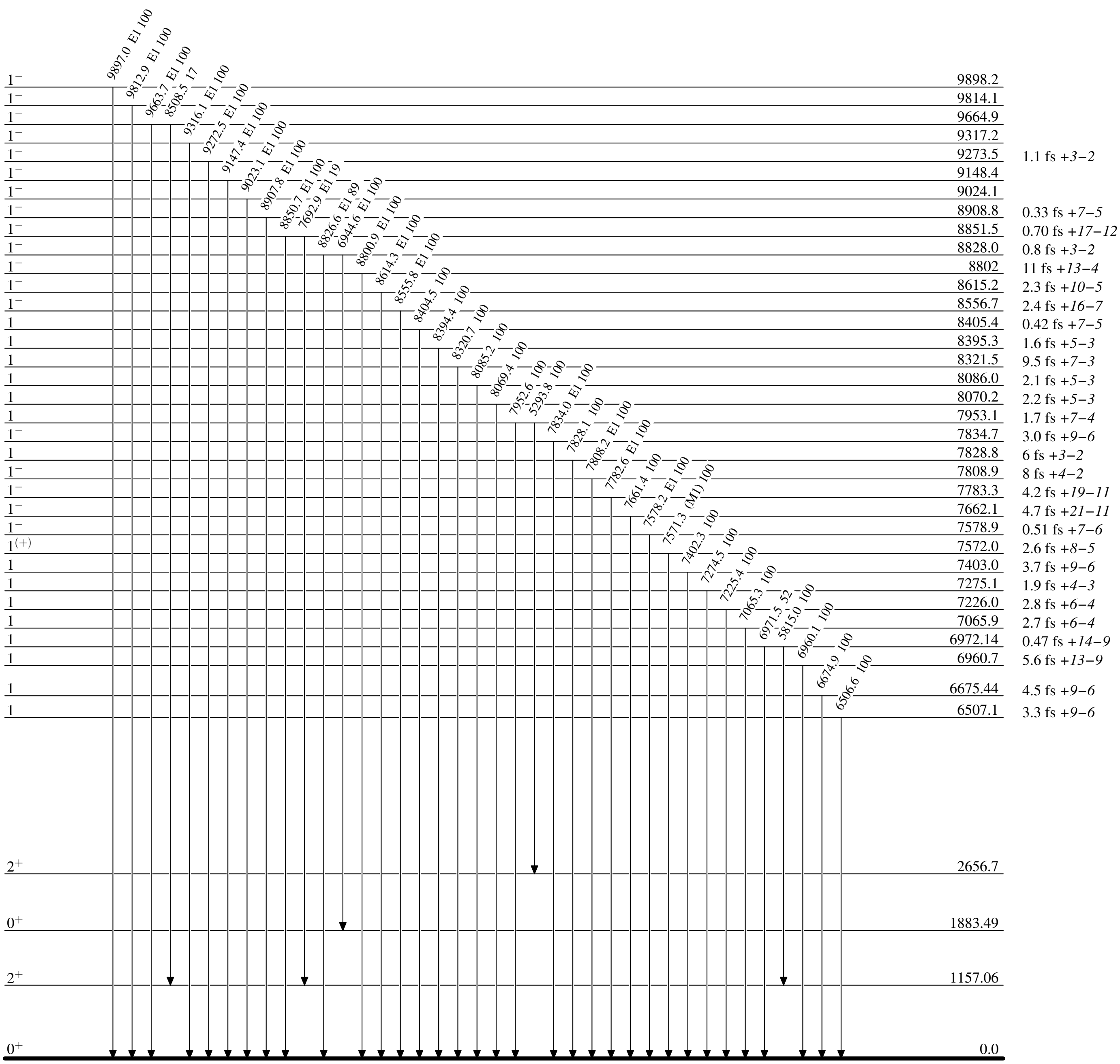
From γ(linear polarization), E1 for negative value of γ polarization asymmetry and M1 for positive value. Exceptions are noted.

@ The pol value of −0.65 *2* is combined for unresolved 7572.0γ+7578.2γ. 2011Is01 estimated pol=−0.61 *6* if the stronger state at 7578 keV is assumed as 1^- and weaker state at 7572 keV as 1^+. Based on this estimate, evaluators assign mult=E1 for the 7578.2-keV transition, and (M1) for the 7571.3-keV transition, since the measured polarization value is likely dominated by the stronger 7578.2 transition.

^{44}Ca(γ,γ′),(pol γ,γ′) 2011Is01,1986Be30

Level Scheme

Intensities: Relative photon branching from each level

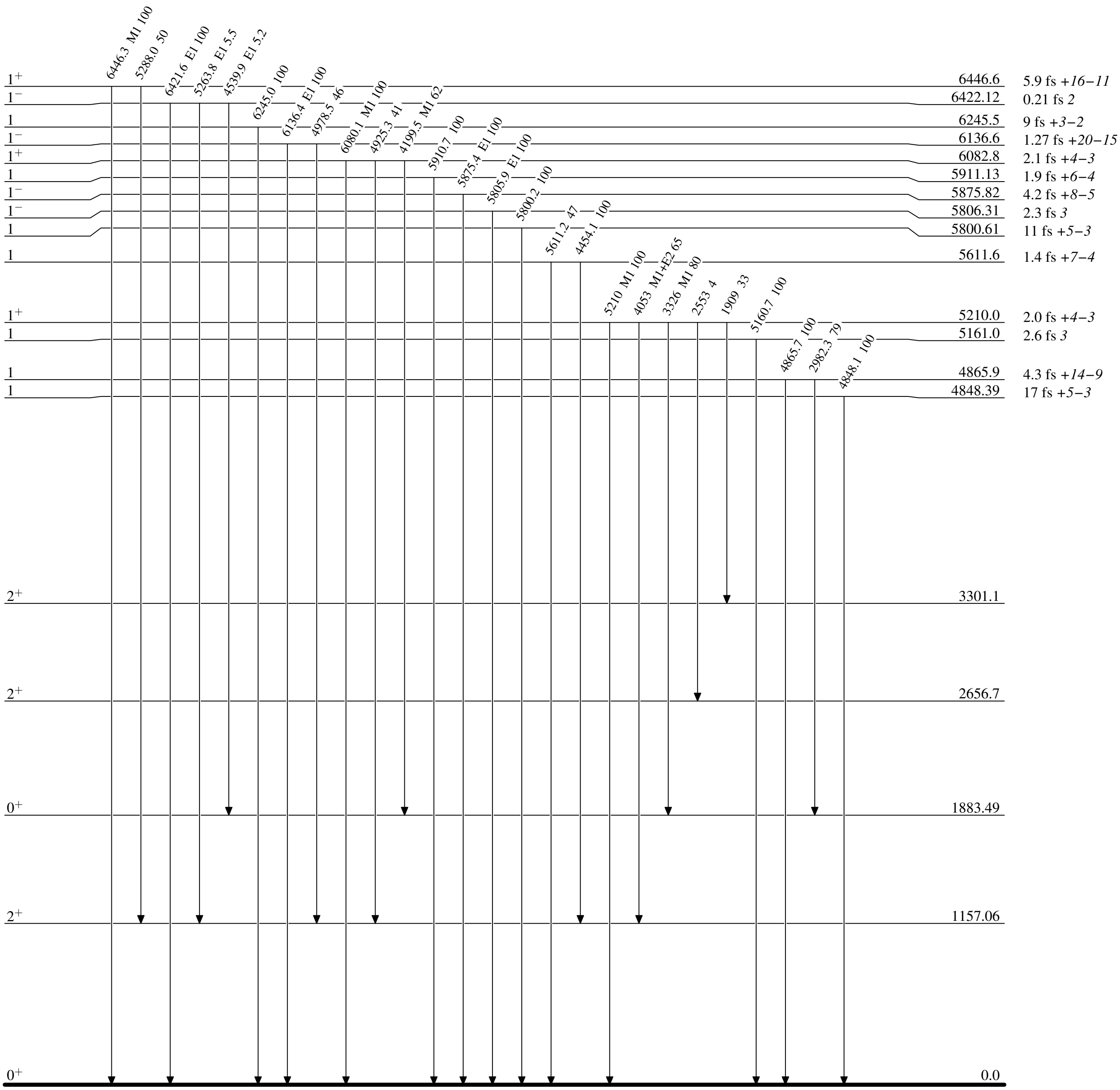


$^{44}_{20}Ca_{24}$

^{44}Ca(γ,γ′),(pol γ,γ′) 2011Is01,1986Be30

Level Scheme (continued)

Intensities: Relative photon branching from each level

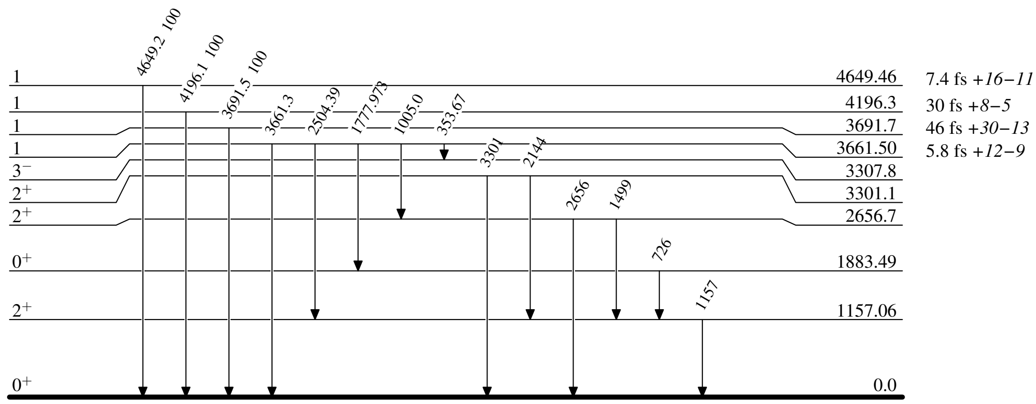


$^{44}_{20}Ca_{24}$

$^{44}Ca(\gamma,\gamma')$,(pol γ,γ') 2011Is01,1986Be30

Level Scheme (continued)

Intensities: Relative photon branching from each level



$^{44}_{20}Ca_{24}$