

⁹Be(α,α):res

Type	Author	History	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell		NDS 198,1 (2024)	1-Aug-2024

1964Gr39: ⁹Be(α,α),(α,α') E=23.8 MeV; measured $\sigma(\theta)$ for $\theta=20^\circ$ to 175° .
 1965Ta04: ⁹Be(α,α) E=4-20 MeV; measured $\sigma(E;\theta)$ for $\theta=15^\circ$ to 165° . Multiple peaks are reported.
 1969Ha14: ⁹Be(α,α) E=104 MeV; measured $\sigma(\theta)$ for $\theta_{c.m.}=5^\circ$ to 80° ; deduced phase shifts, optical potentials.
 1973Go15: ⁹Be(α,α) E=1.7-6.2 MeV; measured $\sigma(E;E_\alpha,\theta)$ for $\theta\approx 50^\circ$ to 175° . ¹³C deduced levels, level-width, J, π . See also (1970GoZX).
 1974Sa16: ⁹Be(α,α) E=1.4-2.5 MeV; measured $\sigma(E,\theta)$ for $\theta=90^\circ-160^\circ$. ¹³C deduced resonance, J, π , α -width, level-width.
 1978Hi06: ⁹Be(α,α_0) E=6.4-6.5 MeV; measured $\sigma(E,\theta)$. for $\theta_{c.m.}=54.7^\circ, 90^\circ, 125.3^\circ$ and 175° . Deduced resonance parameters.
 2011Fr12: XUNDL dataset compiled by TUNL, 2011.
 The authors measured cross sections for ⁹Be+ α resonant scattering with the aims of characterizing the ¹³C excitation spectrum and evaluating the $3\alpha+n$ cluster structure of ¹³C.
 Beams of E(⁹Be)=12, 17, 20 and 21.4 MeV ions impinged on a helium gas cell having 460 to 1020 mb pressure (adequate to stop the ⁹Be beam). Scattered α particles escaped the gas cell and were detected in a 16-by-16 double-sided Si-strip detector that was positioned downstream at 0° . Resonant states in ¹³C are visible in the scattered α -particle energy spectra. Analysis of the spectra indicates that contributions by ⁹Be excited states to the reaction exit channel are minor.
 An R-matrix analysis is used to evaluate the resonance parameters and partial widths. Results are compared with ENSDF and a prior ⁹Be(α,α_0) measurement (1973Go15). Finally there is some commentary given on J^π assignments in ¹³C and associated molecular bands.
 2013Lo16: ⁹Be(α,α),(α,α') E=3.5-10 MeV; measured $\sigma(\theta,E)$ for $\theta=110^\circ-160^\circ$.
 2017Lo04: ⁹Be(α,α),(α,α'); combined data from (2013Lo16, 1973Go15) and performed R-matrix analysis; deduced $J^\pi=9/2^-$ for $E_x=13.42$ MeV in agreement with earlier result. See also (2020De05).
 2018Lo07: ⁹Be(α,α)(α,α') $E_{c.m.}=2.5-7$ MeV; AZURE R-matrix analysis of experimental energy spectra, and differential $\sigma(\theta,E)$. ⁹Be(α,n) reactions are also considered in the fit. Deduced ¹³C levels above the α threshold of $E_x=10.648$ MeV, J, π , Γ , Γ_{α_0} , Γ_{α_1} , Γ_n , and compared with literature data. The work merits consideration as an independent analysis; the narrow resonances deduced in the analysis are consistent with known literature values, but several new $\Gamma\geq 1$ MeV broad resonances have been added to give an improved fit to the rather structureless spectral shapes.
 1975Va19: See for ⁹Be(α,d) E=15-25 MeV.
 1973Ku03: See for α structure amplitudes in transfer reactions.

¹³C Levels

E(level) [†] #	J^π ^{†‡}	Γ [†]	L [†]	E_α (res) (MeV) [†]	Comments
11990	5/2 ⁺	180 keV	1	1.93	E(level), J^π,Γ,E_α (res) (MeV): From (1974Sa16). $\Gamma: \Gamma_\alpha/\Gamma=0.4; \Gamma_\alpha=72$ keV. $\gamma^2=0.36$.
13280	3/2 ⁻	340 keV	(0,2)	3.80	E(level): See also (2011Fr12: from $E_{res}(c.m.)=2730$ keV). J^π : From (2011Fr12). See also (1973Go15: favored by the analysis but the assignment is not certain and more than one state may be involved). Γ : From (2011Fr12: $\Gamma_\alpha=294$ keV; $\Gamma_n=46$ keV); see also $\Gamma=343$ keV (1973Go15).
13420	(7/2 ⁺ ,9/2 ⁻)	58 keV	(4,6)	4.00	E(level): See also (2011Fr12: from $E_{res}(c.m.)=2780$ keV). J^π : $J^\pi=(9/2^-)$ is reported in (1973Go15); this is confirmed in (2017Lo04). This finding is in disagreement with (2002Mi32). In (2011Fr12), 7/2 ⁺ appears favored though 9/2 ⁻ is not excluded. Γ : From (1973Go15); (1991Aj01) indicates a resonance with (9/2 ⁻) and $\Gamma=35$ keV 3.
13560	7/2 ⁻	596 keV	(1,3)	4.20	E(level): See also (2011Fr12: from $E_{res}(c.m.)=2880$ keV).

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$^9\text{Be}(\alpha,\alpha)$:res (continued) ^{13}C Levels (continued)

<u>E(level)†#</u>	<u>J$^\pi$†‡</u>	<u>Γ†</u>	<u>L†</u>	<u>E$_\alpha$(res) (MeV)†</u>	<u>Comments</u>
13760	5/2 ⁺	337 keV	(1,3)	4.50	J $^\pi$: From (2011Fr12); see also J $^\pi$ =5/2 ⁺ (1973Go15), (1973De14: $^9\text{Be}(\alpha,n)$) suggest the opposite ordering (3/2 ⁺ ,5/2 ⁺) for 13560 and 13760 states. Γ : From (2011Fr12: Γ_α =512 keV; Γ_n =84 keV); see also Γ =685 keV (1973Go15). E(level): See also (2011Fr12: from E $_{\text{res}}$ (c.m.)=3280 keV). J $^\pi$: From (2011Fr12); see also J $^\pi$ =3/2 ⁺ (1973Go15), (1973De14: $^9\text{Be}(\alpha,n)$) suggest the opposite ordering (3/2 ⁺ ,5/2 ⁺) for 13560 and 13760 states. Γ : From (2011Fr12: Γ_α =103 keV; Γ_n =334 keV); see also Γ =247 keV (1973Go15).
14110	5/2 ⁻	124 keV	(2,4)	5.00	E(level): See also (2011Fr12: from E $_{\text{res}}$ (c.m.)=3480 keV). J $^\pi$: an equally good fit to the data is obtained with a 7/2 ⁻ state at E $_\alpha$ =5.0 MeV and a (3/2,5/2,7/2) ⁺ state at E $_\alpha$ =5.075 MeV (1973Go15). J $^\pi$: (5/2 ⁻) is reported in (1973Go15); this is confirmed in (2017Lo04). See also J $^\pi$ =5/2 ⁻ (2011Fr12). This finding is in disagreement with an analysis of level spacings in (2002Mi32,2003Mi34); the analysis suggests this level is a J $^\pi$ =9/2 ⁻ member of a rotational band. (1991Aj01) indicates a resonance with J $^\pi$ =3/2 ⁻ and Γ ≈150 keV. Γ : From (2011Fr12: Γ_α =124 keV; Γ_n =0 keV); see also Γ =75 keV (1973Go15).
14162?	7/2 ⁺	73 keV	(3,5)	5.075	J $^\pi$: In (1973Go15) an equally good fit to the data is obtained with a 7/2 ⁻ state at E $_\alpha$ =5.0 MeV and a (3/2,5/2,7/2) ⁺ state at E $_\alpha$ =5.075 MeV. In (2011Fr12), the state appears not to be required.
14390	7/2 ⁻	111 keV			Γ_α =12 keV; Γ_n =999 keV (2011Fr12) E(level): From (2011Fr12: E $_{\text{res}}$ (c.m.)=3760 keV). J $^\pi$, Γ : From (2011Fr12).
14460?	(5/2 ⁺)	400 keV	(1,3)	(5.50)	J $^\pi$: See also J $^\pi$ =7/2 ⁽⁺⁾ (1973Go15) $^9\text{Be}(\alpha,\alpha_0)$. E(level): This level was introduced by (1973Go15) mainly to improve the fit near E $_\alpha$ =5 MeV.
14580	9/2 ⁺	285 keV			Γ_α =244 keV; Γ_n =41 keV (2011Fr12) E(level): From (2011Fr12: E $_{\text{res}}$ (c.m.)=4070 keV). J $^\pi$, Γ : From (2011Fr12).
14983	7/2 ⁻	406 keV			Γ_α =238 keV; Γ_n =168 keV (2011Fr12) E(level): From (2011Fr12: E $_{\text{res}}$ (c.m.)=4310 keV). J $^\pi$, Γ : From (2011Fr12).
15109.3 14	3/2 ⁻	5.49 keV 25		6.4435 20	T=3/2 E(level),J $^\pi$, Γ ,E $_\alpha$ (res) (MeV),T: From (1978Hi06). Γ : weak anomaly. $\Gamma_{\alpha_0}/\Gamma \geq 0.017$ with $\Gamma_{\alpha_0} \geq 0.093$ keV (1978Hi06). See also Γ_{α_0} =0.104 keV 28 (1978Hi06, 1969Ne12).
15270	(5/2 ⁻)	493 keV			Γ_α =154 keV; Γ_n =339 keV (2011Fr12) E(level): From (2011Fr12: E $_{\text{res}}$ (c.m.)=4500 keV). J $^\pi$, Γ : From (2011Fr12). (1991Aj01) and (2003Mi34) indicate a resonance with J $^\pi$ =9/2 ⁺ , but (2011Fr12) find interference from J $^\pi$ =9/2 ⁺ states at E $_\alpha$ =14580 and 15270 is incompatible with their data. In (2018Lo07) J $^\pi$ =3/2 ⁺ is suggested.
16080	7/2 ⁺	140 keV			Γ_α =21 keV; Γ_n =119 keV (2011Fr12) E(level): From (2011Fr12: E $_{\text{res}}$ (c.m.)=5510 keV). J $^\pi$, Γ : From (2011Fr12).
16150	5/2 ⁻	253 keV			Γ_α =23 keV; Γ_n =230 keV (2011Fr12)

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$^9\text{Be}(\alpha,\alpha)$:res (continued) ^{13}C Levels (continued)

<u>E(level)^{†#}</u>	<u>J^π^{†‡}</u>	<u>Γ[†]</u>	<u>L[†]</u>	<u>E_α(res) (MeV)[†]</u>	Comments
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E(level): From (2011Fr12: E_{res(c.m.)}=5490 keV).
 J^π,Γ: From (2011Fr12).

[†] From single-level approximation analysis in (1973Go15) except where noted. Level energies are deduced using E_α(res) and ⁹Be, ⁴He and ¹³C masses from (2021Wa16: AME-2020). E_x=S(α)+E_{c.m.}(relativistic).

[‡] Values from (2011Fr12) are deduced from R-matrix analysis.

[#] Several broad resonances from an R-matrix analysis are reported in (2018Lo07). These resonances are listed here, but are not adopted. E_x= 15.04 MeV 5 with Γ=965 keV 37, 16.27 MeV 5 with Γ=1596 keV 142, 16.64 MeV 5 with Γ=1502 keV 156, 16.67 MeV 5 with Γ=904 keV 100, 16.91 MeV 5 with Γ=1079 keV 200, 17.23 MeV 5 with Γ=393 keV 200, 17.52 MeV 5 with Γ=2153 keV 290.