$^{48}$Ca($^3$He,t)    **2007Gr22,1972Ri07,1970Oh01**

| | Type | Author | History Citation | Literature Cutoff Date |
|---|---|---|---|---|
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2007Gr22: E=420 MeV beam provided by cyclotrons at RCNP. Reaction products were momentum-analyzed with the Grand Raiden Spectrometer (FWHM=40 keV) and detected with two vertical drift chambers and two plastic scintillators. Measured $\sigma(\theta$(c.m.)=0° to 4°). Deduced levels, J, $\pi$, Gamow-Teller strengths.

1972Ri07: E=23 MeV $^3$He from Argonne tandem accelerator. Reaction products were momentum-analyzed with an Enge split-pole spectrograph (FWHM≈35 keV). Measured $\sigma(\theta$=10° to 141.1°). Deduced levels, J, $\pi$, L-transfers from DWBA analysis.

1970Oh01: E=15 MeV $^3$He from Argonne tandem Van de Graaff. Reaction products were momentum-analyzed with a magnetic spectrograph. Measured $\sigma(\theta$=10° to 60°). Deduced levels, J, $\pi$, L-transfers from DWBA analysis.

1980Ga04: E=66,70 MeV $^3$He beam from the variable-energy cyclotron at KVI, Groningen. Reaction products were detected with two ΔE-E telescopes of surface-barrier Si detectors. Measured $\sigma(\theta$(c.m.)=10° to 40°). Deduced levels, Gamow-Teller strength distribution from DWBA analysis.

1978Ta23: E=82 MeV $^3$He beam from the SF cyclotron at the Institute for Nuclear Study at University of Tokyo. Reaction products were detected with two sets of ΔE-E counter telescopes. Measured $\sigma(\theta)$, $\theta$=10° to 80°. Deduced levels, J, $\pi$, L-transfers from DWBA analysis.

2011St03: E=420 MeV from RCNP. Measured triton spectra, $\sigma(\theta)$. The authors claims that 165 new levels within 0.0-14.5 MeV including 45 ΔL=1 levels were identified for $^{48}$Sc but no details and data are given.

Others: 1969Br04, 1969Sc20, 1978Ta23, 1984Cl04, 1985Ha08, 1986Co03, 1989Va09, 1991Br20, 2006Fr03.

### $^{48}$Sc Levels

| E(level)[†] | J$^\pi$[@] | L[&] | $\hat{B}(\hat{G}T^-)$[b] | Comments |
|---|---|---|---|---|
| 0.0 | 6$^{+a}$ | 6 | | J$^\pi$: also from 1980Ga04, 1978Ta23,1970Oh01, 1969Br04, 1969Sc20. |
| 133[‡] 2 | 5$^{+a}$ | 4,6 | | E(level): others: 131 (1980Ga04,1969Sc20), 130 (1978Ta23), 130 30 (1969Br04). J$^\pi$: also from 1980Ga04, 1970Oh01, 1969Sc20. |
| 253[‡] 2 | 4$^{+a}$ | 4 | | E(level): others: 252 (1980Ga04), 250 (1978Ta23), 250 30 (1969Br04), 256 (1969Sc20). J$^\pi$: also from 1980Ga04, 1978Ta23, 1970Oh01, 1969Br04, 1969Sc20. |
| 622 4 | 3$^{+a}$ | 2,4 | | E(level): weighted average of 610 10 (2007Gr22), 624 4 (1970Oh01), and 620 30 (1969Br04). Others: 623 (1980Ga04), 620 (1978Ta23), 624 (1969Sc20). J$^\pi$: also from 2007Gr22, 1980Ga04, 1970Oh01, 1969Br04, 1969Sc20. |
| 1095[‡] 5 | 7$^{+a}$ | 6 | | E(level): others: 1096 (1980Ga04), 1080 30 (1969Br04), 1097 (1969Sc20); not separated from 1143 level (1980Ga04,1978Ta23). J$^\pi$: also from 1970Oh01 and 1969Sc20. 1969Br04 assign 7$^+$ to 1140 and 2$^+$ to 1080 level. |
| 1145[‡] 5 | 2$^{+a}$ | 2 | | E(level): others: 1143 (1980Ga04), 1140 30 (1969Br04), 1150 (1969Sc20). J$^\pi$: also from 1970Oh01, 1969Sc20. |
| 1395 10 | (2$^-$) | 3 | | E(level): weighted average of 1390 10 (2007Gr22) and 1400 10 (1970Oh01). Other: 1406 (1972Ri07). J$^\pi$: also from 2007Gr22. |
| 1432?[‡] 15 | | | | |
| 2104 | (4$^-$) | 5 | | |
| 2196 | (5$^+$) | 4,5,6 | | |
| 2280 10 | (2$^+$) | (2) | | E(level): other: 2281 (1972Ri07). J$^\pi$: also from 2007Gr22. |
| 2526[‡] 5 | (1$^+$)$^d$ | 0 | 1.09 1 | E(level): weighted average of 2530 10 (2007Gr22), 2526 5 (1970Oh01), and 2510 30 (1969Br04). others: 2520 (2006Fr03,1980Ga04,1969Sc20), 2520 (1978Ta23). J$^\pi$: also from 2007Gr22, 2006Fr03, 1980Ga04, 1970Oh01, 1969Br04, 1969Sc20. |
| 2630[‡] 10 | | | | |
| 2655[‡] 10 | | | | |
| 2889 | (2$^-$,3$^-$) | 3 | | |
| 2980$^e$ 10 | (1$^+$) | 2,3,4 | 0.002$^e$ 1 | E(level): other: 2978 (1972Ri07), possible doublet. |

Continued on next page (footnotes at end of table)

## $^{48}$Ca($^3$He,t)    2007Gr22,1972Ri07,1970Oh01 (continued)

### $^{48}$Sc Levels (continued)

| E(level)[†] | J$^\pi$ [@] | L[&] | $\hat{B}(\hat{G}T^-)$[b] | Comments |
|---|---|---|---|---|
| | | | | J$^\pi$: from $\gamma(\theta)$ and transition strength in 2007Gr22. Other: 1$^+$,4$^+$,5$^+$ from 1972Ri07; 10% contribution from J$^\pi$=(2,3)$^+$ (2007Gr22). |
| 3068[‡] 5 | (1$^+$) | 3,4,5 | 0.059 4 | E(level): others: 3070 10 (2007Gr22), 3061 (1972Ri07), 3040 30 (1969Br04), 3074 (1969Sc20). |
| | | | | J$^\pi$: from 2007Gr22. Other: (5$^+$) from 1969Br04; 10% contribution from J$^\pi$=(2,3)$^+$ (2007Gr22). |
| 3160[e] 10 | (1$^+$)[d] | | 0.021[e] 1 | |
| 3179[‡] 10 | (3$^+$,4$^+$) | 4 | | E(level): other: 3164 (1972Ri07). |
| 3230[‡] 7 | (4$^+$) | 4 | | E(level): other: 3219 (1972Ri07). |
| 3341 7 | (4$^-$) | 3,4,5 | | E(level): weighted average of 3342 7 (1970Oh01) and 3320 30 (1969Br04). Others: 3327 (1972Ri07, possible doublet), 3304 (1969Sc20). |
| | | | | J$^\pi$: 3$^+$ from 1969Br04. |
| 3494 7 | 3,4$^+$ | 3,4 | | E(level): weighted average of 3495 7 (1970Oh01) and 3470 30 (1969Br04). Others: 3480 (1972Ri07), 3486 (1969Sc20). |
| | | | | J$^\pi$: 4$^+$ from 1969Br04. |
| 3688 10 | (2$^+$) | 3,4,6 | | E(level): weighted average of 3690 10 (1970Oh01) and 3670 30 (1969Br04). Others: 3665 (1972Ri07), 3670 (1969Sc20). |
| | | | | J$^\pi$: from 1969Br04 and 1969Sc20. |
| 3720 10 | (1$^+$)[d] | | 0.100 2 | |
| 3798 | | 1,2 | | |
| 3820[e] 10 | [d] | | 0.004[e] 1 | |
| 4040[e] 10 | (1$^+$) | | 0.010[e] 1 | J$^\pi$: 20% contribution from J$^\pi$=2$^+$ (2007Gr22). |
| 4171 | | 2,4,5 | | |
| 4190 10 | (1$^+$) | | 0.042 3 | J$^\pi$: 10% contribution from J$^\pi$=(2,3)$^+$ (2007Gr22). |
| 4265[‡] 10 | | 1,2 | | E(level): others: 4246 (1972Ri07), 4270 30 (1969Br04). |
| | | | | J$^\pi$: from 1969Br04. |
| 4330[e] 10 | | | 0.021[e] 1 | J$^\pi$: Contribution from 2$^-$ is negligible at an angle of 0° (2007Gr22). |
| 4.43×10$^3$ | | 1,2 | | |
| 4.56×10$^3$ | | (2) | | |
| 4.67×10$^3$ | | (6) | | |
| 4790 10 | (1$^+$)[d] | | 0.090 4 | E(level): other: 4800 (2006Fr03). |
| | | | | J$^\pi$: also from 2006Fr03. |
| 5050[c] 10 | | | 0.043[c] 7 | J$^\pi$: 20% contribution from J$^\pi$=(2,3)$^+$ for 5050+5111 (2007Gr22). |
| 5111[c] 10 | | | [c] | |
| 5.20×10$^3$ | | (3,4) | | |
| 5230 10 | (1$^+$) | | 0.075 7 | J$^\pi$: 20% contribution from J$^\pi$=2$^+$ (2007Gr22). |
| 5290[c] 10 | | | 0.033[c] 7 | J$^\pi$: 40% contribution from J$^\pi$=(2,3)$^+$ for 5290+5360 (2007Gr22). |
| 5360[c] 10 | | | [c] | |
| 5440[e] 10 | | | 0.027[e] 2 | J$^\pi$: 20% contribution from J$^\pi$=2$^+$ (2007Gr22). |
| 5520[e] 10 | | (2,3) | 0.066[e] 6 | E(level): other: 5490 (1972Ri07, possible doublet). |
| | | | | J$^\pi$: 15% contribution from J$^\pi$=2$^+$ (2007Gr22). |
| 5.59×10$^3$ | | (2,3) | | |
| 5760 10 | (1$^+$)[d] | | 0.081 4 | |
| 5.88×10$^3$ | | (4) | | |
| 5900[e] 10 | | | 0.118[e] 11 | J$^\pi$: 30% contribution from J$^\pi$=(2,3)$^+$ for 5900+5960+6020 (2007Gr22). |
| 5960[e] 10 | | | [e] | |
| 6020[e] 10 | | (3) | [e] | E(level): other: 5990 (1972Ri07). |
| 6250 10 | (1$^+$)[d] | | 0.139 9 | |
| 6400[e] 10 | | | 0.031[e] 4 | E(level): other: 6420 30 (1969Br04). |
| | | | | J$^\pi$: 20% contribution from J$^\pi$=2$^+$ (2007Gr22). |
| 6460[e] 10 | | | 0.071[e] 4 | J$^\pi$: 5% contribution from J$^\pi$=2$^+$ (2007Gr22). |

$^{48}\text{Ca}(^{3}\text{He,t})$    **2007Gr22,1972Ri07,1970Oh01 (continued)**

$^{48}\text{Sc}$ Levels (continued)

| E(level)[†] | J$^{\pi}$ [@] | L [&] | $\hat{\text{B}}(\hat{\text{GT}}^{-})$ [b] | Comments |
|---|---|---|---|---|
| 6620[e] *10* | [d] | | 0.214[e] *3* | |
| 6710 *10* | 0$^{+}$ | 0 | | E(level): IAS of $^{48}$Ca g.s. Others: 6670 (1980Ga04), 6680 (1978Ta23), 6667 (1972Ri07), 6680 *30* (1969Br04), 6680 (1969Sc20). |
| $\approx$7.78$\times$10$^{3}$[#] | | | | |
| $\approx$10.6$\times$10$^{3}$[#] | | | | |
| $\approx$13.3$\times$10$^{3}$[#] | | | | |
| 16840 *10* | (1$^{+}$) | | | T=4 |
| | | | | E(level): analog of 10220, 1$^{+}$ state in $^{48}$Ca. |
| | | | | L: from 2007Gr22. |

[†] Values with uncertainties are from 2007Gr22 and those without uncertainties are from 1972Ri07, unless otherwise noted.

[‡] From 1970Oh01. For members of the $(\pi 1\text{f}_{7/2})(\nu 1\text{f}_{7/2})_{1}$ multiplet, 1972Ri07 note that there is good agreement between their values and those of 1970Oh01. Above $\approx$2.5 MeV it appears that the absolute energy is systematically different in 1970Oh01 and 1972Ri07 with values from 1970Oh01 higher in this region.

[#] Broad structures observed by 1980Ga04. $\sigma(\theta)$ similar to the 2.52 MeV, 1$^{+}$, and 1.14 MeV, 2$^{+}$, state although the 2$^{+}$ was not resolved from the 7$^{+}$.

[@] From 1972Ri07 for levels up to 3480 and from 2007Gr22 above that, unless otherwise noted. J$^{\pi}$ assignments are based on DWBA analysis of measured $\sigma(\theta)$ and on transition strengths.

[&] From DWBA analysis of measured $\sigma(\theta)$ in 1972Ri07. Values for E(level)>4500 are considered tentative and speculative by 1972Ri07.

[a] Identified as the T=3 states of the $(\pi 1\text{f}_{7/2})(\nu 1\text{f}_{7/2})_{1}$ multiplet (1972Ri07).

[b] Quoted uncertainties are statistical only and the systematic uncertainty is estimated to be 25% (2007Gr22).

[c] 5050 and 5111; 5290 and 5360; 5900, 5960 and 6020 form unresolved structures (2007Gr22).

[d] No contribution from higher multipoles J$^{\pi}$=2$^{+}$ or 3$^{+}$ (2007Gr22).

[e] Weak (2007Gr22).