

Table 16.12 from (1977AJ02): Resonances in $^{12}\text{C} + \alpha$

E_α (MeV \pm keV)	$\Gamma_{\text{c.m.}}$ (keV)	Outgoing particles ^a (x)	Γ_x	Γ_{α_0}/Γ	$^{16}\text{O}^*$ (MeV)	$J^\pi; T$	Refs. ^b	
3.322 ± 30	550	γ_0	23 ± 3 meV	≈ 1	8.87^i	1^-	(1976MCZX) (1974KO06, 1975DA10)	
		α_0						
3.575 ± 10	0.9 ± 0.3	γ_0	5.9 ± 0.6 meV		9.842	2^+	(1970BR14, 1976MCZX)	
		γ_3	2.2 ± 0.4 meV					
		α_0						
4.256 ± 11	27 ± 4	γ_0	58 ± 7 meV	1	10.353	4^+	(1972MA01, 1975CH30)	
		γ_3						
		α_0						
5.245 ± 8	0.28 ± 0.05	γ_2	3.1 ± 1.3 meV		11.094	4^+	(1975BR06)	
		γ_3	2.5 ± 0.6 meV					
		α_0						
5.47	2500	α_0			11.26	0^+	(but see 1972MA01)	
5.809 ± 18	73 ± 5	γ_0	0.65 ± 0.08 eV		11.52	2^+	(1970BR14, 1972MA01)	
		γ_3	29 ± 7 meV					
		α_0		1				
5.92 ± 20	800 ± 100	α_0		1	11.60	3^-	(1954BI96, 1972MA01, 1974DA22)	
6.518 ± 10	1.5 ± 0.5	α_0			12.049	0^+		
7.045 ± 5	99 ± 7	γ_0	9.5 ± 1.7 eV ^d		12.444	$1^-; 0$	(1972MA01, 1973BR19, 1975DA10)	
		γ_1	0.12 ± 0.06 eV ^d					
		p	1.1 keV					
		α_0	92 ± 8 keV	1.0				
		α_1	0.025 keV					
7.82 ± 10	150 ± 11	γ_0	^e		13.02^k	2^+	(1971KE09, 1972MA01, 1974SN02)	
		α_0	150 ± 11 keV	0.8				
7.915 ± 10	130 ± 5	γ_0	44 ± 8 eV ^f		13.096	$1^-; 1$	(1971KE09, 1972MA01, 1973BR19)	
		γ_4	1.35 ± 0.4 eV					

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E_α (MeV \pm keV)	$\Gamma_{\text{c.m.}}$ (keV)	Outgoing particles ^a (x)	Γ_x	Γ_{α_0}/Γ	$^{16}\text{O}^*$ (MeV)	$J^\pi; T$	Refs. ^b
7.960 ± 10	110 ± 30	p	100 keV	0.3	13.129	$3^-; 0$	(1971KE09, 1972MA01)
		α_0	45 ± 18 keV				
		α_1	1 keV				
		γ_0	> 0.01 eV				
8.130 ± 15	26 ± 7	p	1 keV	0.7	13.257	$3^-; 1$	
		α_0	90 ± 14 keV				
		α_1	≈ 20 keV				
		γ					
8.960 ± 10	75 ± 7	p	4.5 keV	0.65 ± 0.05	13.879 ± 8	4^+	(1971OP01, 1972MA01, 1973MA03, 1975DA10)
		α_0	9 ± 4 keV				
		α_1	7.5 keV				
		$\gamma_{4.4}$					
9.1	4800	α_0	23 keV		14.0	0^+	(1968CL04)
9.164 ± 15	200 ± 50	α_0	≈ 200 keV	> 0.9	14.032	0^+	(1971OP01, 1972MA01, 1973MA03)
9.3 ± 100	750 ± 200	α_0		0.2 ± 0.1	14.1	3^-	(1973MA03)
9.96 ± 40	500 ± 100	α_1		0.8 ± 0.1	14.63	4^+	(1972MA01, 1973MA03)
		α_0					
10.02 ± 40^g	650 ± 100	α_1		≈ 0.95	14.67	5^-	(1973MA03)
		α_0					
10.195 ± 7^g	70 ± 8	α_0	22 keV	0.45 ± 0.05	14.805	6^+	(1971BE50, 1971OP01, 1971RA24, 1972KE18, 1973MA03)
10.68 ± 50	190 ± 30	α_1	48 keV		15.17	0^+	(1972MA01)
		α_0					
11.05 ± 20	100 ± 20	$p_0, \alpha_0, \alpha_1, \gamma_{4.4}$		0.6	15.45	3^-	(1972MA01)

Table 16.12 from (1977AJ02): Resonances in $^{12}\text{C} + \alpha$ (continued)

E_α (MeV \pm keV)	$\Gamma_{\text{c.m.}}$ (keV)	Outgoing particles ^a (x)	Γ_x	Γ_{α_0}/Γ	$^{16}\text{O}^*$ (MeV)	$J^\pi; T$	Refs. ^b
11.5	≈ 400	$\alpha_0, \alpha_1, \gamma_{4.4}$			15.8	3^-	
11.6	≈ 600	γ_0			15.9	2^+	(1974SN02)
		$\Gamma_\alpha \Gamma_\gamma / \Gamma \approx 0.4 \text{ eV}$					
12.18 \pm 40	490 \pm 40	α_0			16.29	6^+	(1972MA01)
12.32 \pm 25	45	$\gamma_0, \text{n}, \text{p}_0, \alpha_0, \alpha_1, \gamma_{4.4}$			16.40 ^h	2^+	(1974SN02)
		$\Gamma_\alpha \Gamma_\gamma / \Gamma = 0.45 \text{ eV}$					
12.5	730	p_0, α_0			16.5		
12.9	400	α_0			16.8	(4^+)	
13.0	700	α_0			16.9	5^-	
13.05	≈ 280	^8Be			16.94	2^+	
13.26	110	$\text{n}, (\text{p}_0), \alpha_0, \alpha_1, \gamma_{4.4}$			17.10	$(1^-, 2^+, 0^+)$	
13.35	200	^8Be			17.17	2^+	
13.50	< 100	n			17.28		
13.59	150	$\alpha_1, \gamma_{4.4}$			17.35		
13.86	165	n, α_0			17.55	(4^+)	
13.95	120	p_0, α_0			17.62		(1971BE07)
14.1		^8Be			17.7	$0^+, 2^+$	
14.21	225	$\text{n}, \alpha_1, \gamma_{4.4}, ^8\text{Be}$			17.81	4^+	
14.483 \pm 15	14	$\text{p}_0, \alpha_0, \alpha_1, ^8\text{Be}$			18.018	$4^+; 0$	
14.50	40	$\text{n}, \alpha_0, \alpha_1, \gamma_{4.4}$			18.03	(4^+)	
14.6 \pm 100	220 \pm 60	$(\gamma_0), \text{n}_0$			18.1 ^h	$(2^+; 0 + 1)$	(1971BE07)
14.85	280	$\gamma_0, \text{p}_0, (\alpha_0), \alpha_1, \gamma_{4.4}$			18.29 ^h		(1974SN02)
		$\Gamma_\alpha \Gamma_\gamma / \Gamma = 0.95 \text{ eV}$					
15.0	510	$\alpha_0, (\alpha_1, \gamma_{4.4})$			18.4	5^-	
15.2		^8Be			18.6	$0^+, 2^+$	
15.2	140	$\alpha_0, (\alpha_1, \gamma_{4.4})$			18.6	$(1^-, 5^-)$	
15.46	55	α_0			18.75	(1^-)	

Table 16.12 from (1977AJ02): Resonances in $^{12}\text{C} + \alpha$ (continued)

E_α (MeV \pm keV)	$\Gamma_{\text{c.m.}}$ (keV)	Outgoing particles ^a (x)	Γ_x	Γ_{α_0}/Γ	$^{16}\text{O}^*$ (MeV)	$J^\pi; T$	Refs. ^b
15.52	220	n, p ₀ , α_0 , α_1 , ^8Be			18.80	(4 ⁺)	
15.88	broad	α_1 , $\gamma_{4.4}$			19.06		
15.96	41	(n), α_0			19.12	(2 ⁺ , 4 ⁺)	
16.13	23	(n), α_0			19.25	(5 ⁻)	
16.25	50	^8Be , (α_2)			19.34	6 ⁺	(1976GL1D)
16.30	23	α_0			19.39	(4 ⁺ , 0 ⁺)	
16.4	broad	α_1 , α_2			19.5		(1976GL1D)
16.62	240	n			19.62		
16.73	17	α_0			19.70	even	
17.0	825	α_0 , α_2			19.9	(4 ⁺)	(1976GL1D)
17.10	140	α_0 , α_1			19.98	(2 ⁺ , 0 ⁺ , 1 ⁻)	
17.22	310	γ_0 , n			20.07	2 ⁺	(1974SN02)
17.5	≈ 1500	p ₀			20.3		
17.66	< 150	n			20.40		
(17.75)	110	α_0			(20.47)	(4 ⁺)	
17.90		α_1			20.58		
18.21	< 25	n			20.81		
18.4	750	α_0			21.0	7 ⁻	
18.48	55	n			21.01		
18.50 \pm 25	240 \pm 80	γ_0			21.03 ^h	1 ⁻	
18.5	900	α_0			21.0	(5 ⁻)	
(18.6)	450	n, α_0 , α_1			(21.1)	(6 ⁺)	
19.37	55	n			21.68		
19.52	55	n			21.79		
19.85	60	n			22.04		
19.89	340	n			22.07		
19.95	< 150	n, ^8Be			22.11		(1974JA21)

Table 16.12 from (1977AJ02): Resonances in $^{12}\text{C} + \alpha$ (continued)

E_α (MeV \pm keV)	$\Gamma_{\text{c.m.}}$ (keV)	Outgoing particles ^a (x)	Γ_x	Γ_{α_0}/Γ	$^{16}\text{O}^*$ (MeV)	$J^\pi; T$	Refs. ^b
20.49	375	n			22.52		
20.71	60	n, ^8Be			22.68		(1974JA21)
20.760 \pm 5	12.5 \pm 2.5	$n_0, p_0, \alpha_0, \alpha_2$			22.721	0 ⁺ ; T = 2	(1972NE10, 1973AD1B)
21.28	\approx 20	$\alpha_0, \alpha_1, ^8\text{Be}$			23.11		(1974JA21)
21.3	\lesssim 500	^8Be			23.1	6 ⁺	(1974JA21)
21.67	< 40	n			23.40		
21.85	300	α_0, α_1			23.54		
22.0	1500	$\gamma_{12.71}$			23.6		(1975SP04)
22.14	120	n			23.75		
22.306 \pm 6	26 \pm 4	$p_0, \alpha_0, \alpha_1, \alpha_2, ^8\text{Be}$	j	0.06 \pm 0.02	23.879	6 ⁺	(1974JA21, 1976BR07)
22.37	165	n			23.93		
22.75	\lesssim 500	^8Be			24.21		(1974JA21)
23.2	750	$\gamma_{12.71}, \gamma_{15.11}$			24.5	T = 1	(1975SP04)
24.1	450	$\gamma_{15.11}$			25.2	T = 1	(1975SP04)
24.6	450	$\gamma_{15.11}$			25.6	T = 1	(1975SP04)
25.5	450	$\gamma_{15.11}$			26.3	T = 1	(1975SP04)
25.6	1200	$\alpha_0, \gamma_{12.71}$ $\Gamma_\alpha \Gamma_\gamma / \Gamma = 1.2 \text{ eV}$			26.3	2 ⁺	(1974SN02, 1975SP04)
30	broad	α_0, α_1			30		

^a p_0 corresponds to $^{15}\text{N}(0)$. α_0, α_1 correspond to $^{12}\text{C}^*(0, 4.4)$ and $\gamma_{4.4}$ corresponds to the γ -ray from the decay of $^{12}\text{C}^*(4.4)$; $\gamma_0, \gamma_1, \gamma_2, \gamma_3, \gamma_4$ correspond to the transitions to $^{16}\text{O}^*(0, 6.05, 6.13, 6.92, 7.12)$.

^b See also [Table 16.11 in \(1971AJ02\)](#).

^c $\theta_\alpha^2(7.12)/\theta_\alpha^2(9.63) = 0.19_{-0.11}^{+0.16}$ ([1974KO06](#)).

^d Branching ratios to $^{16}\text{O}^*(0, 6.05) = 98.8\%$ and 1.2% .

^e $\Gamma_{\gamma_0} = 0.7 \pm 0.2$ eV ([1971KE09](#)), based on $\Gamma_{\alpha_0}/\Gamma = 1.0$ ([1968MO08](#)) and $\Gamma_{\text{c.m.}} = 190 \pm 40$ keV ([1971KE09](#)). See also ([1974SN02](#)).

^f $\Gamma_{\alpha_0}\Gamma_{\gamma_0}/\Gamma^2 = (1.49 \pm 0.17) \times 10^{-4}$ ([1971KE09](#)).

^g See also ([1972MA01](#)).

^h $\Gamma_\gamma\Gamma_\alpha/\Gamma = 0.2, 0.7$ and 6 eV, respectively, for $^{16}\text{O}^*(16.42, 18.18, 20.9)$ ([1967SU02](#)).

ⁱ An attempt is reported by ([1976MCZX](#)) to observe a 0^+ state in the vicinity of the known 2^- state at 8.87 MeV: no such state exists with $8.842 < E_x < 8.907$ MeV [this region was covered in 0.5 keV steps, with 1.5 to 3% statistics for the α_0 yield].

^j $\Gamma_{\text{sBe}}, \Gamma_{\alpha_0}$ and $\Gamma_{\alpha_2} \approx 3.5, 1.5 \pm 0.5$ and ≈ 6 keV, respectively ([1976BR07](#)).

^k The previously reported 2^+ state at 13.14 MeV (see [1971AJ02](#)) appears to be identical to this level: a revised value for the width of that state is $\Gamma_{\text{c.m.}} \approx 180$ keV (F.C. Barker, private communication).