

$^{31}\text{P}(^3\text{He},\text{p})$ 1971Gr04,1971Kn04

Type	Author	History	Citation	Literature Cutoff Date
Full Evaluation	Jun Chen and Balraj Singh		NDS 199,1 (2025)	30-Sep-2024

Target $J^\pi(^{31}\text{P g.s.})=1/2^+$.

1971Gr04: E=12.0 MeV ^3He beam was produced from the MIT-ONR Van de Graaff accelerator. Target was Zn_3P_2 evaporated onto a $5\text{ }\mu\text{g}/\text{cm}^2$ formvar backing, with $51\text{ }\mu\text{g}/\text{cm}^2$ of ^{31}P . Reaction products were momentum-analyzed with the MIT multiple-gap spectrograph (FWHM=30 keV) and detected with nuclear emulsions. Measured $\sigma(E_p, \theta)$, $\theta \approx 5^\circ$ to 85° . Deduced levels, J, π , L-transfers from the DWBA analysis of the data.

1971Kn04: E=12 and 13 MeV ^3He beams were produced from the FN tandem at the Argonne National Laboratory. Target was a $45\text{ }\mu\text{g}/\text{cm}^2$ Zn_3P_2 on a $10\text{ }\mu\text{g}/\text{cm}^2$ carbon backing. Reaction products were detected with a split-pole magnetic spectrograph (FWHM $\approx$ 20 keV) and detected with nuclear emulsions. Measured $\sigma(E_p, \theta)$, $\theta_{\text{c.m.}}=7^\circ$ to 49° . Deduced levels. **1971Kn04** also report data on $(^3\text{He},\text{py})$. See that dataset for more details.

Others:

1971Na23: E=14.0 MeV ^3He beam was produced from the Frankfurt/M Van de Graaff accelerator. Target was Zn_3P_2 evaporated onto thin carbon backings, with $70\text{ }\mu\text{g}/\text{cm}^2$ of ^{31}P . Reaction products were detected with 16 Si surface-barrier detectors. Measured $\sigma(E_p, \theta)$, $\theta_{\text{c.m.}}=10^\circ$ to 130° . Deduced levels, L-transfers from DWBA analysis.

1968Co25: E=6.0 MeV ^3He beam was produced from the University of Kansas 3 MV Van de Graaff accelerator. Target was $70\text{ }\mu\text{g}/\text{cm}^2$ Zn_3P_2 evaporated onto gold backings. Reaction products were detected with Si surface-barrier detectors. Measured $\sigma(E_p, \theta)$, $\theta_{\text{c.m.}}=0^\circ$ to 70° . Deduced deformation parameter of ground state.

 ^{33}S Levels

$(d\sigma/d\Omega)_{\text{max}}$ given under comments are from **1971Gr04**.

E(level) [†]	L [@]	Comments
0	2	$(d\sigma/d\Omega)_{\text{max}}=0.0178\text{ mb/sr}$ at $\theta=22.5^\circ$. Deformation parameter $\beta_2=-0.20$ from analysis of $\sigma(\theta)$ (1968Co25).
842 12	0	E(level): other: 843 15 (1971Kn04). $(d\sigma/d\Omega)_{\text{max}}=0.193\text{ mb/sr}$ at $\theta=7.5^\circ$.
1966 12	(2)	E(level): other: 1967 15 (1971Kn04). $(d\sigma/d\Omega)_{\text{max}}=0.018\text{ mb/sr}$ at $\theta=22.5^\circ$.
2314 12	0+2	E(level): other: 2315 15 (1971Kn04). $(d\sigma/d\Omega)_{\text{max}}=0.062\text{ mb/sr}$ at $\theta=7.5^\circ$.
2869 12	(2)	E(level): weighted average of 2868 12 (1971Gr04) and 2870 15 (1971Kn04). $(d\sigma/d\Omega)_{\text{max}}=0.017\text{ mb/sr}$ at $\theta=30^\circ$.
2936 12	(3)	E(level): weighted average of 2934 12 (1971Gr04) and 2938 15 (1971Kn04). L: for 2934+2974 doublet (1971Gr04). $(d\sigma/d\Omega)_{\text{max}}=0.071\text{ mb/sr}$ at $\theta=37.5^\circ$ for 2934+2974.
2974 12	(3)	E(level): other: 2973 15 (1971Kn04).
3222 12	1	E(level): weighted average of 3223 12 (1971Gr04) and 3220 15 (1971Kn04). $(d\sigma/d\Omega)_{\text{max}}=0.207\text{ mb/sr}$ at $\theta=15^\circ$.
3836 12		E(level): weighted average of 3832 12 (1971Gr04) and 3843 15 (1971Kn04). L $\leq$ (3). $(d\sigma/d\Omega)_{\text{max}}=0.019\text{ mb/sr}$ at $\theta=30^\circ$.
3942 12	2	E(level): weighted average of 3939 12 (1971Gr04) and 3947 15 (1971Kn04). $(d\sigma/d\Omega)_{\text{max}}=0.054\text{ mb/sr}$ at $\theta=30^\circ$.
4063 12	0+2	E(level): weighted average of 4059 12 (1971Gr04) and 4068 15 (1971Kn04). $(d\sigma/d\Omega)_{\text{max}}=0.198\text{ mb/sr}$ at $\theta=7.5^\circ$.
4109 [‡] 15		
4151 12	(1)	E(level): weighted average of 4146 12 (1971Gr04) and 4158 15 (1971Kn04). $(d\sigma/d\Omega)_{\text{max}}=0.052\text{ mb/sr}$ at $\theta=15^\circ$.
4218 12	1	E(level): weighted average of 4214 12 (1971Gr04) and 4224 15 (1971Kn04). $(d\sigma/d\Omega)_{\text{max}}=0.161\text{ mb/sr}$ at $\theta=7.5^\circ$.

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$^{31}\text{P}(^3\text{He},\text{p})$ **1971Gr04,1971Kn04** (continued) ^{33}S Levels (continued)

E(level) [†]	L [@]	Comments
4382 <i>I2</i>		E(level): weighted average of 4377 <i>I2</i> (1971Gr04) and 4389 <i>I5</i> (1971Kn04).
4435 <i>I2</i>		E(level): weighted average of 4432 <i>I2</i> (1971Gr04) and 4439 <i>I5</i> (1971Kn04).
4742 [‡] <i>I5</i>		E(level): 4746 <i>I2</i> in 1971Gr04 could correspond to 4742+4761 in 1971Kn04 . ($d\sigma/d\Omega$) _{max} =0.078 mb/sr at $\theta=7.5^\circ$ for a group at 4746 <i>I2</i> .
4761 [‡] <i>I5</i>		
4932 [#] <i>I2</i>	1	E(level): weighted average of 4933 <i>I2</i> (1971Gr04) and 4931 <i>I5</i> (1971Kn04). ($d\sigma/d\Omega$) _{max} =0.100 mb/sr at $\theta=15^\circ$.
4955 [‡] <i>I5</i>		
5286 <i>I2</i>		E(level): weighted average of 5281 <i>I2</i> (1971Gr04) and 5294 <i>I5</i> (1971Kn04). ($d\sigma/d\Omega$) _{max} =0.188 mb/sr at $\theta=7.5^\circ$.
5414 [‡] <i>I5</i>		
5490 <i>I2</i>	0	E(level): weighted average of 5487 <i>I2</i> (1971Gr04) and 5495 <i>I5</i> (1971Kn04). ($d\sigma/d\Omega$) _{max} =1.48 mb/sr at $\theta=7.5^\circ$.
5611 <i>I2</i>		E(level): weighted average of 5607 <i>I2</i> (1971Gr04) and 5616 <i>I5</i> (1971Kn04).
5725 <i>I2</i>	1	E(level): weighted average of 5723 <i>I2</i> (1971Gr04) and 5728 <i>I5</i> (1971Kn04). ($d\sigma/d\Omega$) _{max} =0.201 mb/sr at $\theta=7.5^\circ$.
5882 [‡] <i>I5</i>		Weak (1971Kn04).
5911 <i>I2</i>		E(level): weighted average of 5913 <i>I2</i> (1971Gr04) and 5907 <i>I5</i> (1971Kn04).
5931 [‡] <i>I5</i>		E(level): this level is likely the same level as 5911 <i>I2</i> ; not adopted in Adopted Levels.
5994 [‡] <i>I5</i>		
6083 [‡] <i>I5</i>		Weak (1971Kn04).
6251 [‡] <i>I5</i>		Weak (1971Kn04).
6278 [‡] <i>I5</i>		Weak (1971Kn04).
6376 <i>I2</i>	(2)	E(level): weighted average of 6370 <i>I2</i> (1971Gr04) and 6384 <i>I5</i> (1971Kn04). ($d\sigma/d\Omega$) _{max} =0.209 mb/sr at $\theta=30^\circ$.
6438 [‡] <i>I5</i>		
6512 <i>I2</i>		
6635 [‡] <i>I5</i>		
6689 [#] <i>I2</i>		E(level): weighted average of 6684 <i>I2</i> (1971Gr04) and 6697 <i>I5</i> (1971Kn04). ($d\sigma/d\Omega$) _{max} =0.170 mb/sr at $\theta=22.5^\circ$.
6802 [‡] <i>I5</i>		
6905 <i>I2</i>	2	E(level): weighted average of 6900 <i>I2</i> (1971Gr04) and 6912 <i>I5</i> (1971Kn04). ($d\sigma/d\Omega$) _{max} =0.131 mb/sr at $\theta=22.5^\circ$.
6977 <i>I2</i>	2	E(level): weighted average of 6973 <i>I2</i> (1971Gr04) and 6983 <i>I5</i> (1971Kn04). ($d\sigma/d\Omega$) _{max} =0.140 mb/sr at $\theta=22.5^\circ$.
7018 [‡] <i>I5</i>		E(level): 7032 <i>I2</i> in 1971Gr04 could correspond to 7018+7052 in 1971Kn04 .
7052 [‡] <i>I5</i>		
7153 [‡] <i>I5</i>	(2)	E(level): probable doublet of 7163 <i>I2</i> in 1971Gr04 could correspond to 7153+7383 in 1971Kn04 . ($d\sigma/d\Omega$) _{max} =0.294 mb/sr at $\theta=30^\circ$ for a group at 7163 <i>I2</i> .
7183 [‡] <i>I5</i>		
7206 [‡] <i>I5</i>		
7348 [#] <i>I2</i>	(2)	E(level): weighted average of 7346 <i>I2</i> (1971Gr04) and 7351 <i>I5</i> (1971Kn04). ($d\sigma/d\Omega$) _{max} =0.199 mb/sr at $\theta=22.5^\circ$.
7415 [‡] <i>I5</i>		
7435 [‡] <i>I5</i>		E(level): probable doublet of 7463 <i>I2</i> in 1971Gr04 could correspond to 7435+7473 in 1971Kn04 . ($d\sigma/d\Omega$) _{max} =0.238 mb/sr at $\theta=22.5^\circ$ for a group at 7463 <i>I2</i> .
7473 [‡] <i>I5</i>		
7498 [‡] <i>I5</i>		
7521 [‡] <i>I5</i>		

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$^{31}\text{P}(^3\text{He,p})$ [1971Gr04](#),[1971Kn04](#) (continued) ^{33}S Levels (continued)

<u>E(level)[†]</u>	<u>L[@]</u>	<u>Comments</u>
7567 [#] $_{12}$		E(level): other: 7580 $_{15}$, contaminated peak in 1971Kn04 .
7613 [‡] $_{15}$		Weak (1971Kn04).
7679 [‡] $_{15}$		Weak (1971Kn04).
7713 [‡] $_{15}$		Weak (1971Kn04).
7830 [‡] $_{15}$		
7860 [‡] $_{15}$		Weak (1971Kn04).
7909 [#] $_{12}$	0	E(level): weighted average of 7902 $_{12}$ (1971Gr04) and 7920 $_{15}$ (1971Kn04). ($d\sigma/d\Omega$) _{max} =1.03 mb/sr at $\theta=7.5^\circ$.
8013 $_{12}$		($d\sigma/d\Omega$) _{max} =0.231 mb/sr at $\theta=15^\circ$.
8107 $_{12}$		
8329 $_{12}$		($d\sigma/d\Omega$) _{max} =0.450 mb/sr at $\theta=7.5^\circ$.

[†] From [1971Gr04](#), unless otherwise noted.

[‡] From [1971Kn04](#) only.

[#] Probably doublet ([1971Gr04](#)).

[@] From the comparison of the $\sigma(\theta)$ data with the DWBA predication in [1971Gr04](#).