

Table 20.23 from (1978AJ03): Resonances in  $^{16}\text{O}(\alpha, \alpha)^{16}\text{O}$  <sup>a</sup>

$E_\alpha$ (MeV $\pm$ keV)	$\Gamma_{\text{c.m.}}$ (keV)	Outgoing particles	$\theta^2$ (%) <sup>a</sup>	$E_x$ (MeV)	$J^\pi$	Refs.
2.490 $\pm$ 10	19	$\alpha_0$	22	6.722	0 <sup>+</sup> i	(1953CA44)
3.045 $\pm$ 10	8	$\alpha_0$	36	7.166	3 <sup>-</sup> g	(1953CA44)
3.090 $\pm$ 10	4	$\alpha_0$	1.1	7.202	0 <sup>+</sup> j	(1953CA44)
3.380 $\pm$ 10	8	$\alpha_0$	4.7	7.434	2 <sup>+</sup> i	(1953CA44)
3.885 $\pm$ 10	2	$\alpha_0$	0.6	7.838	2 <sup>+</sup> j	(1953CA44)
4.653 $\pm$ 5	0.013 $\pm$ 0.004	$\alpha_0$	0.07	8.452	5 <sup>-</sup> h	(1973HA63)
$\approx$ 4.9	> 800	$\alpha_0$	$\approx$ 70	$\approx$ 8.6	0 <sup>+</sup> k	(1960MC09)
5.002	2.5	$\alpha_0$	0.23	8.731	1 <sup>-</sup>	(1960MC09)
5.058 $\pm$ 3	0.11 $\pm$ 0.02	$\alpha_0$	8.5 $\pm$ 1.5	8.776	6 <sup>+</sup> f	(1972HA07)
$\approx$ 5.1	> 800	$\alpha_0$	$\approx$ 95	$\approx$ 8.8	2 <sup>+</sup> k	(1960MC09)
5.11	< 1	$\alpha_0$		8.82	(5 <sup>-</sup> )	(1960MC09)
5.152 $\pm$ 5	19	$\alpha_0$	1.1	8.851	1 <sup>-</sup>	(1960MC09, 1969JO18)
5.395 $\pm$ 5	3	$\alpha_0$	3.9	9.046	4 <sup>+</sup> j	(1960MC09, 1969JO18)
5.486 $\pm$ 5	3.2	$\alpha_0$	0.49	9.118	3 <sup>-</sup>	(1960MC09, 1969JO18)
5.955 $\pm$ 10	24	$\alpha_0$	1.4	9.493	2 <sup>+</sup>	(1960MC09, 1967HU06, 1969JO18)
6.569 $\pm$ 10	97	$\alpha_0$	17	9.984	4 <sup>+</sup> i	(1967HU06, 1969JO18)
6.912 $\pm$ 5	141	$\alpha_0$	66	10.259	5 <sup>-</sup> g	(1967HU06, 1969JO18)
6.92 $\pm$ 10	$\leq$ 0.3	$\alpha_0$	$\leq 1.3 \times 10^{-3}$	10.27	(2 <sup>+</sup> )	(1978ST08)
7.092 $\pm$ 5	81	$\alpha_0$	4.8	10.403	3 <sup>-</sup>	(1967HU06, 1969JO18)
7.276 $\pm$ 5	16	$\alpha_0$	1.8	10.550	4 <sup>+</sup>	(1969JO18)
7.314 $\pm$ 10	24	$\alpha_0$	0.85	10.580	2 <sup>+</sup>	(1965MC02, 1967HU06, 1969JO18)
7.580 $\pm$ 100	349	$\alpha_0$	33	10.79	4 <sup>+</sup> k	(1967HU06, 1969JO18)
7.635 $\pm$ 5	13	$\alpha_0$	0.42	10.837	2 <sup>+</sup>	(1965MC02, 1967HU06, 1969JO18)
7.636	45	$\alpha_0$	2.1	10.838	3 <sup>-</sup>	(1969JO18)

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$E_\alpha$ (MeV $\pm$ keV)	$\Gamma_{\text{c.m.}}$ (keV)	Outgoing particles	$\theta^2$ (%) <sup>a</sup>	$E_x$ (MeV)	$J^\pi$	Refs.
(7.75)	80	$\alpha_0$		(10.93)		(1967HU06)
$7.80 \pm 150$	576	$\alpha_0$	14	10.97	$0^+$	(1969JO18)
$7.860 \pm 10$	24	$\alpha_0$	2.0	11.017	$4^+$	(1965MC02, 1967HU06, 1969JO18)
$7.93 \pm 10$	$\leq 0.5$	$\alpha_0$	$\leq 0.05$	11.07	( $4^+$ )	(1978ST08)
$8.132 \pm 30$	172	$\alpha_0$	4.2	11.234	$1^-$	(1969JO18)
$8.16 \pm 10$	$\leq 0.3$	$\alpha_0$	$\leq 0.009$	11.26	( $1^-$ )	(1978ST08)
$8.24 \pm 10$	$40 \pm 10$	$\alpha_0$	1.4	11.32	$2^+$	(1965MC02, 1967HU06, 1969JO18, 1978ST08)
$8.528 \pm 10$	$1.0 \pm 0.5$	$\alpha_0$	0.03, 0.02	11.551	( $2^+, 0^+$ )	(1978ST08)
( $\approx 8.6$ )	$\approx 500$	$\alpha_0$		( $\approx 11.6$ )	( $2^+$ )	(1967HU06)
$8.930 \pm 20$	46	$\alpha_0$	1.1	11.872	$2^+$	(1969JO18)
$8.997 \pm 5$	$0.44 \pm 0.15$	$\alpha_0, \gamma_{6.13}$	$0.04 \pm 0.01$	11.926	$4^+$	(1972HA07)
$9.026 \pm 5$	$(35 \pm 10) \times 10^{-3}$	$\alpha_0$	$1.0 \pm 0.3$	11.949	$8^+ \text{ f}$	(1972HA07)
$9.043 \pm 10$	$30 \pm 5$	$\alpha_0$	0.72	11.962	$1^-$	(1967HU06, 1969JO18, 1972HA07, 1978ST08)
( $9.37 \pm 20$ )	$\leq 20$	$\alpha_0$	$\leq 0.5$	(12.22)	( $2^+$ )	(1978ST08)
$9.39 \pm 30$	$148 \pm 20$	$\alpha_0$	7.7	12.24	$4^+$	(1964PE05, 1967HU06, 1969JO18, 1978ST08)
$9.530 \pm 100$	$\approx 500$	$\alpha_0$	$\approx 13$	12.35	$2^+$	(1969JO18, 1978ST08)
$9.58 \pm 10 \text{ b,c}$	$37 \pm 5$	$\alpha_0, \gamma_{6.13}$	1.2	12.39	$3^-$	(1964PE05, 1969JO18, 1977MA07, 1978ST08)
$9.605 \pm 5$	$\leq 8$	$\alpha_0$	$< 0.15$	12.412	$0^+ \text{ e}$	(1969JO18)
$9.790 \pm 10$	$88 \pm 10$	$\alpha_0$	28	12.560	$6^+ \text{ k}$	(1967HU06, 1969JO18, 1978ST08)
( $9.860 \pm 100$ )		$\alpha_0$		(12.62)		(1969JO18)
$9.944 \pm 15$	97	$\alpha_0$	7.3	12.683	$5^-$	(1969JO18)

Table 20.23 from (1978AJ03): Resonances in  $^{16}\text{O}(\alpha, \alpha)^{16}\text{O}$  <sup>a</sup> (continued)

$E_\alpha$ (MeV $\pm$ keV)	$\Gamma_{\text{c.m.}}$ (keV)	Outgoing particles	$\theta^2$ (%) <sup>a</sup>	$E_x$ (MeV)	$J^\pi$	Refs.
10.050 $\pm$ 100 <sup>d</sup>	100	$\alpha_0$		12.77	4 <sup>+</sup>	(1967ME10, 1969JO18)
10.14 $\pm$ 70	55	$\alpha_0, \gamma_{6.13}$		12.84		(1967ME10)
10.32 $\pm$ 75	60	$\alpha_0, \gamma_{6.13}$		12.98	(4 <sup>+</sup> )	(1967ME10)
10.43 $\pm$ 90	70	$\alpha_0, \gamma_{6.13}$		13.07	(4 <sup>+</sup> )	(1967ME10)
10.57 $\pm$ 75	60	$\alpha_0, \gamma_{6.13}$		13.18	(4 <sup>+</sup> )	(1967ME10)
10.759 $\pm$ 6	$(80 \pm 30) \times 10^{-5}$	$\alpha_0$	0.08 $\pm$ 0.03	13.334	7 <sup>-</sup> <sup>h</sup>	(1972HA07)
10.770 $\pm$ 6	20 $\pm$ 5	$\alpha_0, \gamma_{6.13}$	0.07 $\pm$ 0.03	13.343	4 <sup>+</sup>	(1967ME10, 1972HA07)
10.83 $\pm$ 50	40	$\gamma_{6.13}$		13.39		(1967ME10)
10.87 $\pm$ 140	110	$\alpha_0, \gamma_{6.13}$		13.42	(4 <sup>+</sup> )	(1967ME10)
11.20 $\pm$ 400	320	$\alpha_0, \gamma_{6.13}$		13.7	(3, 7) <sup>-</sup>	(1967ME10)
11.51 $\pm$ 125	400	$\alpha_0, \gamma_{6.13}$		13.93	(6 <sup>+</sup> )	(1967ME10)
11.77		$\alpha_0, \gamma_{6.9+7.1}$		14.14		(1967ME10)
11.97 $\pm$ 300	240	$\alpha_0, \gamma_{6.13}, \gamma_{6.9+7.1}$		14.3	6 <sup>+</sup>	(1967ME10)
(12.06)		$\alpha_0, \gamma_{6.9+7.1}$		(14.37)		(1967ME10)
12.31 $\pm$ 300	240	$\alpha_0, \gamma_{6.9+7.1}$		14.6	(4 <sup>+</sup> )	(1967ME10)
12.66 $\pm$ 150	120	$\alpha_0, \gamma_{6.13}, \gamma_{6.9+7.1}$		14.85		(1967ME10)
12.86 $\pm$ 150	120	$\alpha_0, \gamma_{6.13}, \gamma_{6.9+7.1}$		15.01		(1967ME10)
13.165 $\pm$ 150	120	$\alpha_0, \gamma_{6.13}$		15.26		(1967ME10)
13.22		$\alpha_0$		15.30		(1967ME10)
13.37 $\pm$ 470	380	$\alpha_0, \gamma_{6.13}, \gamma_{6.9+7.1}$		15.4	7 <sup>-</sup> <sup>g</sup>	(1967ME10, 1975CE01)
13.58		$\alpha_0, \gamma_{6.13}, \gamma_{6.9+7.1}$		15.59		(1967ME10)
13.73		$\alpha_0, \gamma_{6.13}, \gamma_{6.9+7.1}$		15.71	(6 <sup>+</sup> )	(1967ME10, 1975CE01)
14.05		$\alpha_0, \gamma_{6.13}, \gamma_{6.9+7.1}$		15.97	(6 <sup>+</sup> )	(1967ME10, 1975CE01)
14.26		$\gamma_{6.13}, \gamma_{6.9+7.1}$		16.13		(1967ME10)

Table 20.23 from (1978AJ03): Resonances in  $^{16}\text{O}(\alpha, \alpha)^{16}\text{O}$  <sup>a</sup> (continued)

$E_\alpha$ (MeV $\pm$ keV)	$\Gamma_{\text{c.m.}}$ (keV)	Outgoing particles	$\theta^2$ (%) <sup>a</sup>	$E_x$ (MeV)	$J^\pi$	Refs.
14.40		$\gamma_{6.13}$		16.25		(1967ME10)
14.501 $\pm$ 15	43	$\alpha_0, \alpha_{1+2}$		16.326	4 <sup>+</sup>	(1973HA63)
14.636 $\pm$ 15	34	$\alpha_0, \alpha_{1+2}$		16.434	(0, 2, 4) <sup>+</sup>	(1973HA63)
14.732 $\pm$ 15	23	$\alpha_0, \alpha_{1+2}$		16.510	(2, 4, 6) <sup>+</sup>	(1973HA63)
14.935 $\pm$ 15	110	$\alpha_0$		16.673	(0, 2) <sup>+</sup>	(1973HA63)
14.993 $\pm$ 15	10	$\alpha_0, \alpha_{1+2}$		16.719	(1, 3, 7) <sup>-</sup>	(1973HA63)
15.162 $\pm$ 15	10	$\alpha_0, \alpha_{1+2}$		16.854	5 <sup>-</sup>	(1973HA63)
15.547 $\pm$ 15	37	$\alpha_0, \alpha_{1+2}$		17.162	5 <sup>-</sup> , (7 <sup>-</sup> )	(1973HA63)
15.695 $\pm$ 15	32	$\alpha_0, \alpha_{1+2}$		17.280	1 <sup>-</sup> , 3 <sup>-</sup> , 4 <sup>+</sup>	(1973HA63)
15.828 $\pm$ 15	< 10	$\alpha_{1+2}$		17.387		(1973HA63)
16.023 $\pm$ 15	136	$\alpha_0, \alpha_{1+2}$		17.542	6 <sup>+</sup>	(1973HA63)
16.285 $\pm$ 15	36	$\alpha_0, \alpha_{1+2}$		17.752	4 <sup>+</sup> , (0 <sup>+</sup> )	(1973HA63)
16.598 $\pm$ 15	< 10	$\alpha_0, \alpha_{1+2}$		18.002	7 <sup>-</sup>	(1973HA63)
16.623 $\pm$ 15	45	$\alpha_0, \alpha_{1+2}$		18.022	(2 <sup>+</sup> , 5 <sup>-</sup> , 6 <sup>+</sup> )	(1973HA63)
16.737 $\pm$ 15	33	$\alpha_0, \alpha_{1+2}$		18.113	7 <sup>-</sup>	(1973HA63)
16.98 $\pm$ 300	240	$\alpha_0, \gamma_{6.13}, \gamma_{6.9+7.1}$		18.31	(6 <sup>+</sup> )	(1967ME10)
17.45	600	$\alpha_0, \gamma_{6.13}$		18.7	(6 <sup>+</sup> )	(1967ME10)
18.05 $\pm$ 250	200	$\alpha_0, \gamma_{6.9+7.1}$		19.16	(6 <sup>+</sup> )	(1967ME10)
18.35 $\pm$ 350	280	$\alpha_0$		19.40	6 <sup>+</sup>	(1967ME10)
18.90 $\pm$ 350	280	$\alpha_0$		19.84	6 <sup>+</sup>	(1967ME10)
19.30 $\pm$ 120	250	$\alpha_0$		20.16	7 <sup>-</sup>	(1971BE17)
19.6 $\pm$ 180	360	$\alpha_0$		20.4	6 <sup>+</sup>	(1971BE17)
19.6 $\pm$ 100	200	$\alpha_0$		20.4	7 <sup>-</sup>	(1971BE17)
19.95 $\pm$ 60	120	$\alpha_0$		20.68	9 <sup>-</sup>	(1971BE17)

Table 20.23 from (1978AJ03): Resonances in  $^{16}\text{O}(\alpha, \alpha)^{16}\text{O}$  <sup>a</sup> (continued)

$E_\alpha$ (MeV $\pm$ keV)	$\Gamma_{\text{c.m.}}$ (keV)	Outgoing particles	$\theta^2$ (%) <sup>a</sup>	$E_x$ (MeV)	$J^\pi$	Refs.
20.18		$\alpha_0$		20.9		(1971BE17)
20.4 $\pm$ 100	200	$\alpha_0$		21.0	7 <sup>-</sup>	(1971BE17)
20.45 $\pm$ 40	80	$\alpha_0$		21.08	9 <sup>-</sup>	(1971BE17)
20.70	300	$\alpha_0$		21.3	7 <sup>-</sup>	(1962JO14, 1971BE17, 1971TA05)
21.3 $\pm$ 200	300	$\alpha_0$		21.8	7 <sup>-</sup>	(1971BE17, 1971TA05)
22.0 $\pm$ 200	500	$\alpha_0$		22.3	7 <sup>-</sup>	(1971BE17, 1971TA05)
22.5 $\pm$ 250	500	$\alpha_0$		22.7	9 <sup>-</sup>	(1971BE17)
22.65 $\pm$ 125	250	$\alpha_0$		22.84	9 <sup>-</sup>	(1971BE17)
23.3 $\pm$ 250	500	$\alpha_0$		23.4	8 <sup>+</sup>	(1971BE17, 1971TA05)
24.24 $\pm$ 150	350	$\alpha_0$		24.11	8 <sup>+</sup>	(1971BE17, 1971TA05)
25.4 $\pm$ 300	600	$\alpha_0$		25.0	8 <sup>+</sup>	(1971BE17)
26.2 $\pm$ 200	400	$\alpha_0$		25.7		(1971BE17)
28.1 $\pm$ 350	700	$\alpha_0$		27.2		(1971BE17)
29	1600	$\alpha_0$		28	8 <sup>+</sup>	(1969CO19, 1970CO13)
29.4 $\pm$ 350	700	$\alpha_0$		28.2		(1971BE17)

<sup>a</sup> See also discussion and Table 2 in (1973HA63).

<sup>b</sup>  $^{20}\text{Ne}^*(12.39)$  decays by  $\alpha_2$  to  $^{16}\text{O}^*(6.13)$  with  $\omega\Gamma_{\alpha}\Gamma'_{\alpha}/\Gamma = 3 \pm 1$  keV (1964PE05),  $2.0 \pm 0.1$  keV (1978ST08).

<sup>c</sup>  $\omega\gamma = 0.8 \pm 0.2$  and  $1.94 \pm 0.15$  eV to  $^{20}\text{Ne}^*(1.63, 4.25)$ , respectively;  $\omega\gamma_0 < 0.02$  eV (1978ST08).

<sup>d</sup> Values quoted are taken preferentially from the elastic scattering results (1967ME10).

<sup>e</sup> (1977BA3W, 1977BA3X) report a probable  $0^+$  state at  $E_x = 12.436 \pm 0.005$  MeV,  $\Gamma_{\text{lab}} = 29 \pm 1$  keV,  $\Gamma_{\alpha_0} = 22.7 \pm 2.0$  keV,  $\Gamma_{\alpha_1} = 6.3 \pm 2.0$  keV. These data are preliminary and are not used in Table 20.18.

<sup>f</sup>  $K^\pi = 0_1^+$  (1972HA07, 1973HA63).

<sup>g</sup>  $K^\pi = 0^-$  (1973HA63).

<sup>h</sup>  $K^\pi = 2^-$  (1972HA07, 1973HA63).

<sup>i</sup>  $K^\pi = 0_2^+$  (1973HA63).

<sup>j</sup>  $K^\pi = 0_3^+$  (1973HA63).

<sup>k</sup>  $K^\pi = 0_4^+$  (1973HA63).