^{76}Ge(α,2nγ) 1987Sc07,1982Ma45

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Ameenah R. Farhan, Balraj Singh	NDS 110, 1917 (2009)	30-Jun-2009

1987Sc07: E=16-27 MeV, ^{76}Ge(α,2nγ); measured γ, $\gamma\gamma$, σ(E,Eγ, θ), linear polarization, Doppler shift, γ(t); deduced levels, J$^{\pi}$, $T_{1/2}$; enriched target,Ge(Li) detector.

1982Ma45: E=25-33 MeV; ^{76}Ge(α,2nγ); enriched target, hyperpure≥Compton polarimeter; measured γ, $\gamma\gamma$, σ(Eγ,θ), γ-linear polarization.

Others:

1973Wy01,1971WyZX: E=27.5 MeV, ^{76}Ge(α,2n); report ce measurements. Ice(K) and Ice(L) were measured At 90° to the beam direction and corrected for angular distribution effects.

1970Li11: E=20-70 MeV. ^{76}Ge(α,2nγ); measured γ, $\gamma\gamma$, and $\gamma(\theta)$.

Additional information 1.

The decay scheme is mainly from 1987Sc07. Data agree partly well with those of 1982Ma45 except for a few cases. Polarization data In 1987Sc07 are consistent with those of 1982Ma45. Discrepancies appear In spin and parity assignments and placements of a few levels. ce data are from 1973Wy01 and 1971WyZX.

^{78}Se Levels

E(level)[†]	J$^{\pi}$[‡]	$T_{1/2}$[#]	Comments
0.0[b]	0$^+$		
613.71[b] 10	2$^+$	8.3[&] ps 14	
1308.65[c] 16	2$^+$	3.8[&] ps 10	
1502.58[b] 18	4$^+$	0.9 ps 2	$T_{1/2}$: 0.87 ps 21 from DSA and 0.97 ps 28 recoil-distance method (1987Sc07) with adopted value of 0.9 ps 2.
1854.02[c] 21	3$^+$	1.2[a] ps 4	
2190.54[c] 20	4$^+$	0.7[a] ps 3	
2507.52[d] 22	3$^-$	6.2[&] ps 14	
2546.42[b] 22	6$^+$	0.49[a] ps 14	
2629.4 6			
2735.8[c] 3	(5$^+$)	0.62[a] ps 21	
2742.45[d] 21	4$^-$	0.42[&] ns 14	
2889.86[d] 20	5$^-$	18[&] ps 5	
2949.37 25	4$^-$	>1.4[@a] ps	
3013.89[e] 21	6$^-$	3.0 ns 5	$T_{1/2}$: adopted by 1987Sc07. Recoil-distance method gives 3.8 ns 7, pulsed beam γ-timing method gives 2.7 ns 3.
3140.1[c] 4	(6$^+$)	0.28[a] ps +14 −7	
3306.82[d] 23	6$^-$	11[&] ps 4	
3488.1? 6		0.12[@a] ps 4	
3522.9[d] 3	7$^-$	1.4[a] ps +7 −4	
3550.0[e] 3	(7$^-$)	3.5 ps 21	$T_{1/2}$: adopted by 1987Sc07 from their DSA value of>1.4 ps, and recoil-distance value of<5.5 ps.
3584.9[b] 3	8$^+$	0.42[a] ps 14	
3704.8[c] 6	(7$^+$)	0.83[a] ps 21	
3830.6[c] 3	8$^+$	0.55[a] ps 14	E(level): the 8$^+$ member of β band is either 3831 or 4121 level.
4048.1[d] 3	8$^-$	0.9[a] ps 3	
4121.2 4	8$^+$	>0.7[a] ps	E(level): this level May Be the 8$^+$ member of β band, although, 3831 level is presently assigned As the 8$^+$ member. $T_{1/2}$: upper limit is<0.35 ns from pulsed-beam γ-timing method (1987Sc07).
4214.0[e] 4	(8$^-$)	>1.4[a] ps	
4411.5[d] 4	(9$^-$)		
4623.7[b] 5	(10$^+$)		

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^{76}Ge(α,2nγ) 1987Sc07,1982Ma45 (continued)

^{78}Se Levels (continued)

E(level)[†]	J$^{\pi}$[‡]	$T_{1/2}$[#]
4785.4[c] *5*	(10^{+})	>1.4[a] ps
4819.0[e] *6*	(9^{-})	0.9[@a] ps *3*
4857.7[c] *7*	(9^{+})	1.1[@a] ps *4*
5094.9 *7*		
5687.6 *8*		
5782.4[b] *7*	(12^{+})	>0.6[a] ps

[†] From least-squares fit to Eγ′s.
[‡] From 'Adopted Levels'.
[#] From DSAM or recoil-distance Doppler shift (RDM) (1987Sc07).
[@] Derived on the basis of the tentative assignment of the transition and the assumption that its lineshape is not influenced by unknown transitions (1987Sc07).
[&] From recoil-distance Doppler shift (RDM) method (1987Sc07).
[a] From Doppler-shift attenuation (DSA) method (1987Sc07).
[b] Band(A): g.s. band.
[c] Band(B): Possible β band.
[d] Band(C): Possible Octupole band.
[e] Band(D): ΔJ=1 band based on 6^{-}.

γ(^{78}Se)

E$_{\gamma}$[†]	I$_{\gamma}$[†]	E$_i$(level)	J$^{\pi}_i$	E$_f$	J$^{\pi}_f$	Mult.[‡]	α[a]	Comments
124.1 *1*	2.0 *1*	3013.89	6^{-}	2889.86	5^{-}	M1(+E2)	0.0566	α(K)=0.0502 *8*; α(L)=0.00547 *8*; α(M)=0.000854 *12*; α(N+..)=7.23×10^{-5} *11* α(N)=7.23×10^{-5} *11* α: for pure M1. Mult.,δ: 1982Ma45 deduce M1+E2 with δ=−0.12 *+10−11*. A$_2$=−0.04 *3* (1987Sc07).
161.9 *2*	≈2[#]	4785.4	(10^{+})	4623.7	(10^{+})			pol=+0.74 *13* (1987Sc07); A$_2$=+0.07 *1*, pol=+0.06 *5* (1982Ma45).
216.1 *2*	0.8 *1*	3522.9	7^{-}	3306.82	6^{-}	M1	0.01327	α(K)=0.01179 *17*; α(L)=0.001265 *18*; α(M)=0.000197 *3*; α(N+..)=1.675×10^{-5} *24* α(N)=1.675×10^{-5} *24* δ=−0.05 *5*, A$_2$=−0.32 *5*, A$_4$=+0.16 *7*, pol=−0.5 *4* (1987Sc07).
245.6 *2*	1.8 *1*	3830.6	8^{+}	3584.9	8^{+}	M1(+E2)	0.00960	α(K)=0.00854 *12*; α(L)=0.000912 *13*; α(M)=0.0001422 *21*; α(N+..)=1.209×10^{-5} *18* α(N)=1.209×10^{-5} *18* α: for pure M1. Mult.,δ: 1982Ma45 give M1+E2 with δ=+0.29 *+3−6*. A$_2$=+0.40 *5*, A$_4$=+0.08 *7*, pol=+0.48 *15*, δ=+0.05 *21* (1987Sc07); A$_2$=+0.44 *3*, pol=+1.27 *17* (1982Ma45).
271.4 *1*	6.2 *2*	3013.89	6^{-}	2742.45	4^{-}	(E2)	0.0211	α(K)=0.0187 *3*; α(L)=0.00211 *3*; α(M)=0.000327 *5*; α(N+..)=2.69×10^{-5} *4* α(N)=2.69×10^{-5} *4* A$_2$=+0.17 *2*, pol=+0.22 *6* (1987Sc07); A$_2$=+0.19

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^{76}Ge(α,2nγ) 1987Sc07,1982Ma45 (continued)

γ(^{78}Se) (continued)

E_γ [†]	I_γ [†]	E_i(level)	J^π_i	E_f	J^π_f	Mult. [‡]	δ [‡]	α [a]	Comments
									1, A_4=−0.07 *2*, pol=+1.19 *4* (1982Ma45). Mult.,δ: 1982Ma45 deduce M1+E2 with δ=1.28 *+26−21*.
290.5 *2*	0.9 *1*	4121.2	8^+	3830.6	8^+	M1(+E2)		0.00633	α(K)=0.00563 *8*; α(L)=0.000599 *9*; α(M)=9.33×10^{-5} *14*; α(N+..)=7.94×10^{-6} *12* α(N)=7.94×10^{-6} *12* α: for pure M1. δ=+0.07 *17* from A_2=+0.36 *5*, pol=+0.62 *27* (1987Sc07); A_2=+0.54 *6*, pol=+0.97 *24* (1982Ma45).
343.5 *2*	2.1 *1*	2889.86	5^-	2546.42	6^+	E1			A_2=−0.15 *3*, A_4=+0.07 *5*, pol=+0.52 *12* (1987Sc07).
357.3 *3*	1.2 *1*	3306.82	6^-	2949.37	4^-	E2		0.00816	α(K)=0.00723 *11*; α(L)=0.000796 *12*; α(M)=0.0001236 *18*; α(N+..)=1.027×10^{-5} *15* α(N)=1.027×10^{-5} *15* A_2=+0.28 *7*, pol=+0.54 *17* (1987Sc07); A_2=+0.25 *4*, pol=+0.63 *14* (1982Ma45).
363.1 *4*	0.9 *1*	4411.5	(9^-)	4048.1	8^-				
382.4 *2*	4.4 *2*	2889.86	5^-	2507.52	3^-	E2		0.00650	α(K)=0.00576 *9*; α(L)=0.000631 *9*; α(M)=9.81×10^{-5} *14*; α(N+..)=8.17×10^{-6} *12* α(N)=8.17×10^{-6} *12* A_2=+0.22 *2*, pol=+0.30 *8* (1987Sc07); A_2=+0.15 *2*, A_4=−0.08 *3*, pol=+0.40 *6* (1982Ma45).
416.9 *2*	5.6 *3*	3306.82	6^-	2889.86	5^-	M1+E2	−0.4 *1*		A_2=−0.70 *4*, A_4=−0.01 *5*, pol=−0.06 *4* (1987Sc07).
441.8 *2*	0.9 *1*	2949.37	4^-	2507.52	3^-	M1+E2	−0.6 *3*		A_2=−0.79 *7* (1987Sc07); A_2=−0.36 *5* (1982Ma45).
467.4 *2*	1.5 *1*	3013.89	6^-	2546.42	6^+	E1			A_2=+0.09 *5*, pol=−0.5 *4* (1987Sc07); A_2=+0.08 *4*, pol=−0.38 *17* (1982Ma45).
509 *1*	4 [#]	3522.9	7^-	3013.89	6^-				
536.2 [d] *2*	4.5 [d#]	3550.0	(7^-)	3013.89	6^-	[@]			
536.2 [d] *2*	0.5 [d#]	4121.2	8^+	3584.9	8^+	M1+E2 [@]	−0.4 *3*		
545.4 *2*	4.1 *2*	1854.02	3^+	1308.65	2^+	M1+E2	+0.45 *10*		A_2=+0.24 *3*, A_4=+0.08 *4* (1987Sc07); A_2=+0.21 *2* (1982Ma45). δ: 1982Ma45 report δ=−2.6 *+10 −12*.
551.9 *2*	5.1 *3*	2742.45	4^-	2190.54	4^+	E1			A_2=+0.26 *4*, A_4=+0.02 *5*, pol=−0.32 *10* (1987Sc07); A_2=+0.20 *2*, A_4=−0.07 *2*, pol=−0.25 *6* (1982Ma45).
564.4 *4*	1.5 *2*	3306.82	6^-	2742.45	4^-	E2			A_2=+0.24 *10*, A_4=−0.19 *17* (1987Sc07).
593.7 *5*	2.0 *2*	3140.1	(6^+)	2546.42	6^+	M1(+E2)	−0.2 *2*		A_2=+0.21 *12*, pol=+0.6 *4* (1987Sc07).
613.7 *1*	100	613.71	2^+	0.0	0^+	E2			A_2=+0.24 *1*, A_4=−0.06 *1*, pol=+0.25 *1* (1987Sc07): A_2=+0.19 *1*, A_4=−0.09 *1*, pol=+0.36 *1* (1982Ma45); Ice(K)=100 *15*, Ice(L)=9.4 *2*. α(K)=0.00133 and α(L)=0.00014 were used for normalization.

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^{76}Ge(α,2nγ) 1987Sc07,1982Ma45 (continued)

γ(^{78}Se) (continued)

E_γ[†]	I_γ[†]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[‡]	δ[‡]	Comments
633.0 *5*	6.2 *3*	3522.9	7⁻	2889.86	5⁻	E2		A_2=+0.29 *3*, A_4=−0.06 *4*, pol=+0.25 *7* (1987Sc07).
655.8[e]	<0.5	4785.4	(10⁺)					
664.0 *3*	0.8 *1*	4214.0	(8⁻)	3550.0	(7⁻)			A_2=−0.92 *10*, A_4=+0.33 *15* (1987Sc07); A_2=−0.23 *6*, A_4=+0.28 *9* (1982Ma45).
688.0 *3*	2.9 *2*	2190.54	4⁺	1502.58	4⁺	(M1)		Mult.,δ: 1982Ma45 assume mult=M1+E2 with 2 values of δ, *i.e.* δ=−1.43 *+58−82* and δ=0.08 *+17−15*. A_2=+0.26 *5*, A_4=+0.01 *7* (1987Sc07); A_2=+0.19 *3*, A_4=−0.07 *4*, pol=+0.24 *11* (1982Ma45).
695.0 *2*	13.0 *6*	1308.65	2⁺	613.71	2⁺	M1+E2	+4.0 *7*	A_2=+0.08 *2*, A_4=−0.04 *3* (1987Sc07); A_2=−0.03 *1*, A_4=−0.01 *2*, pol=+0.11 *4* (1982Ma45); Ice(K)=25 *5*, α(K)exp=0.0017 *4*.
741.2 *2*	6.4 *3*	4048.1	8⁻	3306.82	6⁻	E2		A_2=+0.45 *3*, A_4=−0.11 *5*, pol=+0.77 *19* (1987Sc07); A_2=+0.29 *2*, A_4=−0.11 *3*, pol=+0.77 *9* (1982Ma45).
760.4 *3*	2.4 *1*	3306.82	6⁻	2546.42	6⁺	(E1)		A_2=+0.35 *5*, pol=−0.34 *27* (1987Sc07); A_2=+0.32 *4*, pol=−0.19 *17* (1982Ma45).
794.6[e] *4*	<0.8[#]	4623.7	(10⁺)	3830.6	8⁺			
862.0 *5*	2.7 *3*	4411.5	(9⁻)	3550.0	(7⁻)			A_2=+0.13 *10*, A_4=−0.01 *5* (1987Sc07).
881.9[c] *2*	8[c#]	2190.54	4⁺	1308.65	2⁺	&		
881.9[c] *2*	8[c#]	2735.8	(5⁺)	1854.02	3⁺	&		
888.8 *2*	78[#]	1502.58	4⁺	613.71	2⁺	E2		A_2=+0.30 *1*, A_4=−0.07 *1*, pol=+0.39 *2* (1987Sc07); A_2=+0.27 *1*, A_4=−0.11 *1*, pol=+0.44 *1* (1982Ma45); Ice(K)=29 *5*, Ice(L)=2.8 *6*, α(K)exp=5.8×10^{-4} *11*, α(L)exp=5.9×10^{-5} *13*.
889[de] *1*	0.5[d#]	2742.45	4⁻	1854.02	3⁺			
889[de] *1*	3.5[d#]	4411.5	(9⁻)	3522.9	7⁻			
902.2 *6*	≈1	5687.6		4785.4	(10⁺)			
941.7 *5*	≈1	3488.1?		2546.42	6⁺			
949.6 *4*	3.3 *4*	3140.1	(6⁺)	2190.54	4⁺			A_2=+0.31 *3* (1982Ma45).
955.9 *5*	2.3 *2*	4785.4	(10⁺)	3830.6	8⁺	(E2)		A_2=+0.13 *10* (1987Sc07); A_2=+0.16 *3*, A_4=−0.28 *5*, pol=+0.54 *24* (1982Ma45).
969.0 *5*	4.0 *3*	3704.8	(7⁺)	2735.8	(5⁺)	E2		A_2=+0.43 *7*, A_4=−0.12 *11* (1987Sc07); A_2=+0.21 *2*, A_4=−0.17 *3*, pol=+0.40 *18* (1982Ma45).
976.7 *4*	3.3 *6*	3522.9	7⁻	2546.42	6⁺	D		A_4=−0.14 *12* (1987Sc07); A_2=−0.12 *4*, A_4=−0.14 *6* (1982Ma45). Negative A_4 In 1982Ma45 is inconsistent with ΔJ=1 transition. Mult.: 1982Ma45 assign mult=E1 with δ=+0.06 *+11−10*.
1005.0 *6*	2.4 *2*	2507.52	3⁻	1502.58	4⁺	(E1)		A_2=−0.16 *7*, A_4=−0.11 *11*, pol=+0.5 *4* (1987Sc07).
1038.6 *3*	21.3 *10*	3584.9	8⁺	2546.42	6⁺	E2		A_2=+0.25 *3*, A_4=−0.10 *4*, pol=+0.46 *8* (1987Sc07); A_2=+0.332, A_4=−0.086, from 1970Li11; Ice(K)=5.9 *12*, α(K)exp=4.2×10^{-4} *11*.
1040.3 *6*	3.8 *9*	4623.7	(10⁺)	3584.9	8⁺			
1043.9 *3*	46.3 *9*	2546.42	6⁺	1502.58	4⁺	E2		A_2=+0.26 *3*, A_4=−0.10 *5*, pol=+0.46 *5* (1989Sc07); A_2=+0.19 *1*, A_4=−0.19 *1*, pol=+0.56 *2* (1982Ma45); Ice(K)=11.7 *24*, α(K)exp=4.38×10^{-4} *11*.
1046.8 *6*	1.8 *3*	5094.9		4048.1	8⁻			

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$^{76}Ge(\alpha,2n\gamma)$ 1987Sc07,1982Ma45 (continued)

$\gamma(^{78}Se)$ (continued)

E_γ[†]	I_γ[†]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[‡]	Comments
1095.2 *5*	0.5[#]	2949.37	4^-	1854.02	3^+		
1126.8 *5*	2.1 *2*	2629.4		1502.58	4^+		A_2=+0.43 *8*, A_4=+0.11 *11* (1987Sc07).
1152.9 *4*	1.6 *1*	4857.7	(9^+)	3704.8	(7^+)	(E2)	A_2=+0.35 *8* (1987Sc07); A_2=+0.99 *5*, A_4=−0.07 *6*, pol=+0.7 *4* (1982Ma45).
1158.7[be] *5*	0.5[#]	3704.8	(7^+)	2546.42	6^+		
1158.7[b] *5*	1.5[#]	5782.4	(12^+)	4623.7	(10^+)		
1199.3 *6*	5.2 *3*	2507.52	3^-	1308.65	2^+	(E1)	A_2=−0.24 *5* (1987Sc07); A_2=−0.14 *2*, A_4=−0.25 *3*, pol=+0.33 *15* (1982Ma45).
1200 *1*	≈1	4214.0	(8^-)	3013.89	6^-		
1202.2[e] *6*	≤0.3[#]	4785.4	(10^+)	3584.9	8^+		
1232.6 *5*	2.1 *3*	2735.8	(5^+)	1502.58	4^+		A_2=+0.21 *15*, A_4=+0.01 *23* (1987Sc07).
1239.3 *4*	3[#]	2742.45	4^-	1502.58	4^+		A_2=+0.35 *2*, A_4=+0.04 *3* (1987Sc07);
1240.5 *4*	6[#]	1854.02	3^+	613.71	2^+	M1+E2	A_2=+0.35 *2*, A_4=+0.04 *3* (1987Sc07); A_2=+0.23 *1*, A_4=−0.04 *2*, pol=+0.17 *7* (1982Ma45).
1269.0 *5*	1.5 *2*	4819.0	(9^-)	3550.0	(7^-)		
1273.2[e] *5*	0.8 *2*	4857.7	(9^+)	3584.9	8^+		
1284.1 *3*	5.5 *3*	3830.6	8^+	2546.42	6^+	E2	A_2=+0.26 *5*, A_4=−0.18 *7* (1987Sc07); A_2=+0.23 *2* A_4=−0.18 *3*, pol=+0.30 *17* (1982Ma45).
1308.7 *3*	7.2 *3*	1308.65	2^+	0.0	0^+	(E2)	A_2=+0.21 *3* (1987Sc07); A_2=+0.08 *2*, A_4=+0.02 *2*, pol=+0.13 *11* (1982Ma45).
1387.4 *2*	13.2 *6*	2889.86	5^-	1502.58	4^+	E1	A_2=−0.15 *3*, pol=+0.27 *11* (1987Sc07); A_2=−0.21 *1*, A_4=−0.04 *2*, pol=+0.12 *7* (1982Ma45).
1446.7[e] *5*	0.6[#]	2949.37	4^-	1502.58	4^+		
1574 *1*	0.7 *2*	4121.2	8^+	2546.42	6^+	(Q)	A_2=+0.38 *15*, A_4=−0.23 *32* (1987Sc07).
1576 *1*	0.7 *2*	2190.54	4^+	613.71	2^+		
1893.6 *4*	1.8 *2*	2507.52	3^-	613.71	2^+		A_2=−0.05 *6*, A_4=−0.12 *9* (1987Sc07); A_2=−0.25 *4*, (1982Ma45).

† From 1987Sc07.
‡ From angular distribution and polarization data In 1987Sc07.
# The intensity was obtained from the coincidence measurements (1987Sc07). No uncertainties given.
@ Mult=M1+E2 with δ=0.4 *3* (1987Sc07) or −0.84 *+17−23* (1982Ma45) for the doubly-placed 536γ.
& Mult=E2 for the doubly-placed 881.9γ (1987Sc07).
a Total theoretical internal conversion coefficients, calculated using the BrIcc code (2008Ki07) with Frozen orbital approximation based on γ-ray energies, assigned multipolarities, and mixing ratios, unless otherwise specified.
b Multiply placed.
c Multiply placed with undivided intensity.
d Multiply placed with intensity suitably divided.
e Placement of transition in the level scheme is uncertain.

<u>^{76}**Ge(α,2nγ) 1987Sc07,1982Ma45**</u>

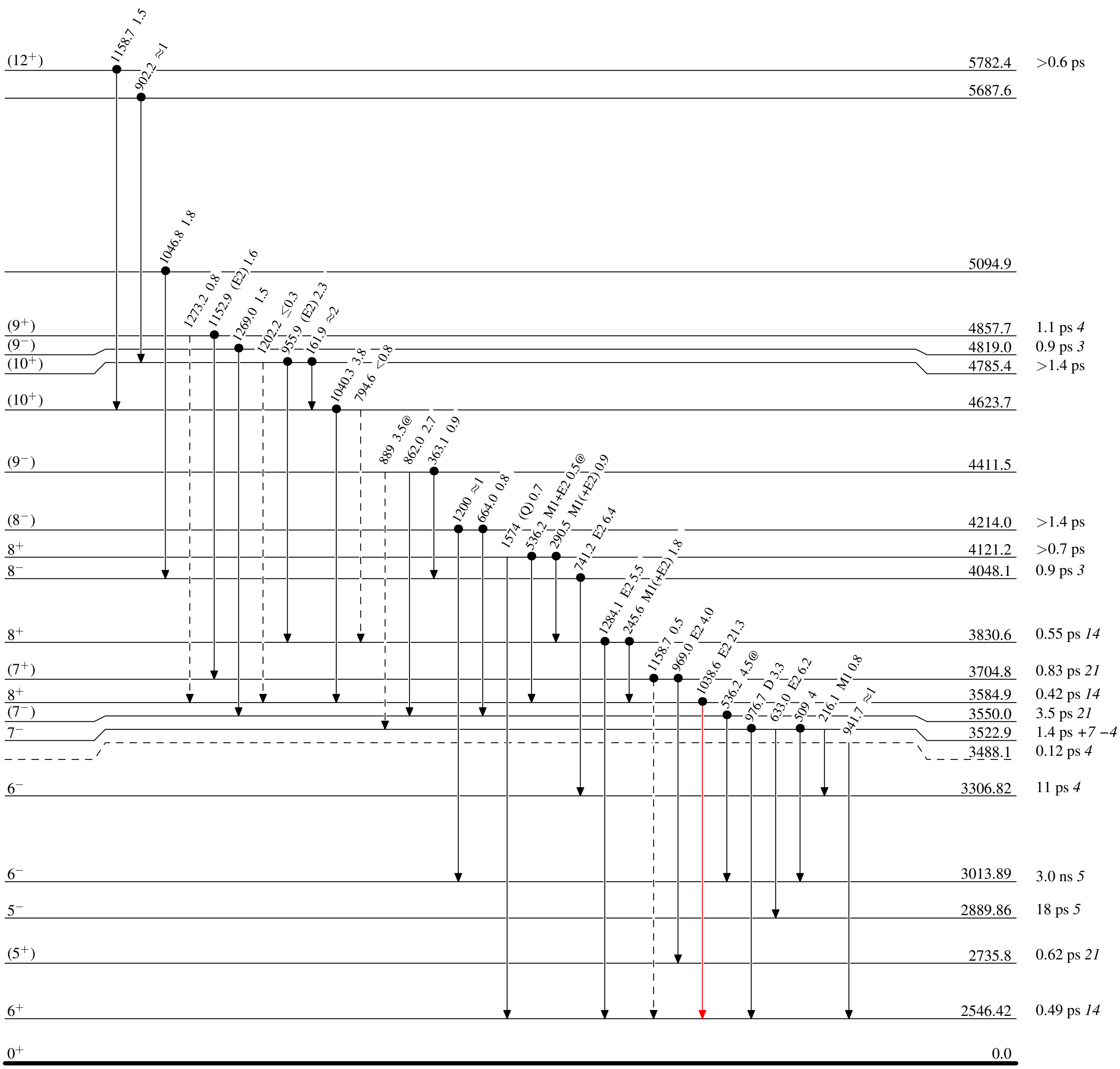
<u>Level Scheme</u>

Intensities: Relative I_γ

@ Multiply placed: intensity suitably divided

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

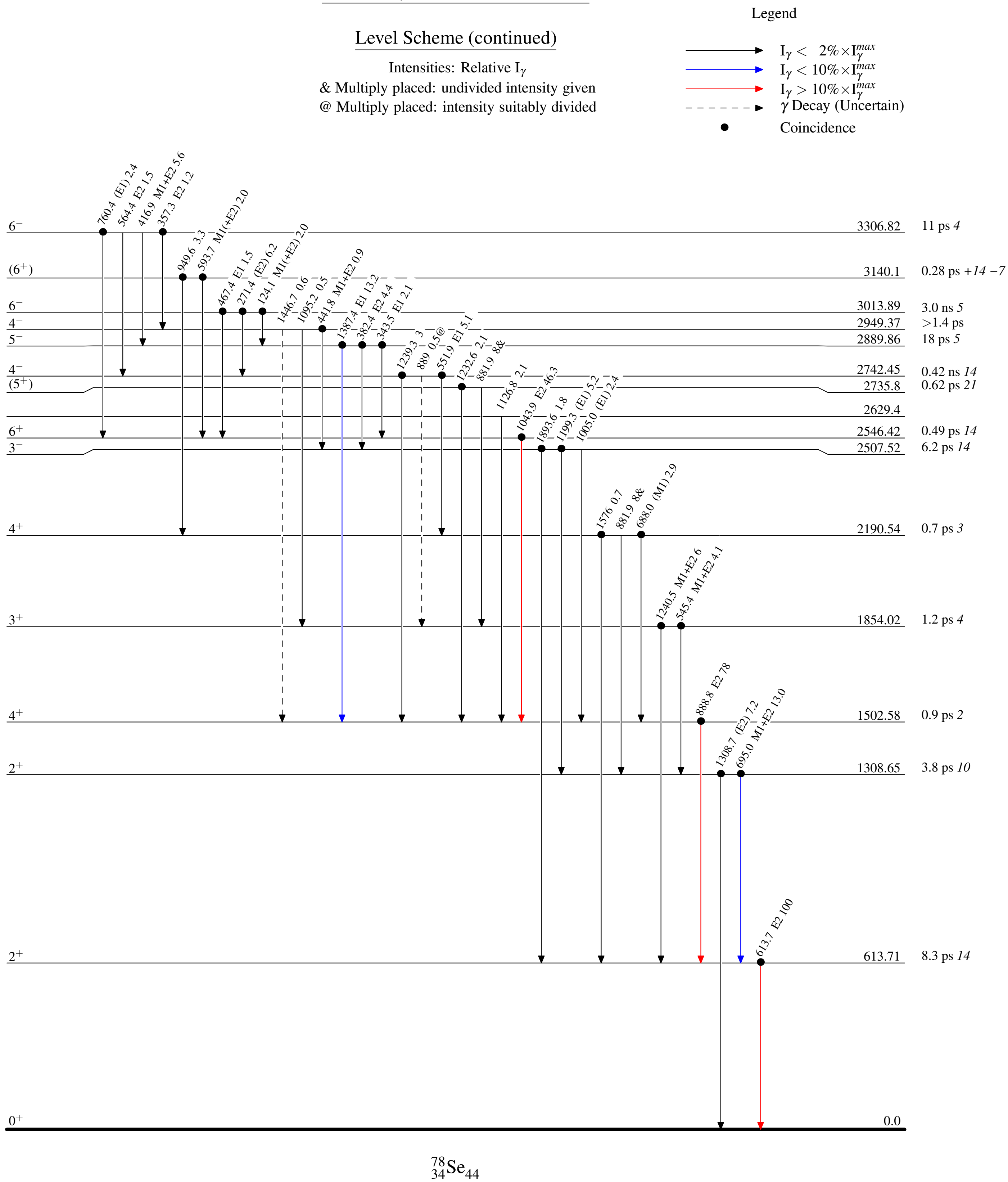


$^{78}_{34}Se_{44}$

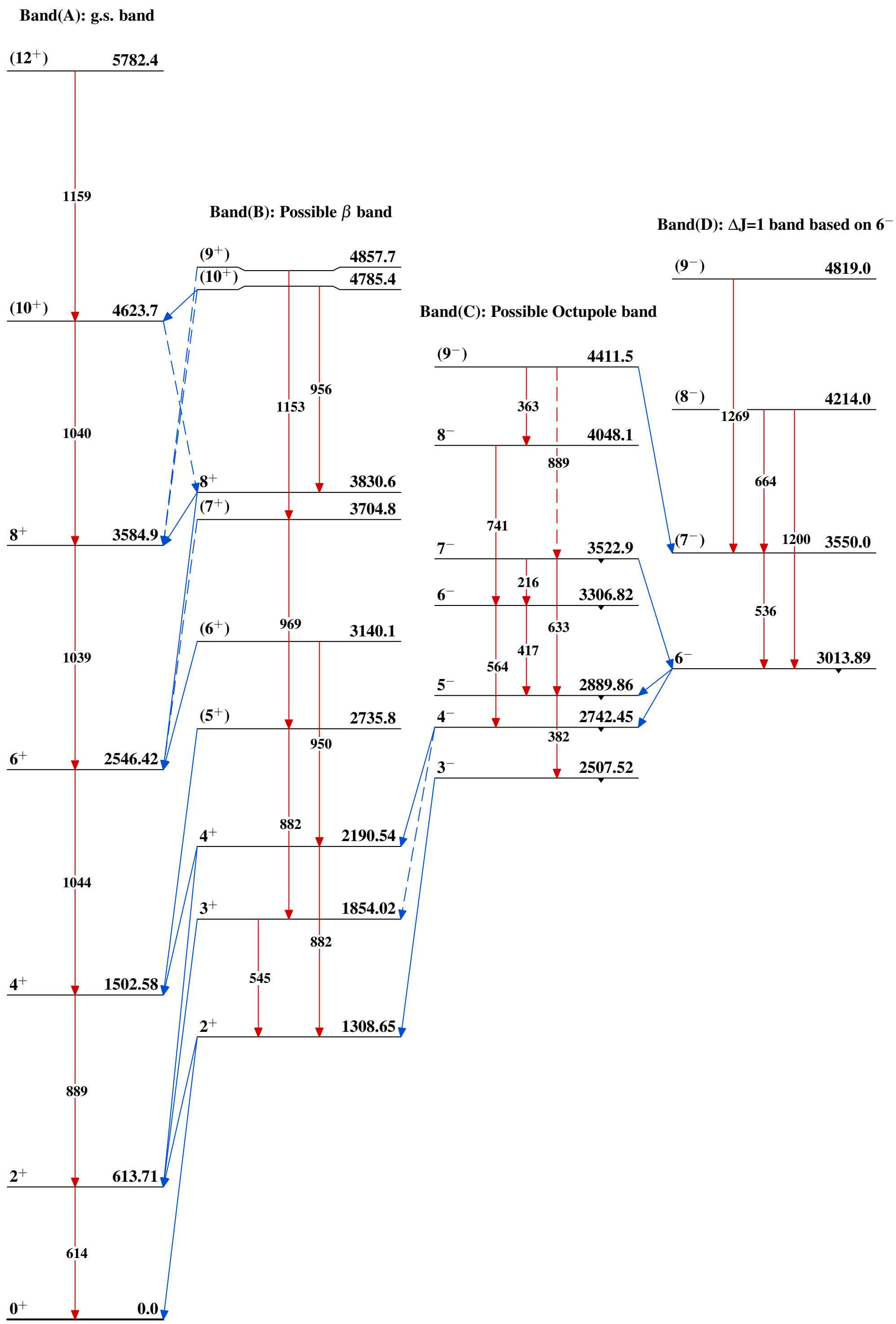
^{76}Ge(α,2nγ) 1987Sc07,1982Ma45

Level Scheme (continued)

Intensities: Relative I_γ
& Multiply placed: undivided intensity given
@ Multiply placed: intensity suitably divided



^{76}Ge(α,2nγ) 1987Sc07,1982Ma45



$^{78}_{34}Se_{44}$