$^{12}C(^{12}C,n\gamma)$ 2013Je04,1977Ev02

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	M. S. Basunia[#], A. Chakraborty[##]	NDS 171, 1 (2021)	1-Jun-2020

Others: 2015Bu08,2006Ag08,2006Je06,2005Je06,2004Je02,1990Ti02,1977Ev02, 1974Sp03,1973Wa26.

2013Je04,2004Je02: E(^{12}C)=16,22 MeV provided by the ATLAS accelerator at Argonne National Laboratory. Target=160 μg/cm^2 ^{12}C. Measured Eγ, Iγ,$\gamma\gamma$-coin,$\gamma\gamma(\theta)$(DCO), $T_{1/2}$ using the Gammasphere array and the fractional Doppler shift technique. Deduced levels, J, π, multipolarity, bands, mirror energy differences. 2005Je06 and 2006Je06 are conference reports from the same research group.

1977Ev02: E=19.3, 37-40 MeV; Two runs with pulsed beam and one run with a dc beam. 1) with two Ge(Li) at +90° and −90° and a Si detector; 2) γ rays were detected at 0°, 30° and 60° with Ge(Li) and at −90° with Ge(Li) and six NaI(Tl); 3) NE213 liquid scintillator detector ±50° and γ at 90°. Measured particle-γ coin, time-of-flight, angular distribution of neutrons; Deduced excited levels, spin, parity, $T_{1/2}$ by DSA method, L.

2015Bu08: ^{12}C(^{12}C,n), E=7.5, 9.5 MeV; measured reaction products, deduced yields, S-factors, astrophysical reaction rate.

^{23}Mg Levels

E(level)[†]	J$^\pi$[@]	$T_{1/2}$[&]	Comments
0.0[a]	3/2$^+$		
450.3[a] *6*	5/2$^+$	1.15 ps *12*	E(level): From 1973Wa26. $T_{1/2}$: From τ=1.66 ps *17*: wt. ave. of τ=1.57 ps *12* (1990Ti02) and τ=2.00 ps *24* (1973Wa26).
2050.3[a] *6*	7/2$^+$		
2356.3 *8*	1/2$^+$		
2713.6[a] *7*	9/2$^+$	61 fs *8*	$T_{1/2}$: From τ=88 fs *12*: wt. ave. of τ=91 fs *12* (1990Ti02) and τ=80 fs *20* (1973Wa26). Δt lowest input value.
2770.8[b] *7*	1/2$^-$		
2903.5 *7*	3/2$^+$		
3793.3 *8*	3/2$^-$		
3859.6 *7*	5/2$^+$	8.3 fs *21*	$T_{1/2}$: From τ=12 fs *3* (2013Je04).
3970.7[b] *7*	5/2$^-$		
4680.6 *8*	7/2$^+$	6.9 fs *21*	$T_{1/2}$: From τ=10 fs *3* (2013Je04).
5286.7 *9*	5/2$^+$	3.5 fs *14*	$T_{1/2}$: From τ=5 fs *2* (2013Je04).
5452.6[a] *7*	11/2$^+$		
5690.4 *7*	7/2$^+$		
5936.8 *9*	11/2$^+$		
5992.3 *10*	3/2$^-$		
6128.5 *8*	7/2$^-$	12.5 fs *21*	$T_{1/2}$: From τ=18 fs *3* (2013Je04).
6131.7 *13*	(1/2,5/2)		
6193.1[a] *9*	13/2$^+$	11.9 fs *21*	$T_{1/2}$: From τ=17 fs *3* (2013Je04).
6238.7 *12*	(9/2$^+$)		
6372.1 *12*	(7/2$^+$)		
6375.7 *12*	(7/2$^+$)		
6446.7 *13*	9/2$^-$		
6448.8[b] *8*	(9/2$^-$)	24.3 fs *55*	$T_{1/2}$: From τ=35 fs *8* (2013Je04).
6513.1 *12*	(7/2$^+$)		
6574.1 *12*	(5/2$^+$)		
6774.8 *13*	(1/2,5/2)		
6802.9 *12*	5/2$^-$		
6804.2 *12*	(7/2$^+$)		
7020.4 *9*	(9/2$^+$)		
7111.3 *12*	(7/2$^+$)		
7143.9 *9*	13/2$^+$		
7149.2 *9*	(9/2$^+$)		

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$^{12}C(^{12}C,n\gamma)$ **2013Je04,1977Ev02 (continued)**

^{23}Mg Levels (continued)

E(level)[†]	J^{π}[@]	$T_{1/2}$[&]	L	Comments
7200[#]				E(level): not reported in any other studies – not adopted. Might be the same level at 7228.
7227.9 *13*	(1/2,5/2)			
7260.9 *10*	$11/2^+$	1.4 fs *7*		$T_{1/2}$: From τ=2 fs *1* (2013Je04).
7382.4 *12*	$7/2^+$			
7449.7 *9*	$9/2^+$			
7496.0 *12*	$(9/2^+)$			
7624.0 *11*	$9/2^+$	2.8 fs *14*		Γ_p=1.6 meV +*22*−*10* × 10^{-13} (2004Je02). $T_{1/2}$: From τ=4 fs *2* (2004Je02).
7647 *3*	$3/2^+$			Γ_p=2.4 meV +*34*−*15* × 10^{-9} (2004Je02).
7769.4 *8*	$(9/2^-)$	1.4 fs *7*		$T_{1/2}$: From τ=2 fs *1* (2004Je02).
7780.7 *10*	$11/2^+$	<0.7 fs		Γ_p=(6 × 10^{-2}) meV (2004Je02). $T_{1/2}$: From τ < 1 fs (2004Je02).
7785.2 *13*	$7/2^{(+)}$	6.9 fs *21*		$T_{1/2}$: From τ=10 fs *3* (2004Je02).
7852.3 *15*	$(7/2^+)$			E(level),J^{π}: Reported in 2004Je02 as 7851.5. Missing in the full version 2013Je04. First author expressed it might be a mistake but did not confirm, while communicated by the reviewer of this manuscript B. Singh (dated: March 14, 2019).
8015.8 *9*	$(5/2^+$ to $11/2^+)$			J^{π}: In 2004Je02.
8160.7 *19*	$5/2^+$			
8945[‡] *8*	$(15/2^+)$	<70 fs	4	%p=15 (1977Ev02) J^{π}: From angular correlations and decay into the g.s. rotational band (1977Ev02). $T_{1/2}$,L: From 1977Ev02.
9610[‡] *8*	$(17/2^+)$	<70 fs		%p=23 (1977Ev02) J^{π}: From angular correlations and comparison to analogue state in ^{23}Na (1977Ev02). $T_{1/2}$: From 1977Ev02.
10040[#]				E(level): not adopted – may be a doublet of 9970 and 10120 in Adopted Levels.
11040[#]				
11210[#]				
11540[#]				
11760[#]				
12210[#]				E(level): not adopted – not reported by others.
12830[#]				E(level): not adopted – not reported by others. May be a doublet of 12690 and 12940 in Adopted Levels.
14000[#]				E(level): not adopted – not reported by others.
14130[‡] *20*	$(21/2^+)$		2	%p=100 (1977Ev02) J^{π}: Consistency with proton penetrability ratios (1977Ev02). L: From 1977Ev02.
14400				E(level): From Table 1 in 1977Ev02. Not included in the level scheme. Not adopted.
14560[‡] *20*	$(19/2^+)$			%p=100 (1977Ev02) J^{π}: Consistency with proton penetrability ratios (1977Ev02).

[†] From least-squares fit to γ-ray energies, except otherwise noted.
[‡] From 1977Ev02.
[#] From Fig 1 in 1977Ev02.
[@] From 2013Je04, based on decay scheme, γ-ray multipolarity, and band assignments.

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$^{12}C(^{12}C,n\gamma)$ 2013Je04,1977Ev02 (continued)

^{23}Mg Levels (continued)

& From 2013Je04 (Doppler shift technique), except otherwise noted.
a Band(A): π+ band.
b Band(B): K^{π}=(1/2$^-$) band.

$\gamma(^{23}Mg)$

E_γ †	I_γ †	E_i(level)	J^π_i	E_f	J^π_f	Mult.&	Comments
178 *1*	1.4 *1*	3970.7	5/2$^-$	3793.3	3/2$^-$		
450.70# *15*		450.3	5/2$^+$	0.0	3/2$^+$	M1+E2	DCO=0.76 *1*
662.04# *40*	28.1 *4*	2713.6	9/2$^+$	2050.3	7/2$^+$	M1+E2	DCO=1.12 *1*
740 *1*	2.0 *1*	6193.1	13/2$^+$	5452.6	11/2$^+$	M1+E2	DCO=0.71 *4*
951 *1*	0.3 *1*	7143.9	13/2$^+$	6193.1	13/2$^+$		
956 *1*		3859.6	5/2$^+$	2903.5	3/2$^+$		
996 *1*	0.8 *2*	6448.8	(9/2$^-$)	5452.6	11/2$^+$		
1023 *1*	0.4 *1*	3793.3	3/2$^-$	2770.8	1/2$^-$		
1067 *1*	0.3 *1*	3970.7	5/2$^-$	2903.5	3/2$^+$		
1200 *1*	0.6 *1*	3970.7	5/2$^-$	2770.8	1/2$^-$		
1207 *1*	0.7 *1*	7143.9	13/2$^+$	5936.8	11/2$^+$		
1459 *1*	0.9 *1*	7149.2	(9/2$^+$)	5690.4	7/2$^+$		
1503 *1*	0.5 *1*	3859.6	5/2$^+$	2356.3	1/2$^+$		
1600 *1*	100.0	2050.3	7/2$^+$	450.3	5/2$^+$	D+Q	DCO=0.59 *1*
1691 *1*	0.6 *1*	7143.9	13/2$^+$	5452.6	11/2$^+$		
1766 *1*		6446.7	9/2$^-$	4680.6	7/2$^+$		
1808 *1*	0.8 *2*	7260.9	11/2$^+$	5452.6	11/2$^+$		
1809 *1*	1.2 *2*	3859.6	5/2$^+$	2050.3	7/2$^+$		
1830 *1*		5690.4	7/2$^+$	3859.6	5/2$^+$		
1906 *1*	6.2 *4*	2356.3	1/2$^+$	450.3	5/2$^+$		
1920 *1*	15.7 *5*	3970.7	5/2$^-$	2050.3	7/2$^+$	D	DCO=0.97 *2*
1967 *1*	2.0 *2*	4680.6	7/2$^+$	2713.6	9/2$^+$	M1+E2	DCO=1.34 *15*
2050 *1*	13.3 *11*	2050.3	7/2$^+$	0.0	3/2$^+$		
2158 *1*	1.4 *2*	6128.5	7/2$^-$	3970.7	5/2$^-$	M1+E2	DCO=1.28 *9*
2263 *1*	66.5 *5*	2713.6	9/2$^+$	450.3	5/2$^+$	E2	DCO=1.84 *1*
2316.9‡ *5*	0.8 *1*	7769.4	(9/2$^-$)	5452.6	11/2$^+$		
2453 *1*	5.0 *2*	2903.5	3/2$^+$	450.3	5/2$^+$	D	DCO=1.14 *4*
2478 *1*	7.4 *2*	6448.8	(9/2$^-$)	3970.7	5/2$^-$	E2	DCO=1.73 *5*
2630 *1*	5.5 *2*	4680.6	7/2$^+$	2050.3	7/2$^+$		
2739 *1*	11.6 *3*	5452.6	11/2$^+$	2713.6	9/2$^+$	D+Q	DCO=0.49 *2*
2752@		8945	(15/2$^+$)	6193.1	13/2$^+$		E_γ: 2745 in 1977Ev02.
2771 *1*	1.8 *1*	2770.8	1/2$^-$	0.0	3/2$^+$		
2832 *1*	0.7 *2*	6802.9	5/2$^-$	3970.7	5/2$^-$		
2903 *1*	3.3 *3*	2903.5	3/2$^+$	0.0	3/2$^+$		
3221 *1*	0.4 *1*	5992.3	3/2$^-$	2770.8	1/2$^-$		
3223 *1*	9.5 *3*	5936.8	11/2$^+$	2713.6	9/2$^+$	D+Q	DCO=0.71 *4*
3236 *1*	2.7 *3*	5286.7	5/2$^+$	2050.3	7/2$^+$		
3343 *1*	11.9 *2*	3793.3	3/2$^-$	450.3	5/2$^+$	D	DCO=0.99 *2*
3402 *1*	5.8 *3*	5452.6	11/2$^+$	2050.3	7/2$^+$	Q	DCO=1.80 *6*
3415 *1*	2.9 *6*	6128.5	7/2$^-$	2713.6	9/2$^+$		
3417@		9610	(17/2$^+$)	6193.1	13/2$^+$		E_γ: 3410 in 1977Ev02.
3480 *1*	17.0 *3*	6193.1	13/2$^+$	2713.6	9/2$^+$	E2	DCO=1.89 *3*
3636 *1*	1.9 *2*	5992.3	3/2$^-$	2356.3	1/2$^+$		
3735 *1*	1.2 *2*	6448.8	(9/2$^-$)	2713.6	9/2$^+$		
3775 *1*	3.1 *2*	6131.7	(1/2,5/2)	2356.3	1/2$^+$		
3886 *1*	1.8 *2*	5936.8	11/2$^+$	2050.3	7/2$^+$		DCO=1.41 *12*

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$^{12}C(^{12}C,n\gamma)$ 2013Je04,1977Ev02 (continued)

$\gamma(^{23}Mg)$ (continued)

E_γ [†]	I_γ [†]	E_i(level)	J^π_i	E_f	J^π_f	Mult. [&]	Comments
							Mult.: E2 in 2013Je04. DCO ratio 1.41 is low for a stretched quadrupole transition.
4188 *1*	4.4 *5*	6238.7	(9/2$^+$)	2050.3	7/2$^+$	D+Q	DCO=0.62 *2*
4230 *1*	11.5 *3*	4680.6	7/2$^+$	450.3	5/2$^+$	M1+E2	DCO=0.59 *1*
4307 *1*	2.4 *3*	7020.4	(9/2$^+$)	2713.6	9/2$^+$		DCO=1.30 *18* Mult.: ΔJ=0 transition.
4325 *1*	2.2 *3*	6375.7	(7/2$^+$)	2050.3	7/2$^+$		DCO=1.6 *3* Mult.: ΔJ=0 transition.
4398 *1*	5.3 *2*	6448.8	(9/2$^-$)	2050.3	7/2$^+$	D	DCO=0.97 *3*
4418 *1*	2.4 *2*	6774.8	(1/2,5/2)	2356.3	1/2$^+$		
4430 *1*	6.1 *3*	7143.9	13/2$^+$	2713.6	9/2$^+$		I_γ: for 4430+4435 γ-ray doublet.
4435 *1*	6.1 *3*	7149.2	(9/2$^+$)	2713.6	9/2$^+$		I_γ: for 4430+4435 γ-ray doublet.
4547 *1*	9.4 *2*	7260.9	11/2$^+$	2713.6	9/2$^+$	M1+E2	DCO=0.75 *6*
4836 *1*	2.5 *1*	5286.7	5/2$^+$	450.3	5/2$^+$		DCO=1.66 *8* Mult.: ΔJ=0 transition.
4871 *1*	0.5 *1*	7227.9	(1/2,5/2)	2356.3	1/2$^+$		
4969 *1*	1.6 *1*	7020.4	(9/2$^+$)	2050.3	7/2$^+$	D+Q	DCO=1.06 *4*
5054.8[‡] *6*	1.1 *2*	7769.4	(9/2$^-$)	2713.6	9/2$^+$		
5067.1[‡] *11*	0.8 *1*	7780.7	11/2$^+$	2713.6	9/2$^+$		
5138.1 *13*		7852.3	(7/2$^+$)	2713.6	9/2$^+$		E_γ: Reported in 2004Je02. Missing in the full version 2013Je04. First author expressed it might be a mistake, but did not confirm, while communicated by the reviewer of this manuscript B. Singh (dated: March 14, 2019).
5240 *1*	1.7 *1*	5690.4	7/2$^+$	450.3	5/2$^+$		DCO=0.44 *3*
5300.2[‡] *9*	0.5 *1*	8015.8	(5/2$^+$ to 11/2$^+$)	2713.6	9/2$^+$		
5399 *1*	1.0 *1*	7449.7	9/2$^+$	2050.3	7/2$^+$	D+Q	DCO=0.98 *5*
5445 *1*	0.2 *1*	7496.0	(9/2$^+$)	2050.3	7/2$^+$		
5677 *1*	1.0 *1*	6128.5	7/2$^-$	450.3	5/2$^+$	D	DCO=0.87 *13*
5690 *1*	5.4 *4*	5690.4	7/2$^+$	0.0	3/2$^+$		
5729.1[‡] *11*	0.4 *1*	7780.7	11/2$^+$	2050.3	7/2$^+$	E2	DCO=1.42 *11*
5921 *1*	1.5 *1*	6372.1	(7/2$^+$)	450.3	5/2$^+$	D+Q	DCO=2.48 *21*
5966.7[‡] *11*	0.2 *1*	8015.8	(5/2$^+$ to 11/2$^+$)	2050.3	7/2$^+$		E_γ: In 2013Je04, the γ-ray placement from (9/2$^+$) is most likely a typo.
6062 *1*	3.2 *2*	6513.1	(7/2$^+$)	450.3	5/2$^+$	D+Q	DCO=0.69 *3*
6109.5[‡] *18*	0.07 *1*	8160.7	5/2$^+$	2050.3	7/2$^+$		
6123 *1*	0.7 *1*	6574.1	(5/2$^+$)	450.3	5/2$^+$		
6353 *1*	2.4 *2*	6804.2	(7/2$^+$)	450.3	5/2$^+$		
6660 *1*	1.5 *1*	7111.3	(7/2$^+$)	450.3	5/2$^+$		
6931 *1*	2.8 *1*	7382.4	7/2$^+$	450.3	5/2$^+$	D+Q	DCO=0.74 *3*
6998 *1*	1.6 *1*	7449.7	9/2$^+$	450.3	5/2$^+$	Q	DCO=1.58 *12*
7172.5[‡] *9*	0.5 *1*	7624.0	9/2$^+$	450.3	5/2$^+$	E2	DCO=1.57 *24*
7196.0[‡] *26*	0.4 *1*	7647	3/2$^+$	450.3	5/2$^+$	D+Q	DCO=0.87 *15*
7333.7[‡] *11*	1.9 *1*	7785.2	7/2$^{(+)}$	450.3	5/2$^+$	M1+E2	DCO=0.89 *5*

[†] From 2013Je04, except otherwise noted. Eγ uncertainty of 1 keV is assigned based on a statement in 2013Je04 that crossover transition energies were reproduced within 0.5 to 1 keV as compared to the energy sums of two coincident γ-ray energies. All the data are from 2013Je04 unless otherwise stated.
[‡] From 2004Je02.
[#] From 1973Wa26.

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$^{12}C(^{12}C,n\gamma)$ 2013Je04,1977Ev02 (continued)

$\gamma(^{23}Mg)$ (continued)

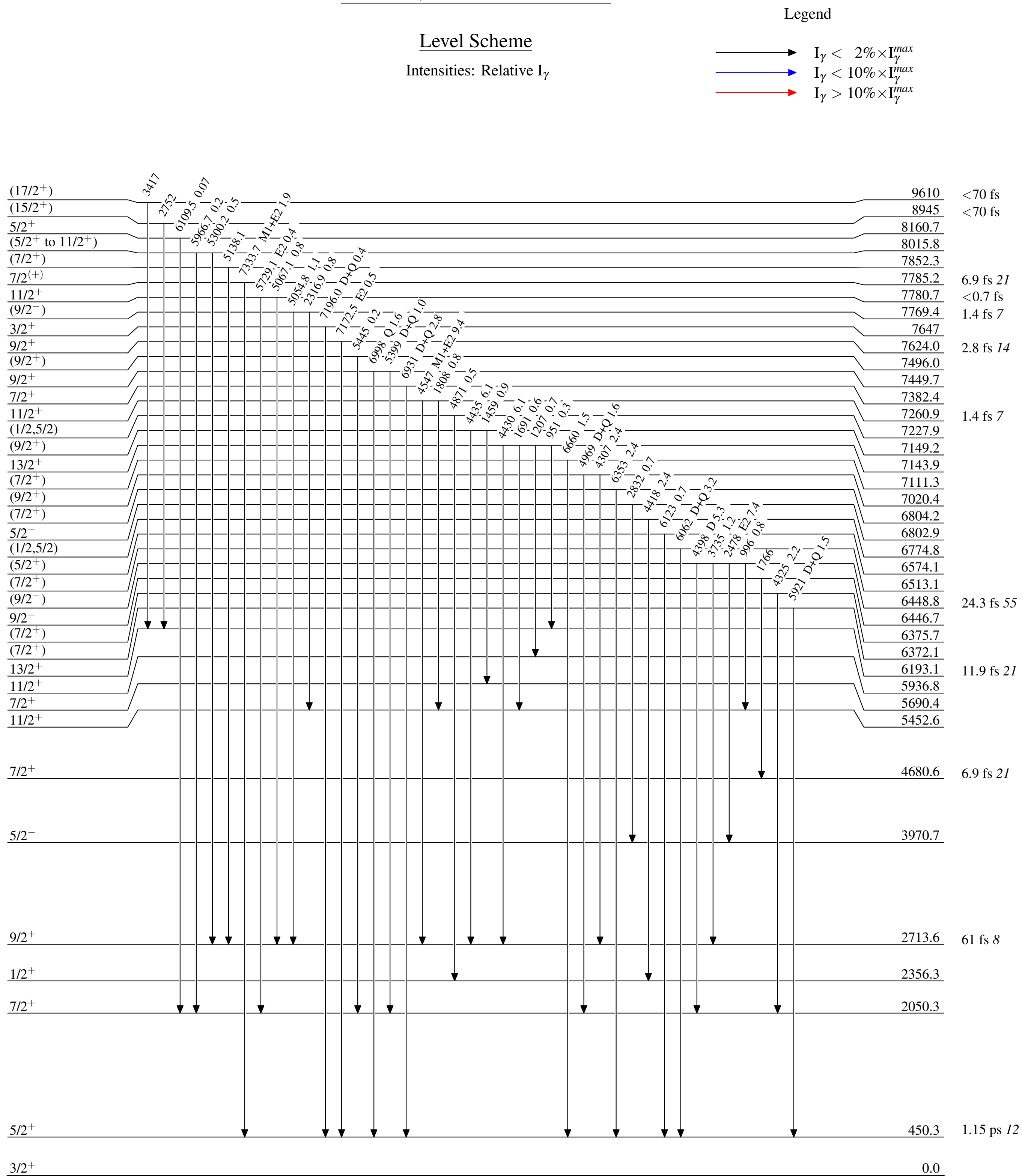
@ From level energy difference, recoil corrected, rounded to nearest keV. Placement in 1977Ev02.

& Assigned by 2013Je04 based on DCO ratio 0.9 *1* for pure stretched-dipole transitions and 1.8 *1* for pure stretched-quadrupole ones. Magnetic/electric assignments from depopulating level′s mean lifetime measurements (RUL).

$^{12}C(^{12}C,n\gamma)$ 2013Je04,1977Ev02

Level Scheme

Intensities: Relative I_γ



$^{23}_{12}Mg_{11}$

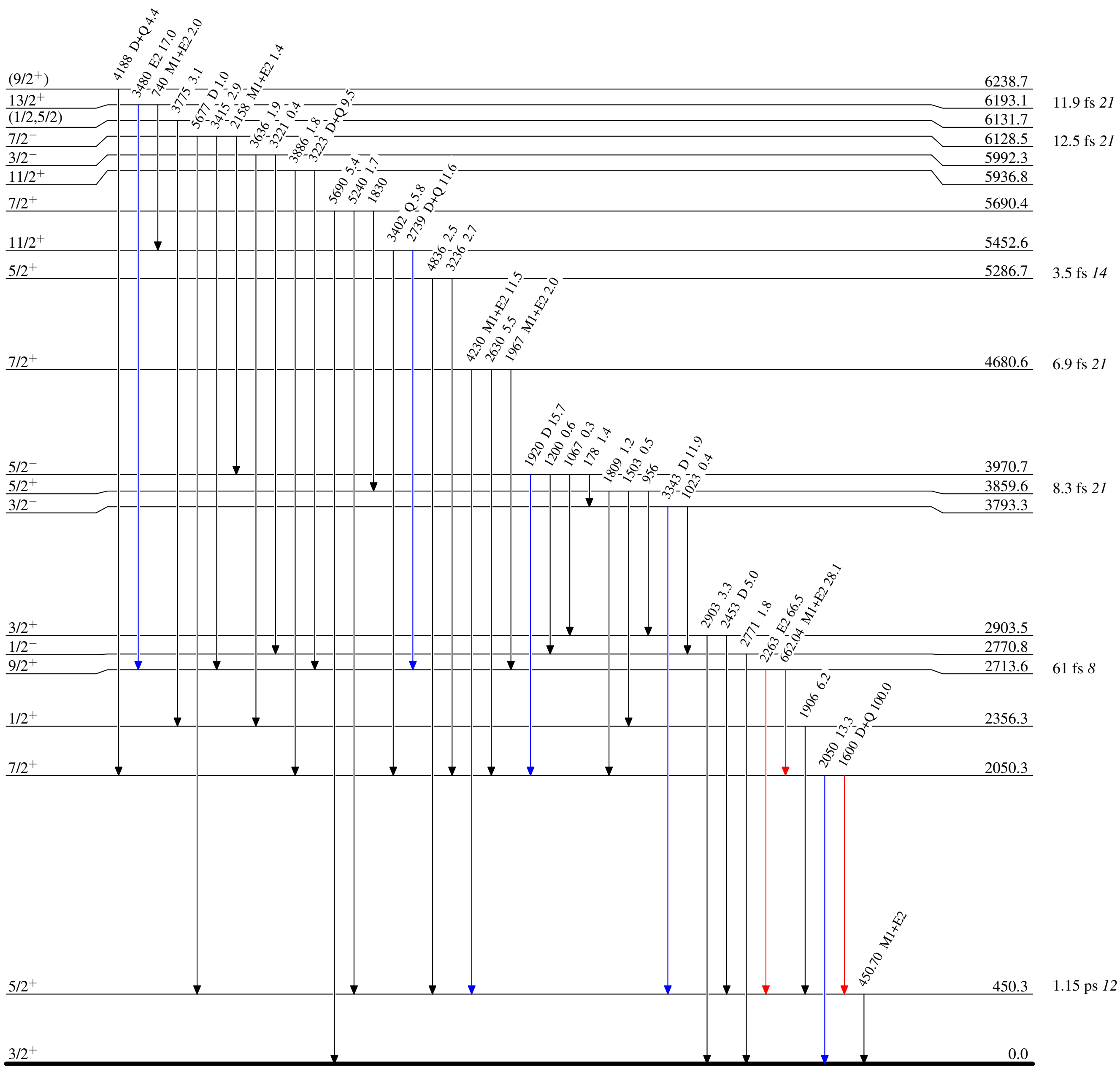
^{12}C(^{12}C,nγ) **2013Je04,1977Ev02**

Level Scheme (continued)

Intensities: Relative I_γ

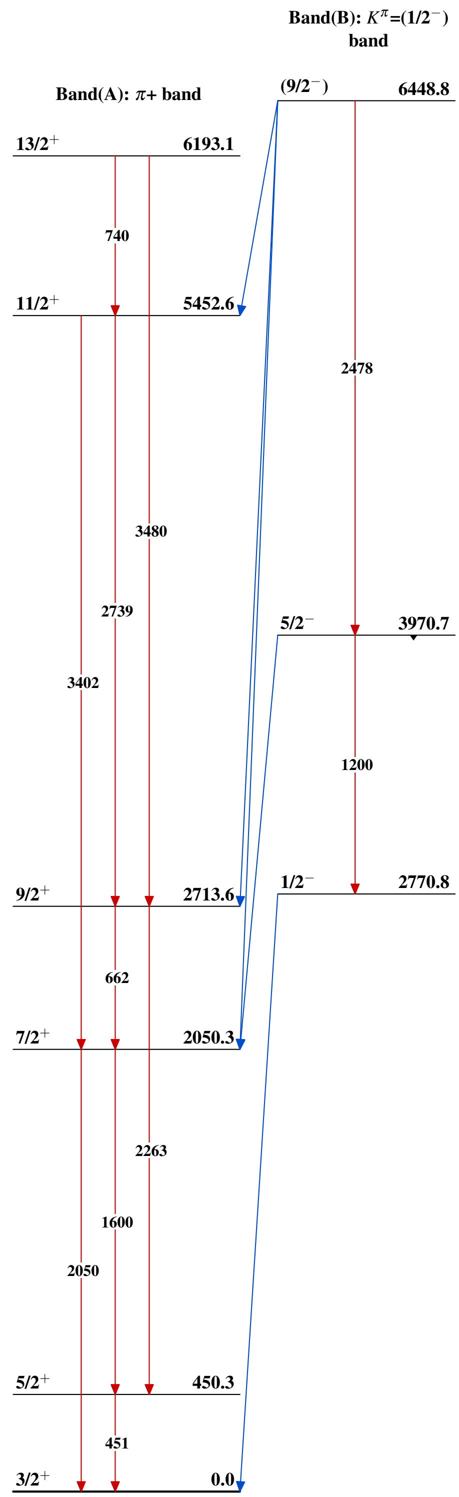
Legend

- $I_\gamma < 2\% \times I_\gamma^{max}$
- $I_\gamma < 10\% \times I_\gamma^{max}$
- $I_\gamma > 10\% \times I_\gamma^{max}$



$^{23}_{12}$Mg$_{11}$

$^{12}C(^{12}C,n\gamma)$ 2013Je04,1977Ev02



$^{23}_{12}Mg_{11}$