Revised Manuscript *24 June 2021*

Energy Levels of Light Nuclei
$A = 5$

F. Ajzenberg-Selove

University of Pennsylvania, Philadelphia, Pennsylvania 19104-6396

Abstract: An evaluation of $A = 5$–10 was published in *Nuclear Physics A*227 (1974), p. 1. This version of $A = 5$ differs from the published version in that we have corrected some errors discovered after the article went to press. Figures and introductory tables have been omitted from this manuscript. Reference key numbers have been changed to the NNDC/TUNL format.

(References closed December 31, 1973)

The original work of Fay Ajzenberg-Selove was supported by the US Department of Energy [DE-FG02-86ER40279]. Later modification by the TUNL Data Evaluation group was supported by the US Department of Energy, Office of High Energy and Nuclear Physics, under: Contract No. DEFG05-88-ER40441 (North Carolina State University); Contract No. DEFG05-91-ER40619 (Duke University).

Table of Contents for $A = 5$

Below is a list of links for items found within the PDF document. Figures from this evaluation have been scanned in and are available on this website or via the link below.

^{5}n

(Not illustrated)

^{5}n has not been observed in the interaction of π^- and ^{14}N and ^{16}O: see (1972AG01).

^{5}H

(Fig. 3)

From the work of (1967AD05)[†] on the ^{3}He(^{3}He, n)^{5}Be reaction (see ^{5}Be) it follows that ^{5}H is unstable by more than 2.1 MeV to decay into ^{3}H + 2n (using Coulomb corrections based on the 16.7 MeV states in ^{5}He–^{5}Li). [With the "conventional" correction of (1966LA04, p.2) ^{5}H is unbound by > 0.7 MeV.] A study of ^{9}Be(α, ^{8}B)^{5}H at $E_\alpha = 129$ MeV shows no evidence for sharp ^{5}H states for several MeV above ^{3}H + 2n (1968MC02). In ^{3}H(t, p)^{5}H, at $E_t = 22.25$ MeV, a broad peak appears in the proton spectrum which may correspond to a ^{5}H state at ^{3}H + 2n + 1.8 MeV, but which could also result from a four-body breakup (1968YO06). Several recent attempts to observe ^{5}H formation in ^{7}Li(π^-, pn) and ^{7}Li(π^-, d) have been unsuccessful: see (1965CO1D, 1968BO32, 1969MI10). See (1966LA04) for a review of the earlier work, (1965AR04), and (1965AR08, 1966DE1E, 1968CE01, 1970WA1G, 1971WA08).

^{5}He

(Figs. 1 and 3)

GENERAL: (See also (1966LA04).):

Shell model calculations: (1966FR1B, 1967BO1C, 1967EL03, 1967YA1A, 1968EL1A, 1968GO01, 1968GO36, 1969EL1B, 1970IR01, 1970RA1D, 1970ZO1A, 1971RA15, 1971WA08, 1972KA38, 1972LE1L, 1973HA49).

Cluster calculations: (1965NE1B, 1966HO06, 1967BE1G, 1969ME1C, 1969WI1C, 1971LE1N, 1972DE30).

Special levels: (1971RA15, 1973FE1J).

Electromagnetic transitions: (1966HO06, 1973HA49).

General reviews: (1966DE1E).

Reactions involving pions: (1969GO1C, 1969KO30, 1972GA11, 1973EI01).

Special reactions: (1971CH31, 1972CH31, 1972PN1A, 1973GR22).

[†] References are collected at the end of this article.

Other topics: (1967BO1C, 1967EL03, 1968GO01, 1968HE1D, 1969GI1A, 1969HE1L, 1969SC1J, 1970SU1B, 1970ZO1A, 1971BA2Y, 1971CH50, 1971ZA1D, 1972CA37, 1972GI11, 1972JA14, 1972KA38, 1972LE1L, 1972MA57, 1972RI10, 1973MA20, 1973RA1E, 1973RO1R).

States of ^{5}He[‡] :

Ground state: The ground and first excited states of ^{5}He comprise the components $^2P_{3/2}$ and $^2P_{1/2}$ formed by $l = 1$ scattering of a neutron by an α-particle. Shape parameters of the state are best described by tabulated phase shifts, but it is sufficiently narrow to appear as a distinct group in many reactions. The central energy of this group is generally taken as defining the "mass" of ^{5}He.

First excited state: Ordinarily appears as a broad continuum in particle spectra, centered several MeV (3–5) above the ground state. The resonant phase shift goes through $\frac{1}{2}\pi$ at $E_{\rm cm} = 6.43$ MeV, about 5.5 MeV above the ground state.

16.8 MeV: Conspicuous in the ^{3}H + d reactions, the state is almost entirely of a $3 + 2$ configuration, with relative angular momentum zero, and a quite small reduced width for neutron ($l_{\rm n} = 2$) emission. Properties of the state are listed in Table 5.2.

19.9 MeV: In the range $E_{\rm x} = 20 - 25$ MeV, there appears to be a number of broad overlapping states, principally of $3 + 2$ configuration, with even parity. There is some indication from ^{7}Li(p, ^{3}He), [^{7}Li(p, t)] that they have mainly $S = \frac{3}{2}$. Among this manifold, a level at 19.9 ± 0.4 MeV is reported to form a well-defined group ($\Gamma = 3$ MeV) in ^{7}Li(p, ^{3}He). There are indications of another structure near $E_{\rm x} = 24 - 25$ MeV.

1. ^{3}H(d, γ)^{5}He $\qquad\qquad$ $Q_{\rm m} = 16.70$

At low energies the reaction is dominated by a resonance at $E_{\rm d} = 107$ keV; the mirror reaction shows resonance at $E_{\rm d} = 430$ keV. (1969BE56) have measured the cross section for emission of 16.7 MeV γ-rays for $E_{\rm d} = 25$ to 100 keV: the ratio σ(d, γ)/σ(d, n) is approximately constant at $(2.1 \pm 0.6) \times 10^{-4}$, leading to $\Gamma_\gamma = 14 \pm 4$ eV, where $\Gamma_{\rm n}$ is taken as 66 keV. (1963BU07) have measured thick target yields from $E_{\rm d} = 150$ to 1300 keV. The derived cross sections are analyzed into resonant and direct-capture contributions: the cross section at resonance is here reported as 60 μb [vs. 1 mb reported by (1969BE56)]. At $E_{\rm d} = 1025 \pm 47$ keV, the differential cross section id 0.44 ± 0.12 μb/sr $(90°)$ and the γ to n branching ratio is an order of magnitude smaller: 2.3×10^{-5}. The angular distribution of the γ-rays is forward peaked and the total cross section is estimated to be 4.8 μb (1970KO09). A cluster model calculation of major even parity states predicts a broad peak in dipole strength due mainly to a $\frac{5}{2}^+$ state in a cluster of positive parity states some 4 MeV above the $\frac{3}{2}^+$ state (1971WA08).

[‡] Similar considerations prevail for ^{5}Li.

Table 5.1: Energy levels of ^{5}He [a]

E_x (MeV)	$J^\pi; T$	$\Gamma_{c.m.}$ (MeV)	Decay	Reactions
g.s.	$\frac{3}{2}^-; \frac{1}{2}$	0.60 ± 0.02 [b]	n, α	1, 5, 7, 9, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26
4 ± 1.5	$\frac{1}{2}^-; \frac{1}{2}$	4 ± 1.5	n, α	5, 7, 11, 12, 14, 20
16.76 ± 0.13	$\frac{3}{2}^+; \frac{1}{2}$	0.10 ± 0.05	γ, n, d, t, α	1, 2, 6, 7, 9, 12, 14, 19, 20
19.9 ± 0.4 [a]	$(\frac{3}{2}, \frac{5}{2})^+; \frac{1}{2}$	3 ± 0.6	n, d, t, α	2, 4, 6, 11, 17, 19, 20
$24 - 25$		broad		19, 20

[a] See also the discussion "States of ^{5}He" section in ^{5}He.

[b] See Table 5.2 in (1966LA04).

Table 5.2: Resonance parameters for ^{3}H(d, n)^{4}He and ^{3}He(d, p)^{4}He

E_r (keV)	Γ_{lab} (keV)	l_d	J^π	$l_{n,p}$	R (fm)	E_λ (keV)	γ_d^2 (keV)	$\gamma_{n,p}^2$ (keV)	θ_d^2 [c]	$\theta_{n,p}^2$ [c]	E_x (MeV)
107 [a]	135	0	$\frac{3}{2}^+$	2	5.0	-464	2000 ± 500	50 ± 10	1.0	0.018	16.76
					7.0	-126	715	17	0.7	0.011	
450 [b]	≈ 450	0	$\frac{3}{2}^+$	2	5.0	-391	2930	42	1.4	0.013	16.66
					7.0	129	780	12	0.7	0.008	

[a] ^{3}H(d, n)^{4}He.

[b] ^{3}He(d, p)^{4}He.

[c] Units of $3\hbar^2/2MR^2$.

2. (a) ^{3}H(d, n)^{4}He $Q_{\rm m} = 17.5900$ $E_{\rm b} = 16.70$

(b) ^{3}H(d, 2n)^{3}He $Q_{\rm m} = -2.9885$

(c) ^{3}H(d, pn)^{3}H $Q_{\rm m} = -2.2246$

Below $E_{\rm d} = 100$ keV, the cross section for reaction (a) follows the Gamow function, $\sigma = (A/E)\ \exp\ (-44.40\ E^{-1/2})$ (1953JA1A, 1954AR02). A strong resonance, σ(peak) $= 5.0$ b, appears at $E_{\rm d} = 107$ keV: see Table 5.2. From $E_{\rm d} = 10$ to 500 keV, the cross section is well fitted with the assumption of s-wave formation of a $J^\pi = \frac{3}{2}^+$ state (1952AR30, 1952CO35, 1955KU03). Excitation curves and angular distributions for reaction (a) have been measured from $E_{\rm d} = 8$ keV to 21 MeV: see (1966LA04) for earlier references and (1966KO19: differential cross section $(90°)$; $E_{\rm d} = 0.115$ to 1.65 MeV), (1968IV01: excitation functions at 3 angles; $E_{\rm d} = 3.97$ to 10.99 MeV), (1973MC05: angular distributions, at ≈ 1 MeV intervals; absolute $0°$ cross sections to within $\pm 3.1\%$; $E_{\rm d} = 5.0$ to 15.7 MeV) and (1968SI1B: differential cross sections $(0°)$, angular distributions; $E_{\rm d} = 7.0$, 11.4, 15.0 and 19.0 MeV; relative cross sections at 1 MeV intervals, $E_{\rm d} = 7.0$ to 21.0 MeV). There is some evidence of resonant behavior between $E_{\rm d} = 3$ and 9 MeV (1960ST25). See also (1968SI1B, 1973MC05).

A study of reaction (a) with polarized deuterons at $E_{\rm d} = 0.2$ to 1.0 MeV indicates intervention of the s-wave, $J^\pi = \frac{1}{2}^+$ channel, as well as possible p-waves above $E_{\rm d} = 0.3$ MeV (1965TR01, 1971GR32). This effect is evidently very small below $E_{\rm d} = 100$ keV (1971OH1B). At higher energies, the neutron polarization $P_1(\theta_1)$ shows an angular distribution that peaks typically at $\theta_1 = 30°$ lab, then goes negative with increasing angle and has a minimum between $90°$ and $130°$, depending upon energy. (1971MU04) have made an extensive study of $P_1(30°)$ for $E_{\rm d} = 5$ to 15 MeV and, with deuterium as target, for $E_{\rm t} = 4.5$ to 19.5 MeV (neutrons near $135°$ lab). The polarization increases monotonically from 0.03 at $E_{\rm d} = 3$ MeV to ≈ 0.5 at $E_{\rm d} = 6.5$ MeV and then with a lower slope to 0.69 at $E_{\rm d} = 13$ MeV. The change in the slope may be caused by excited states of ^{5}He near 20 MeV. Comparison with the ^{3}He(d, p)^{4}He mirror reaction at corresponding cm energies shows excellent agreement between the polarization values in the two reactions up to $E_{\rm d} = 6$ MeV, but then the proton polarization becomes $\approx 15\%$ higher, converging back to the neutron values at $E_{\rm d} \approx 12-13$ MeV. This may be due to experimental factors (1971MU04). Using polarized deuterons (1971HI07) find that the average ratio of vector analyzing power of ^{3}He(d, p) to ^{3}H(d, n) is 1.016 ± 0.015 at $E_{\rm d} = 6$ MeV and 1.035 ± 0.020 at 10 MeV. The vector analyzing power of the two reactions agree to within ± 0.025 at all angles. This agreement between the mirror reactions is in apparent conflict with the result of (1971MU04). See also reaction 3 in ^{5}Li. For other polarization measurements see Table 5.3.

(1968BO35) have examined the parity non-conserving effects inn this strong reaction with polarized deuterons ($E_{\rm d} = 0.14$ MeV). The experiment measured the ratio of the number of neutrons emitted parallel and anti-parallel to the direction of the initial polarization vector. The magnitude of the real part of the parity violating amplitude, F, is $\lesssim 3.8 \times 10^{-3}$.

The energy spectrum of ^{3}He particles in reaction (b) has been studied at $E_{\rm d} = 10.9$ MeV at several angles: no evidence was found for a bound dineutron [< 5 μb/sr at $6°$ and $7.5°$]. Strong variations of the spectral shape with angle indicate that the Watson-Migdal approximation is inadequate and that several other first-order processes must be included. The determination of the

Table 5.3: ^{3}H(d, n)^{4}He polarization studies

E_d (MeV)	Refs.
51, 76, 93 keV	(1971OH1B)
0.1, 0.17 MeV	(1961RU1A, 1962SE09)
0.1 – 7.7	(1961PE13, 1964PE14)
0.125	(1968BE05)
0.2 – 1.0	(1971GR32)
0.3 – 1.8	(1968HE16, 1969HE1H)
0.4 – 1.7	(1969WI1D)
0.6, 1.2	(1965BO13)
1.0 – 5.0	(1972SM05)
2.1 – 2.9	(1965CH15)
2.1 – 5.8	(1967BU11)
$E_d = 5 - 15$, $E_t = 4.5 - 19.5$	(1970BR30, 1971MU04)
6 – 10	(1971HI07)
6 – 11	(1964WA22)
8 – 20	(1964AL1E)
10	(1961TR05)
17	(1972RY01)

nn scattering length is ambiguous (1970LA10, 1970LA1K). This problem is also discussed by (1971GR45: $E_d = 13.4$ MeV), (1970SL1A: $E_d = 31.9$ MeV), (1966BA1H: $E_d = 29.8$, 32.5 MeV), (1971GR12: $E_t = 22$ MeV) and (1972BA32: $E_d = 83$ MeV). A discussion and comparison of attempts to measure the $^1S_0$ nn scattering length is presented by (1971GR45): based on kinematically complete measurements and using the Watson-Migdal treatment, they find $a_{nn} = -16.0 \pm 1.0$ fm. Intervention of n–^{3}He final state interactions is believed to be small in this work (1971GR45). See also (1973GR1L, 1973JE02). At $E_t = 22$ MeV no clear evidence is seen for sequential processes via excited states of ^{4}He (1971GR12).

Analysis of reaction (c) at $E_d = 20$ MeV is consistent with the existence of a broad resonance in the ^{3}H+p system correspoding to ^{4}He*(22.) (1968NE1D): see (1973FI04) for a general discussion of the states of ^{4}He. n-p final-state interaction enhancement has been studied by (1973SL03) at $E_d = 35$ MeV. They find that only when $E_{n,p} \leq 1$ MeV is agreement with the Watson-Migdal theory obtained, even if the data far from dominant n-t final-state interaction and p-t quasi-free scattering is chosen. See also (1966LA04).

See also (1965FL1A, 1966BR02, 1966BR1F, 1966BR1E, 1966BU09, 1966VA1A, 1967BO1D, 1967NE1B, 1968OH1A, 1969BU19, 1969ME1B, 1970HA1L, 1971MC1L, 1971OH1A, 1971PO1C,

1971SC1L, 1973GE1G), (1968TO1F, 1970SL1B, 1971HA2G, 1971WA1D, 1972OH1D, 1972SC1R) and (1965DU1A, 1965GO1B, 1966BA1J, 1966HU16, 1967OH1A, 1968HA1F, 1969HA1M, 1969HE1K, 1970PO1A, 1970SE1B, 1971DE20, 1971OH1C, 1971SI30, 1972SE09; theor.).

3. ^{3}H(d, p)^{4}H $\rightarrow$ ^{3}H + n $\quad$ $Q_{\rm m} = -2.2246$ $\quad$ $E_{\rm b} = 16.70$

See (1967JA07, 1973SL03) and (1973FI04).

4. ^{3}H(d, d)^{3}H $\quad$ $E_{\rm b} = 16.70$

The elastic scattering has been studied for $E_{\rm d} = 2.6$ to 11.0 MeV. The excitation curves show an interference at $E_{\rm x} \approx 19$ MeV and a braod ($\Gamma > 1$ MeV) resonance corresponding to $E_{\rm x} = 20.0 \pm 0.5$ MeV, also seen in ^{3}He(d, d) [see ^{7}Li]. Together with data from ^{3}H(d, n)^{4}He, this work favors an assignment $D_{3/2}$ or $D_{5/2}$ with a mixture of doublet and quartet components (channel spin $\frac{1}{2}$ and $\frac{3}{2}$) if only one state is involved (1967TO02, 1968IV01) [any appreciable doublet component would, however, be in conflict with results from ^{7}Li(p, ^{3}He)^{5}He]. Measurements of differential cross section and analyzing power using polarized deuterons with $E_{\rm d} = 3.2$ to 12.3 MeV show resonance-like behavior in the vector analyzing power near $E_{\rm d} = 5$ MeV. The anomaly appears in the odd Legendre coefficients and is interpreted in terms of a $(\frac{1}{2}, \frac{3}{2})^{-}$ excited state of ^{5}He with $E_{\rm x} \approx 19.6$ MeV. Broad structure in the differential cross section near 6 MeV, principally in the even Legendre coefficients, corresponds to an even parity state ^{5}He*(20.0) (1971KI02)[§] . See also (1966BA1J, 1966BA1M, 1966DE1F, 1969BE1M, 1970HE1C, 1973CH27, 1974CH02; theor.) and (1966LA04).

5. (a) ^{3}H(t, n)^{5}He $\quad$ $Q_{\rm m} = 10.44$
(b) ^{3}H(t, 2n)^{4}He $\quad$ $Q_{\rm m} = 11.3324$

At $E_{\rm t} = 0.5$ MeV, the reaction appears to proceed via three channels: (i) direct breakup into ^{4}He + 2n, the three-body breakup shape being modified by the n-n interaction; (ii) sequential decay via ^{5}He(0); (iii) sequential decay via a broad excited state of ^{5}He. The branching ratios at $\theta = 90^{\circ}$ are 0.7: 0.2: 0.1. The width of ^{5}He(0) is estimated to be 0.74 ± 0.18 MeV. Some evidence is also shown for ^{5}He* at $E_{\rm x} \approx 2$ MeV, $\Gamma \approx 2.4$ MeV (1965WO03). For reaction (b), see ^{6}He.

6. (a) ^{3}He(t, p)^{5}He $\quad$ $Q_{\rm m} = 11.20$
(b) ^{3}He(t, pn)^{4}He $\quad$ $Q_{\rm m} = 12.0963$

[§] Tensor analyzing powers have been measured for $E_{\rm d} = 5.0$ to 11.5 MeV by (1973DE51).

Table 5.4: Recent ^{4}He(n, n)^{4}He polarization studies

E_n (MeV)	Refs.
0.262	(1966JE01)
1.02, 2.44	(1968SA25)
3.4, 7.8	(1970ST15)
6.0, 10.0, 16.4, 23.1, 23.7	(1966HO07)
11 – 30	(1972BR10)
12.0, 16.2	(1966BU09)
14, 17.1	(1973LI1K)
15	(1973TO06)
21 – 29	(1971MU04)
25, 28, 34	(1965AR10, 1967HO1D)

Some evidence is reported at $E_t = 22.25$ MeV in reaction (a) for a broad state of ^{5}He at $E_x \approx 20$ MeV, in addition to a sharp peak corresponding to ^{5}He*(16.7) (1968YO06). For reaction (b) see ^{6}Li. See also (1966LA04).

7. ^{4}He(n, n)^{4}He $E_b = -0.89$

The coherent scattering length (thermal, bound) is 3.0 ± 0.1 fm (1973MU14). The thermal scattering cross section is 0.773 ± 0.009 b and the absorption cross section at 2200 m/sec $\sigma^0_{n,\gamma}$ is < 0.05 b (1969RO16). (1973MU14) adopt 0.76 ± 0.01 b for $\overline{\sigma}_s$. Total cross sections for $E_n = 4 \times 10^{-4}$ eV to 147 MeV are summarized in (1958HU18, 1960HU08, 1964ST25, 1966LA04). Recent measurements include those by (1969RO16: $E_n = 0.187$ to 6.195 eV), (1973GO38: $E_n = 0.7$ to 20.0 MeV), (1966ME14: 77.2, 88.2, 110.0, 129.4, 150.9 MeV) and (1968EN1A: 10 GeV/c).

Earlier angular distribution studies are summarized in (1970GA1A). Other recent work is reported by (1968MO26, 1970MO31: $E_n = 0.2$ to 7.0 MeV), (1969CR1B, 1972CR01: $E_n = 0.55$, 0.84, 1.16, 1.33 MeV) and (1971NI06: 17.6, 20.9 and 23.7 MeV). Recent polarization studies are listed in Table 5.4.

The total cross section has a peak of 7.6 b (1973GO38) [see also (1960VA04)] at $E_n = 1.15 \pm 0.05$ MeV, $E_{cm} = 0.92 \pm 0.04$ MeV, with a width of about 1.2 MeV (1964ST25). A second resonance is observed at $E_n = 22.15 \pm 0.12$ MeV, corresponding to the 16.7 MeV $J^\pi = \frac{3}{2}^+$ state (1959BO54, 1964SH30): $\Gamma_{c.m.} = 100 \pm 50$ keV, $\Gamma_n = \Gamma_d = 50 \pm 35$ keV (1960HU08) [(1966HO07) find that the data are fitted best by $\Gamma_n < \Gamma_d$ although $\Gamma_n > \Gamma_d$ is not excluded]. Attempts to detect additional resonances in the total cross section have been unsuccessful: see (1966LA04).

The $P_{3/2}$ phase shift shows strong resonance behavior near 1 MeV, while the $P_{1/2}$ shift changes more slowly, indicating a broad $P_{1/2}$ level at several MeV excitation (1952DO30, 1966HO07, 1970AR1B, 1972ST01). (1966HO07) have constructed a set of phase shifts for $E_n = 0$ to 31 MeV, $l = 0$, 1, 2, 3 using largely p-α phase shifts. They have measured differential cross sections from 6 to 30 MeV, with special attention to the region near 22.15 MeV and have fitted the data with the assumed phase shifts. At the $\frac{3}{2}^+$ state the best fit to all data is given by $E_{res} = 17.669$ MeV ± 10 keV, $\gamma_d^2 = 2.0$ MeV $\pm 25\%$, $\gamma_n^2 = 50$ keV $\pm 25\%$ (see Table 5.2). The polarization has been calculated from the phase shifts and is presented as a contour plat (1966HO07).

(1968MO26) have carried out accurate angular distribution measurements for $E_n = 0.2$ to 7.0 MeV and deduced an independent set of p-wave phase shifts, assuming that s-wave shifts are those those of a hard sphere, $R = 2.44$ fm. The derived total cross sections fit existing data satisfactorily, and polarization results of (1968SA25) and (1963MA29) are well accounted for. Both single-level dispersion formula and Woods-Saxon potential parameters are deduced. A more extensive optical model analysis for $E_n = 0$ to 20 MeV has been carried out by (1968SA1B).

(1970AR1B, 1973AR1N, 1973AR1P) have analyzed existing differential cross sections and polarization data with phase shifts constrained to analytic (effective range) energy dependence, for $E_n = 0$ to 21 MeV. As compared with the (1966HO07) values, the $P_{1/2}$ phase shift is higher in the range 3 to 10 MeV, and both $S_{1/2}$ and $P_{3/2}$ are larger for $E_n = 10$ to 16 MeV. D- and F-wave phase shifts are also determined (1973AR1P).

A single-level-with-background R-matrix parameterization has been carried out by (1972ST01), fitting differential cross section data for $E_n = 0$ to 20 MeV and polarization analyzing power for 0 to 15 MeV. Parameters for $P_{3/2}$ and $P_{1/2}$ levels are $E_{res} = 0.97$ and 6.43 MeV, and $\gamma^2 = 7.55$ and 12.30 MeV, respectively. See also (1973NI1B). Polarization measurements at six energies from $E_n = 11$ to 30.3 MeV are reported by (1972BR10) together with derived phase shifts. Partial waves as high as $l = 4$ are required, but none shows resonance, other than the $D_{3/2}$. See also (1969RO20).

See also (1966BR1E, 1969MA1H, 1973GA17), (1966BA1K, 1971RH1A, 1971ST1J, 1971WA1D, 1972SC1T) and (1966BA1J, 1966DE1F, 1966PE1C, 1966TO04, 1967SC1E, 1967SW1B, 1969ER1B, 1968SE1A, 1968BA1U, 1969BE1M, 1969CO1E, 1969GE1A, 1969HE1L, 1969KU1D, 1969TH06, 1969VO1E, 1970ER1A, 1970FE1C, 1970GN1A, 1970HE1C, 1970HO32, 1970OM1A, 1970RE1A, 1971BA1Y, 1971BA74, 1971EF01, 1971GI1B, 1971PI04, 1971PL06, 1971TH09, 1971ZH05, 1972AD02, 1972IK01, 1972KI1F, 1972LO1K, 1973AD01, 1973PL02, 1974CH02; theor.).

8. ^{4}He(n, d)^{3}H $\quad Q_m = -17.5900$ $\quad E_b = -0.89$

See (1964DE1B, 1966ME03) and (1966LA04).

9. (a) ^{4}He(d, p)^{5}He $\quad Q_m = -3.12$

(b) ^{4}He(d, pn)^{4}He $\quad Q_m = -2.2246$

A typical proton spectrum consists of a peak corresponding to formation of the ground state of ^{5}He, plus a lower continuum of protons ascribed to deuteron breakup (reaction (b)). Ground-state protons show pronounced azimuthal asymmtery when the reaction is induced by 8.5, 10 and 11 MeV vector polarized deuterons. A DWBA calculation is in only qualitative agreement (1967TR05, 1971KE16). See also (1972AV1E).

Coincidence studies of the final state interactions (α + p) and (α + n) have been carried out at $E_{\rm d} = 14.2$ MeV (1967FU1D), $E_\alpha = 18.0$ and 24.0 MeV (1970AS02), 42 MeV (1967WA08, 1968WA01), $E_\alpha = 70$ MeV (1973TR04) and $E_{\rm d} = 78$ MeV (1968BO1M). Spectra of α-particles in coincidence with protons exhibit peaks corresponding to $^5{\rm He}_{\rm g.s.}$ as well as broad spectator peaks which occur where the neutron laboratory energy is a minimum (1967WA08, 1968WA01): see ^{5}Li. [For earlier work see (1966LA04)]. See also (1971LE02).

At $E_\alpha = 70$ MeV, a kinematically complete experiment shows evidence for sequential decay in reaction (a), proceeding through excited states of ^{5}He. Peaks in the coincident yield of protons and deuterons are ascribed to narrow states at $E_{\rm x} = 16.7 \pm 0.1$ MeV, $\Gamma = 80 \pm 30$ keV, at $E_{\rm x} = 18.6 \pm 0.1$, 18.8 ± 0.1 and 19.2 ± 0.1 MeV, all with $\Gamma = 180 \pm 60$ keV (1973TR04).

See also (1968TA11, 1971AL1B, 1972LA1L) and (1966HE1B, 1967NA1D, 1969NA09, 1972BL1F, 1972NA1D, 1973DE2B; theor.).

10. ^{4}He(t, d)^{5}He $\qquad Q_{\rm m} = -7.15$

Not reported.

11. ^{6}Li(γ, p)^{5}He $\qquad Q_{\rm m} = -4.59$

At $E_\gamma = 60$ MeV, the proton spectrum shows prominent peaks attributed to ^{5}He*($0 + 4.0$, 20 ± 2) (1973GA16). See also (1973DE17) and ^{6}Li.

12. ^{6}Li(e, ep)^{5}He $\qquad Q_{\rm m} = -4.59$

At $E_{\rm e} = 1180$ MeV, two values of Q are observed: $Q = -3.5 \pm 1.0$ MeV, corresponding to ^{5}He(0), and $Q = -19.0 \pm 1.0$ MeV, corresponding to ^{5}He*(16.7). Angular distributions at $E_{\rm p} = 1158$ MeV show that the first represents ejection of a proton with $l > 0$ and the second, an s-proton (1972AN24, 1972AN27, 1972AN29).

13. (a) ^{6}Li(n, d)^{5}He $\qquad Q_{\rm m} = -2.37$

(b) ^{6}Li(n, nd)^{4}He $\qquad Q_{\rm m} = -1.4737$

The angular distribution of ground state deuterons has been studied at $E_n = 14.4$ MeV (1965VA05). DWBA analysis does not reproduce either its shape or the cross section: this may be due to neglect of the deuteron knock-on process (1971MI12). At $E_n = 152$ MeV, two broad structures in the forward spectrum are interpreted as being due to transitions to ^{5}He*(0, 14). The $Q = -17$ MeV peak is the stronger of the two (1966ME03, 1967ME11). For reaction (b) see (1967VA12). See also (1970VA1L, 1971HE1M, 1973BO1Y) and (1966WE1B). See also (1966LA04).

14. ^{6}Li(p, 2p)^{5}He $\qquad Q_m = -4.59$

At $E_p = 100$ to 460 MeV, the summed proton spectra show two peaks [$Q = -4.9 \pm 0.3$ and -22.7 ± 0.3 MeV (1966TY01)]. The lower peak corresponds to ejection of an $l = 0$ proton, presumably leaving ^{5}He in the $\frac{3}{2}^+$ state at 16.7 MeV. See also (1966LA04). At $E_p = 100$ MeV, the $\frac{1}{2}^-$ first excited state of ^{5}He is weakly excited (1972MA61). At $E_p = 100$ and 155 MeV, transitions to states above 20 MeV are reported by (1965RO15, 1967RO06, 1972MA61). See also (1965CO1E, 1966BE1B, 1968ZU1A, 1969RU1A, 1973BH1A), (1967KO1B, 1967SH1C, 1968SA1C, 1972KO13, 1973CH1Q; theor.) and ^{6}Li.

15. (a) ^{6}Li(d, ^{3}He)^{5}He $\qquad Q_m = 0.90$
(b) ^{6}Li(d, n^{3}He)^{4}He $\qquad Q_m = 1.795$

At $E_d = 14.5$ MeV, the ground state group is observed (1955LE24). See also (1960HA14, 1971IN1C). A study of the proximity process ^{3}He(n, p)^{3}H in the final state of reaction (b) has led to an estimate of the lifetime of ^{5}He$_{g.s.}$, $\tau = 1.4 \times 10^{-21}$ sec (to within a factor of 2 or 3) (1972KA44). See also (1968LE15).

16. ^{6}Li(t, α)^{5}He $\qquad Q_m = 15.22$

The width of the ground state is 605 ± 45 keV (1966BI1A). See also (1967BE13) and (1966LA04).

17. ^{7}Li(π^+, 2p)^{5}He $\qquad Q_m = 128.51$

The two-proton spectrum shows broad structures attributed to the ground state of ^{5}He, and to $p^{-1}s^{-1}$ and s^{-2} states at ≈ 20 and (≈ 35) MeV excitation (1965CH12).

18. (a) ^{7}Li(n, t)^{5}He $\quad Q_{\rm m} = -3.36$

(b) ^{7}Li(n, tn)^{4}He $\quad Q_{\rm m} = -2.4668$

The angular distriibution of ground state tritons has been measured at $E_{\rm t} = 14.4$ MeV: it is fairly well reproduced by DWBA (1970MI05). Reaction (b) mainly proceeds as a sequential process through ^{5}He$_{\rm g.s.}$ (1967VA12). See also (1972AN1Q, 1973LI02), (1967BA1E; theor.) and (1966LA04).

19. ^{7}Li(p, ^{3}He)^{5}He $\quad Q_{\rm m} = -4.12$

At $E_{\rm p} = 43.7$ MeV, angular distributions of the ^{3}He groups to the ground state of ^{5}He ($\Gamma = 0.80 \pm 0.04$ MeV) and to levels at 16.7 and 19.9 ± 0.4 MeV ($\Gamma = 2.7$ MeV) have been determined. The angular distribution of the ^{5}He ground state group indicates substantial mixing of $L = 0$ and $L = 2$ transfer. The distribution to ^{5}He*(16.7) is consistent with $L = 1$. Since no transitions are observed in the ^{7}Li(p, t)^{5}Li reaction to the analogue 20 MeV state in ^{5}Li [see ^{5}Li], the transition is presumably S-forbidden and the putative states in ^{5}He-^{5}Li near 20 MeV are $^{4}D_{3/2}$ or $^{4}D_{5/2}$ [compare ^{3}H(d, d)] (1966CE05). Particle-particle coincidence data have been obtained at $E_{\rm p} = 43.7$ MeV. They suggest the existence of ^{5}He*(20.0) with $\Gamma = 3.0 \pm 0.6$ MeV and of a broad state at ≈ 25 MeV. No $T = \frac{3}{2}$ states decaying via $T = 1$ states in ^{4}He were observed (1968MC02). See also (1967JO1B, 1969DE04, 1970CO1M).

20. (a) ^{7}Li(d, α)^{5}He $\quad Q_{\rm m} = 14.23$

(b) ^{7}Li(d, n)^{4}He^{4}He $\quad Q_{\rm m} = 15.1233$

At $E_{\rm d} = 24$ MeV, the α-particle spectrum from reaction (a) shows structures corresponding to the ground and 16.7 MeV states and to states at $E_{\rm x} \approx 20.2$ and 23.8 MeV with $\Gamma \approx 2$ MeV and ≈ 1 MeV, respectively (1972BA30). See also (1966BI1A, 1966MI09, 1966PO1D) and ^{9}Be.

Spectra measured in reaction (b) suggest the involvement of a ^{5}He state with $E_{\rm x} = 2.6 \pm 0.4$ MeV, $\Gamma = 4.0 \pm 1.0$ MeV (1964FE01), $E_{\rm x} = 5.2 \pm 0.2$ MeV, $\Gamma = 5.6^{+0.3}_{-0.6}$ MeV (1965AS06, 1966AS04), $E_{\rm x} = 2.6 \pm 0.2$ MeV, $\Gamma = 7 \pm 2$ MeV (1972GI10). See also (1972ST08, 1973HE26). Study of n-α coincidences for $E_{\rm d} = 2.6$ to 4.0 MeV shows that reaction (b) proceeds mainly by sequential decay, primarily via ^{5}He(0) and excited states of ^{8}Be (1967VA11). See also (1966AS04, 1966MI09, 1967JE01, 1972DE44, 1973HE26). Attempts to observe n-α rescattering effects, following formation of ^{8}Be*(16.63, 16.91) have been unsuccessful at $E_{\rm d} = 1.90$ to 2.10 MeV (1972BR08), 2.07 and 2.09 MeV (1971SW10) and 3.0, 3.2 and 3.6 MeV (1968VA12). The upper limit for the rescattering yield is 1% of the yield from sequential decay via intermediate states in ^{5}He and ^{8}Be (1968VA12). Positive results are reported for $E_{\rm d} = 2.07$ to 2.25 MeV by (1969TH02). See also (1967BE13, 1967FL12, 1967WI1C, 1968GA1E, 1968WI1E, 1971HU1H, 1973HE06, 1973KA32), ^{8}Be, ^{9}Be and (1966LA04).

21. ^{7}Li(^{6}Li, 2α)^{5}He $\quad Q_{\rm m} = 12.76$

See (1965BE1C).

22. ^{9}Be(γ, α)^{5}He $\quad Q_{\rm m} = -2.46$

See ^{9}Be.

23. ^{9}Be(p, pα)^{5}He $\quad Q_{\rm m} = -2.46$

Studies of this reaction have been carried out at $E_{\rm p} = 26.0$, 35.0 and 46.8 MeV (1972QU01) and at 57 MeV (1968RO19). Observation of protons and alphas in coincidence at selected angles shows quasifree scattering of the incident protons by S-state α-clusters in ^{9}Be (1968RO19, 1972QU01): see ^{9}Be. See also (1969YA1B, 1970GO12).

24. ^{9}Be(α, 2α)^{5}He $\quad Q_{\rm m} = -2.46$

The population of ^{5}He(0) has been observed at $E_{\alpha} = 28$ MeV (1965YA02) and at 32.3 and 37.4 MeV (1968YA02). See also (1965HI1B, 1965KU1B, 1966HI1A, 1967ME1C) and ^{9}Be.

25. ^{11}Be(d, n)^{4}He^{4}He^{4}He $\quad Q_{\rm m} = 6.4577$

At $E_{\rm d} = 10.4$ and 12.0 MeV, this reaction involves ^{5}He(0) and states in ^{8}Be and ^{9}Be (1971RE19).

26. ^{12}C(n, n)^{4}He^{4}He^{4}He $\quad Q_{\rm m} = -7.2748$

See ^{12}C in (1968AJ02).

^{5}Li

(Figs. 2 and 3)

GENERAL: (See also (1966LA04).):

Shell model calculations: (1966FR1B, 1968GO01, 1968GO36, 1970RA1D, 1971RA15, 1972LE1L, 1973HA49).

Cluster calculations: (1965NE1B, 1971HE05).

Special levels: (1970HE1D, 1971HE05, 1971RA15, 1973JO1J).

Electromagnetic transitions: (1973HA49).

General reviews: (1966DE1E).

Special reactions: (1971CH31).

Other topics: (1968GO01, 1970RA1J, 1971CH50, 1971ZA1D, 1972CA37, 1972HA57, 1972JA14, 1972LE1L, 1973RO1R).

1. ^{3}He(d, γ)^{5}Li $\qquad Q_{\rm m} = 16.39$

Excitation curves and angular distributions have been measured for $E_{\rm d} = 0.2$ to 2.85 MeV (1954BL89), $E_{\rm d} = 0.2$ to 1.2 MeV (1968BU09), $E_{\rm d} = 1$ to 5 and $E(^{3}{\rm He}) = 2$ to 5.5 MeV (1968KR03), $E(^{3}{\rm He}) = 2$ to 26 MeV (1972KI01), $E(^{3}{\rm He}) = 2.3$ to 11.2 MeV (1968DE14) and $E(^{3}{\rm He}) = 3.7$ to 12 MeV (1970SC18).

A broad maximum in the cross section is observed at $E_{\rm d} = 0.45 \pm 0.04$ MeV [^{5}Li*(16.66)]: $\sigma = 50 \pm 10$ μb, $\Gamma_{\gamma} = 11 \pm 2$ eV (1954BU06: $\gamma_0 + \gamma_1$); $\sigma_{\gamma_0} = 21 \pm 4$ μb, $\Gamma_{\gamma_0} = 5 \pm 1$ eV (1968BU09). See also (1968KR03). The radiation at resonance is isotropic, consistent with s-wave capture: see (1954BU06, 1968BU09, 1968KR03). Study of γ_0 and γ_1 yield $\Gamma = 2.6 \pm 0.4$ MeV for the ground state width, and $E_{\rm x} = 7.5 \pm 1.0$ MeV, $\Gamma = 6.6 \pm 1.2$ MeV for the $\frac{1}{2}^{-}$ state. The ratio of γ_0 to γ_1 is 1.00 ± 0.2 and 1.9 ± 0.4 at $E_{\rm d} = 480$ and 1025 keV (1968BU09).

An excess in the cross section at higher bombarding energies is interpreted by (1972KI01) as being due to a state at $E_{\rm x} \approx 18$ MeV: even parity is deduced from the relative intensity of γ_0 and γ_1. It is presumed to be the $\frac{1}{2}^{+}$ state reported in reactions 3 and 7. A broad peak is also observed at $E_{\rm x} \approx 20.7$ MeV in the γ_0 cross section. The cross section for γ_1 is ≈ 0. The observations are consistent with $J^{\pi} = \frac{5}{2}^{+}$: angular distributions appear to require at least one other state with significant strength near 19 MeV (1972KI01). (1970SC18) also report this state but find $E_{\rm x} = 19.7 \pm 0.2$ MeV [$\Gamma = 5.0$ MeV]: $(2J + 1)\,\Gamma_{\gamma_0} = 1.32$ keV ($\pm 50\%$), suggesting E1 (if only one state is involved). See also (1971WA08; theor.).

Table 5.5: Energy levels of ^{5}Li [a]

E_x (MeV)	$J^\pi; T$	$\Gamma_{c.m.}$ (MeV)	Decay	Reactions
g.s.	$\frac{3}{2}^-; \frac{1}{2}$	≈ 1.5	p, α	1, 5, 6, 7, 9, 10, 11, 12, 13, 14, 15, 16
$5-10$	$\frac{1}{2}^-; \frac{1}{2}$	5 ± 2	p, α	1, 7, 12, 14, 15, 16
16.66 ± 0.07	$\frac{3}{2}^+; \frac{1}{2}$	≈ 0.3	γ, p, d, ^{3}He, α	1, 3, 4, 5, 7, 12, 14
(18 ± 1)	$(\frac{1}{2}^+); \frac{1}{2}$	broad	γ, p, d, ^{3}He, α	1, 3, 7
(20.0 ± 0.5) [a]	$(\frac{3}{2}, \frac{5}{2})^+; \frac{1}{2}$	≈ 5	γ, p, d, ^{3}He, α	1, 3, 4, 7, 14

[a] See also discussions in reactions 3, 4, 7, 14 and 15.

2. ^{3}He(d, n)^{4}Li $\quad Q_m = -5.324$

This reaction has not been observed: see (1966LA04) and reaction 7 in ^{4}Li in (1968ME03).

3. (a) ^{3}He(d, p)^{4}He $\quad Q_m = 18.3538 \quad E_b = 16.39$
   (b) ^{3}He(d, np)^{3}He $\quad Q_m = -2.22464$
   (c) ^{3}He(d, 2p)^{3}H $\quad Q_m = -1.4608$
   (d) ^{3}He(d, 2d)^{1}H $\quad Q_m = -5.4938$

Below 100 keV the cross section follows the simple Gamow form: $\sigma = (18.2 \pm 10^3/E) exp(-91E^{-1/2})$ b (E in keV) (1953JA1A, 1954AR02). The zero-energy cross section factor $S_0 = 6700$ keV $\cdot$ b (1964PA1A). A pronounced resonance occurs at $E_d = 430$ keV, $\Gamma \approx 450$ keV. The peak cross section is given as 695 ± 14 mb (1952BO68, 1955KU03): see Table 5.2. See also (1970CA1K, 1972PL02). Excitation functions for gorund state protons have also been reported by (1966WA18: $E(^3\text{He}) = 0.39$ to 1.46 MeV), (1971GR47: $E_d = 2.8$ to 11.5 MeV), (1972BA30: $E_d = 9.4$ to 17.8 MeV) and (1972KI02: $E(^3\text{He}) = 18.7$ to 44.1 MeV). Angular distribution and polarization measurements are summarized in Table 5.6. Below $E_d = 1.1$ MeV, the polarization analyzing power of the reaction is minimally affected by p-wave contributions (less than a few percent). However, at $E_d = 500$ keV, the analyzing power is reduced by $12 \pm 5\%$ by intervention of the s-wave $J^\pi = \frac{1}{2}^+$ channel (1966BR02, 1967MC01, 1971LE27). See also (1971RO35, 1972SI1F, 1973OH02). (1971LE13) have evaluated matrix elements for $l = 1$ at $E_d = 0.43$ MeV. Vector polarization effects at $E_d > 1$ MeV disagree with the predictions of stripping theory (1966BR02). See also (1971ZA1C). Contour maps, T_{ab} $vs.$ θ, E_d for the vector and tensor analyzing powers are presented for $E_d = 0$ to 12 MeV by (1971GR47). See also

(1971KL02, 1973CL13). Energy dependence of the angular distributions indicate resonance-like behavior at $E_x = 16.6$, 17.5, 20.0, 20.9 and 22.4 MeV in ^{5}Li (1971GR47). See also (1972SE09, 1973CL13). At $E_d \approx 6$ MeV (1971KL02) find the angular distribution more complex than could be accounted for by a single $^2D_{3/2}$ or $^2D_{5/2}$ level at $E_x \approx 20$ MeV [see ^{3}He(d, d)]. For E_d(cm) = 7 to 18 MeV, differential cross sections fall monotonically with no indication of states of ^{5}Li with $23.4 < E_x < 34$, with $\Gamma > 0.8$ MeV and with appreciable widths for decay into ^{3}He + d (1972KI02). See also (1972BA30). The analyzing power for ^{3}He polarization has been studied by (1971HA02, 1971HU1B, 1971LE13, 1971LE27): see (1971ST1J). For a discussion of excitation of ^{4}He excited states in reaction (a) see (1973FI04).

Reaction (b) has been studied at $E_d = 10.92$ MeV (1972NI02), 11.0 MeV (1970LA10, 1970LA1K), $E(^3\text{He}) = 16.5$ MeV (1971LI04), 18 MeV (1965ZU02), 18.0 and 24.0 MeV (1970AS02), $E(^3\text{He}) =$ 27 MeV (1971WA18, 1973WA13) and $E_d = 27.5$ MeV (1973CH05). See also (1966LA04). The spectra show the influence of neutron-proton final state interaction. Sequential decay via excited states of ^{4}He is also reported: see (1970AS02, 1972NI02) and (1973FI04).

Reaction (c) has been investigated at $E_d = 10.9$ MeV (1972NI02), 11 MeV (1965TO01, 1970LA10, 1970LA1K), 15.2 and 20.2 MeV (1967NE1B, 1968NE1D), $E(^3\text{He}) = 16.5$ MeV (1971LI04), 18 MeV (1965ZU02), 18.0 and 24.0 MeV (1970AS02), 19.9 MeV (1971GR12), $E_d = 20.7$ MeV (1970WA15), 24 to 33 MeV (1963BI14, 1964CO1A), 29.8 MeV (1970SL1A), $E(^3\text{He}) = 27$ MeV (1971WA18, 1973WA13), 30 MeV (1973TR1H), $E_d = 39.1$ MeV (1971RU07, 1971RU1E), $E_d = 36$ MeV and $E(^3\text{He}) = 53$ MeV (1967MO08, 1967MO1E, 1968MO10) and at $E_d = 83$ MeV (1972BA32). See also (1972SC1R, 1973SL03). The triton spectra are characterized by p-p final state interaction and by sequential decay via ^{4}He*, as in reaction (b). (1970LA10, 1970LA1K) have analyzed the data of (1968MO10) using all first order interactions, in PWBA. The calculations indicate that complex exchange processes cannot be ignored, and that estimates of the nucleon-nucleon scattering length from such experiments are highly ambiguous (1970LA10, 1970LA1K).

Under kinematic conditions such that two outgoing particles have small relative kinetic energy, a DWBA analysis with two-body interactions has some success in accounting for spectral shapes: see (1967HE1B, 1971CH31, 1971WA18, 1972WA22, 1973WA13, 1973SL03). Reaction (d) has been studied at $E(^3\text{He}) = 26.8$ MeV (1972WA22).

See also (1965DA05, 1967ME14, 1967RO07, 1968FI1D, 1968GO1N, 1968HO29, 1969ME1B, 1971FO1J, 1970HO1L, 1970RO1L, 1970WI1G, 1971AL1B, 1971WA18, 1972RO1M, 1974PR1D), (1968TO1F, 1971BA1U, 1971HA2G, 1972OH1D) and (1965DU1A, 1965HE1A, 1966BA1J, 1966CS1A, 1966DE1D, 1966DU1A, 1967DE1G, 1968DE1K, 1968HA1F, 1968TA1J, 1969HE1K, 1969SE1B, 1970BR1L, 1970KH03, 1970PO1A, 1971DE20, 1971HA1L, 1971KH03, 1971SE1G, 1972OT05, 1973GA1H, 1973GR1L, 1973LI19; theor.).

4. ^{3}He(d, d)^{3}He $\qquad E_b = 16.39$

In the range $E_d = 380$ to 570 keV, the scattering cross section is consistent with s-wave formation of the $J^\pi = \frac{3}{2}^+$ state at 16.66 MeV (1954BR05). The excitation curves for $E_d = 1.96$

Table 5.6: Measurements of angular distributions and polarization in ^{3}He(d, p)^{4}He [a]

Angular distributions to ^{4}He(0)		Polarization [b]	
Energy (MeV)	Refs.	$E_{\rm d}$ (MeV)	Refs.
$E_{\rm d} = 0.25 - 0.85$	(1970CA1K)	$0.19 - 0.50$	(1972OH1C)
$E_{\rm d} = 2.8 - 11.5$	(1971GR47)	$0.30 - 2.5$	(1971RO35)
$E_{\rm d} = 5.9, 7.5, 10.4, 12, 12.3, 13.7$	(1960ST25)	$0.31 - 2.94$	(1966BR02)
		$0.34 - 0.73$	(1972GA1N)
$E(^{3}\text{He}) = 18.7 - 44.1$	(1972KI02)	$0.37 - 1.09$	(1972SI1F)
		0.43	(1971LE13, 1971LE27)
$E_{\rm d} = 23.2 - 27.0$	(1964BI06)	0.45	(1969AD05)
		0.45, 0.70, 0.98, 1.5, 2.0, 2.5	(1971HU1B)
		2	(1968SL1A)
		2.0, 2.8, 3.9, 6.0	(1973CL13)
		$2 - 11.2$	(1971GR15)
		$2.23 - 13.0$	(1971KL02)
		$2.8 - 10.0$	(1971LE1G)
		$2.8 - 11.5$	(1971GR47)
		$3.0 - 12.0$	(1963BR10)
		4, 6, 8, 10	(1969PL01)
		$4.0 - 14.0$	(1973HA51)
		$4.78 - 11.88$	(1970HA1M, 1971HA02)
		5.55, 7.97, 10.68	(1966WE03)
		6.0, 7.7, 10	(1968ZA1A, 1971ZA1C)
		6, 8, 10	(1970WA1L)
		6, 10	(1971HI07)
		6.49, 9.30	(1971KO09)
		$6.7 - 15.8$	(1973LI1L)
		9	(1973KA08)
		10, 12, 14	(1968ST1H, 1969ST1F)
		52	(1969BR22)

[a] See also (1957JA37).

[b] See also (1966LA04).

to 10.99 MeV show a broad resonance ($\Gamma > 1$ MeV) corresponding to $E_x = 20.0 \pm 0.5$ MeV. From the behavior of the angular distributions an assignment of $^2D_{3/2}$ or $(^2D, ^4D)_{5/2}$ is favored, if only one state is involved [see, however, ^{7}Li(p, t)^{5}Li] (1967TO02). [There is some evidence that there is more than one D-wave state in this E_x region: see reaction 3]. See also (1969DA1F, 1972AL1P). In the range E_d(cm) = 7 to 18 MeV differential cross sections show only a monotonic variation with energy. There is no evidence for any other resonances from $E_x = 23$ to 34 MeV (1972BA30, 1972KI02). See also (1970WI1G). Angular distributions have been measured at a number of energies from $E(^3\text{He}) = 18.7$ to 44.1 MeV (1972KI02). Polarization measurements are reported for $E_d = 4.0$ to 11.5 MeV (1972KO07), 4 to 12 MeV (1973BA2P), 4.78 to 11.88 MeV (1970HA1M, 1971HA02), 5.7, 7.1, 8.4 and 9.4 MeV (1973LO1D), 6, 8 and 10 MeV (1969PL01), 9.9 and 11.9 MeV (1970WA32) and 10 and 12 MeV (1971DO1C). Strong variations of the angular distributions for all components of the analyzing power are observed between $E_d = 4.0$ and 8.0 MeV: it is suggested that one or more positive parity states are involved ($18.8 < E_x < 21.2$ MeV). At higher energies potential scattering is the dominant mode (1972KO07). See also (1971BA1U, 1971ST1J) and (1966BA1J, 1966BA1M, 1967HE1B, 1970BR1L, 1970HE1D, 1971HA1L, 1972TA1E, 1973CH27, 1974CH02; theor.).

5. (a) ^{3}He(t, n)^{5}Li $\quad Q_m = 10.13$
   (b) ^{3}He(t, np)^{4}He $\quad Q_m = 12.0963$

For reaction (a) see (1966LA04) and (1971KL04). For reaction (b) see (1970GR17) and ^{6}Li.

6. (a) ^{3}He(^{3}He, p)^{5}Li $\quad Q_m = 10.89$
   (b) ^{3}He(^{3}He, 2p)^{4}He $\quad Q_m = 12.8601$
   (c) ^{3}He(^{3}He, 3p)^{3}H $\quad Q_m = -6.9546$

The spectrum of protons shows a pronounced peak corresponding to $^5\text{Li}_{\text{g.s.}}$ superposed on a continuum (1965BA1D, 1965BA1E, 1972DE46: $E(^3\text{He}) = 3$ to 18 MeV): the ^{5}Li breaks up with a strong angular asymmetry (1968BA1N). The α-spectra $E(^3\text{He}) = 6.9$, 7.9, 9.1 MeV) have been analyzed in terms of final state interactions including both p-p and p-α interactions (1972DE46). At $E(^3\text{He}) = 43.7$ and 53.0 MeV, the spectra show a prominent peak at the high energy end whose angular distributions exhibit a pronounced diffraction pattern (1967SL01, 1968MO10). See also (1965ZU02, 1966BL02, 1966WA18, 1967MO1E, 1968BL06) and (1973LI1M; theor.). A search for a three-proton enhancement (reaction (c)) was unsuccessful at $E(^3\text{He}) = 44$ MeV (1968TO01) and 53 MeV (1968MO10). See also (1966LA04).

7. ^{4}He(p, p)^{4}He $\quad E_b = -1.97$

Table 5.7: Measurements of elastic scattering and polarization in ^{4}He(p, p)^{4}He [a]

Elastic scattering angular distribution		Polarization	
$E_{\rm p}$ (MeV)	Refs.	$E_{\rm p}$ (MeV)	Refs.
11.157, 12.040, 13.600, 14.230	(1973JA1M)	0.2 – 0.5	(1967AD1B)
12.0, 14.2, 17.5	(1969GA12)	0.9 – 3.2	(1967BR02, 1967BR03)
19.9 – 39.8	(1972BA24)	2.1 – 4.3	(1965BL02)
20.6, 23.3, 26.1, 27.7	(1968AL1B)	2.38 – 4.46	(1966DR01)
22.2 – 24.8	(1968DA04)	4.58, 5.95, 7.89, 9.89, 11.94	(1971SC04)
25.0 – 29.2	(1971PL07)	6.00, 7.89, 9.89, 11.16	(1967JA09)
39.8 – 47.7	(1973DA1M)	7.9, 9.9, 11.9	(1971OH04)
46	(1969BU10)	10	(1968PL02)
48.8	(1967DA08)	12.0	(1972KE17)
85	(1973VO1M)	12.0, 14.2, 17.5	(1969GA12)
100	(1970GO36)	14.5	(1965RO22)
141	(1972NI04)	17.5 – 27	(1966WE03)
144	(1972JA07)	20 – 45	(1972BA24)
587	(1968BO1K, 1972BO29)	22.2 – 24.8	(1968DA04)
1000	(1967PA25)	25.0 – 29.2	(1971PL07)
		48	(1966GR08)
		70, 80	(1969PE01)
		544	(1968GO1M, 1972BO29)

[a] See also Table 5.5 (1966LA04) for a summary of earlier work.

Differential cross sections and polarizations have been measured at many energies: see Table 5.5 in (1966LA04) and Table 5.7 here.

Phase shifts below $E_{\rm p} = 3.2$ MeV have been determined by (1967BR03) based on polarization measurements of (1967BR02) and available differential cross sections. The results are in essential agreement with earlier phase shifts of (1949CR1A) but are considerably more precise. In this range, the s-wave phase shift is that of a hard sphere with $R = 2.48$ fm; d-wave shifts are zero. The $P_{3/2}$ phase shift shows a pronounced resonance corresponding to $^5{\rm Li}_{\rm g.s.}$ while the $P_{1/2}$ shift changes slowly over a range of several MeV, suggesting that the first excited state is very broad and located 5–10 MeV above the ground state: see (1959AJ76, 1966LA04) for reviews of earlier results.

From $E_{\rm p} = 3$ to 18 MeV (1971SC04) have analyzed available polarization and differential cross section data to produce a set of phase shifts constrained to an analytic (effective range expansion) energy dependence. d- and f-wave phase shifts are positive and become of some importance above 8 MeV. A polarization contour plot is presented for $E_{\rm p} = 1$ to 18 MeV (1971SC04). See also (1968MO26, 1971AR20, 1973AR1N). An R-matrix (single level plus background) formalism is used by (1972ST01). For $P_{1/2}$ and $P_{3/2}$ the resonance energies are given by $E_{\rm R} = 8.10$ and 2.06 MeV and the reduced widths $\gamma^2 = 12.30$ and 8.02 MeV, respectively (1972ST01). See also (1973NI1B).

A resonance is observed at $E_{\rm p} = 23$ MeV, corresponding to the known $\frac{3}{2}^+$ state at $E_{\rm x} = 16.7$ MeV (1968AL1B, 1968DA04). An anomaly in the polarization is also observed at this energy (1966WE03, 1968DA04, 1972BA24). A further broad feature in the polarization excitation function ($\theta = 102°$) is observed at $E_{\rm p} = 30$ MeV ($E_{\rm x} = 22$ MeV) (1972BA24). Cross sections for $23 < E_{\rm p} < 45$ MeV show no further evidence of excited states (1969BU10).

An extensive phase shift analysis, using complex phases with $l \leq 4$ over a range $E_{\rm p} = 20$ to 40 MeV was made by (1972PL02), using mainly polarization and differential cross section data of (1972BA24). The $D_{3/2}$ level is fit with R-matrix formalism, including background interference, with the following parameters: $E_{\rm x} = 16.68$ MeV, $\gamma^2_{\rm p} = 122$ keV, $\gamma^2_{\rm d}(l=0) = 1.58$ MeV (negative sign), $\gamma^2_{\rm d}(l=2) = 1.58$ MeV, $\theta^2_{\rm p} = 0.014$, $\theta^2_{\rm d} = 0.765$.

The $E_{\rm p} = 30$ MeV structure is not reflected in anomalous behavior of any single phase shift. Strong absorption of even partial waves may indicate broad overlapping positive-parity levels, $J^\pi = \frac{1}{2}^+, \frac{3}{2}^+, \frac{5}{2}^+, \frac{7}{2}^+$ of d + ^{3}He character near $E_{\rm x} = 22$ MeV, but there is no umambiguous identification of excited states other than the $\frac{3}{2}^+$ state in the p-α results (1972PL02). In an alaysis of data of (1971PL07) for $E_{\rm p} = 25$ to 29 MeV, (1971RA27) report evidence for a $\frac{5}{2}^+$ level at $E_{\rm x} = 20$ MeV [$\Gamma_{\rm el}/\Gamma_{\rm total} = 0.15$, $\Gamma_{\rm tot} = 8$ MeV] and a $\frac{1}{2}^+$ level at $E_{\rm x} = 18 \pm 1$ MeV.

Other phase-shift analyses are reported by (1971AR20, 1973AR1N: 0 to 23 MeV), (1972ST01: 0.3 to 20 MeV), (1967BR02, 1967BR03: 0.9 to 3.2 MeV), (1966WE03: 14.3 to 31.0 MeV), (1967DA08: 29, 40, 48 MeV) and (1969PE01: 63, 70, 80 and 94 MeV). See also (1968PL02, 1973AR1P, 1973HO1U).

Elastic scattering at $E_{\rm p} = 587$ MeV (1972BO29) and at 1 GeV (1967PA25) reflect the mass distribution and multibody correlations within the α-particle.

Alpha-proton bremsstrahlung is observed at $E_{\rm p} = 7.0$ to 12.0 MeV (1971WO07, 1972WO1E), and at $E_\alpha = 20$ MeV (1967BO1B). See also (1972AN1P). Cross section measurements have

also been carried out at $E_p = 23.4$ to 48.5 MeV (1973DA1N, 1973DA1P), 180 to 560 MeV (1972SC1M) and at 1 GeV (1967IG1A). For inelastic scattering to excited states of ^{4}He, see (1973FI04). For pion production, see (1972GU1D).

See also (1965JA1B, 1965KU13, 1966BL1B, 1967AU1A, 1967CA1E, 1968KO1F, 1968PA1J, 1969KO1M, 1970LI06, 1970RO1M, 1973CO1Y, 1973EK1A), (1966BA1K, 1966HA1F, 1966RO1B, 1970BO1P, 1971HA2G, 1971ST1J) and (1965HO1A, 1965HO1B, 1966RA1B, 1966TO04, 1967BA1F, 1967BA1G, 1967CZ1A, 1967SA1C, 1967TA1B, 1968BA1K, 1968CH35, 1968FR1F, 1968GL1A, 1968SA1B, 1968SC1D, 1968SE1A, 1968TA1E, 1968BA1U, 1969CO1E, 1969CR1A, 1969GE1A, 1969HE15, 1969LE03, 1969TH06, 1970BA1F, 1970HE1D, 1970KU1C, 1970RE1A, 1970SA01, 1970TH1D, 1971BA1Y, 1971BA61, 1971BA74, 1971FE10, 1971HA1L, 1971IK01, 1971KR1A, 1971LO24, 1971MU1H, 1971PI04, 1971PL06, 1971RA15, 1971TH09, 1972BB19, 1972GR06, 1972IK01, 1972TH06, 1973AD01, 1973CL01, 1973FE1H, 1973LA14, 1973LY02, 1973PL02, 1973SA09, 1973UL1C, 1973YO1F, 1974CH02; theor.).

8. (a) ^{4}He(p, d)^{3}He $\quad Q_m = -18.3538 \quad E_b = -1.97$
   (b) ^{4}He(p, pn)^{3}He $\quad Q_m = -20.5785$
   (c) ^{4}He(p, 2p)^{3}H $\quad Q_m = -19.8147$

Angular distributions of ^{3}He ions (reaction (a)) have been measured at $E_p = 27.9$ MeV (1957WI22), 31 MeV (1953BE14, 1964BU16), 46.8 MeV (1969RO1L, 1969RO24), 49.5 MeV (1969HA16, 1970HA36), 53 MeV (1964CA1B), 55 MeV (1964HA13, 1964HA1P, 1964HA49), 94 MeV (1958SE74) and 155.4 MeV (1967BE35, 1970BE49). See also (1973VO1M). The excitation function shows no indication of resonances for $E_p = 38.5$ to 44.6 MeV (1969BU10). Polarization measurements have been carried out at $E_p = 32$, 40, 50 and 52.5 MeV (1973SA1W) and 55 and 63 MeV (1966BO1A). At $E_p = 141$ MeV the total reaction cross section (not including elastic scattering) is 79.5 ± 2.0 mb (1972NI04).

Reactions (b) and (c) have been studied at $E_p = 46.8$ MeV (1969RO1L,1969RO24, 1970RO17, 1970SA01), 49.5 MeV (1969HA16, 1970HA36) and 156 MeV (1967BE35, 1970BE49). See also (1973KI1L, 1973RO1Z). Angular distributions have been measured in the region of the final state interactions. The t and ^{3}He spectra show peaks due to sequential reaction processes via continuum resonance states in ^{4}He: see (1973FI04). See also (1967AU1A, 1968PA1J) and (1969DO1G, 1969NA1F, 1973HA46, 1973JU02; theor.). For ^{4}He(p, $2N + \chi\pi$) see (1965KU1C).

9. (a) ^{4}He(d, n)^{5}Li $\quad Q_m = -4.19$
   (b) ^{4}He(d, np)^{4}He $\quad Q_m = -2.22464$

Reaction (b) has been studied at $E_d = 14.2$ MeV (1967FU1D), $E_\alpha = 29.2$ MeV (1968TA11), 38.8 MeV (1971LE02), 42 MeV (1967WA08, 1968WA01) and at $E_\alpha = 18.0$ and 24.0 MeV

(1970AS02). See also (1971CH1T). The data indicate that at 42 MeV, direct breakup, with quasi-free α-p scattering taking place and the n acting as a spectator, is at least as important a mechanism as the final state interaction in the ^{5}Li ground state (1967WA08, 1968WA01): see ^{5}He. See also (1967NA1D, 1969NA09, 1972NA1D; theor.) and (1966LA04) for the earlier references.

10. ^{4}He(^{3}He, np)^{5}Li $\quad Q_{\rm m} = -9.68$

See (1973HA50).

11. ^{6}Li(γ, n)^{5}Li $\quad Q_{\rm m} = -5.66$

See ^{6}Li and (1965BA16).

12. (a) ^{6}Li(p, d)^{5}Li $\quad Q_{\rm m} = -3.44$
(b) ^{6}Li(p, pd)^{4}He $\quad Q_{\rm m} = -1.4737$

Deuteron groups are observed to ^{5}Li*(0, 16.7). Angular distributions have been measured at $E_{\rm p} = 18.6$ MeV (1955LI09; d_0), 33.6 MeV (1967KU10, 1970KU1D; d_0, d_2), 100 MeV (1969LI02; d_0) and 156 MeV (1968BE72, 1969BA05, 1969TO1A; d_0, d_2). See (1969TO1A) for spectroscopic factors. In addition, the excitation of a state with $E_{\rm x} = 3.72 \pm 0.10$, $\Gamma = 6.3 \pm 0.5$ MeV is reported by (1966SE1C). [See, however, (1967KU10, 1970KU1D)]. (1969BA05) confirm the population of the first excited state. See also (1966SE1C, 1972AZ03) and (1968JA1D; theor.).

At $E_{\rm p} = 9$ and 10 MeV (1968VA02) and at $E_{\rm p} = 45$ MeV (1971BR12), the p-α final state interaction corresponding to ^{5}Li(0) is observed.

13. (a) ^{6}Li(d, t)^{5}Li $\quad Q_{\rm m} = 0.59$
(b) ^{6}Li(d, pt)^{4}He $\quad Q_{\rm m} = 2.5592$

Angular distributions of the tritons to the ground state of ^{5}Li have been measured at $E_{\rm d} = 15$ and 20 MeV (1959VL24, 1960HA14). See also (1971IN1C). For reaction (b) see (1968LE15).

14. (a) ^{6}Li(^{3}He, α)^{5}Li $\quad Q_{\rm m} = 14.91$
(b) ^{6}Li(^{3}He, pα)^{4}He $\quad Q_{\rm m} = 16.880$

At $E(^3\text{He}) = 25.5$ MeV, the spectra show ^{5}Li*(0, 16.7) and two broad peaks at $E_x \approx 19.8$ and 22.7 MeV with $\Gamma_{cm} = 2$ and 1 MeV, respectively (1972BA30).

Cylindrical asymmetry observed in the breakup of ^{5}Li(0) is attributed to the short lifetime of the ^{5}Li imtermediate state and to the memory retained by the proton of its localization at the time of formation of ^{5}Li (1967RE03, 1968RE10). The first excited state of ^{5}Li also appears to be involved (1972TH08, 1972TH1B). See also (1964MA57, 1966LO10, 1967HO1C, 1968VI03, 1969VI05, 1970GA1G), (1966LA04), (1970DE41, 1972TH04; theor.) and ^{8}Be.

15. (a) ^{7}Li(p, t)^{5}Li $\quad Q_m = -4.43$

(b) ^{7}Li(p, pα)^{3}H $\quad Q_m = -2.467$

At $E_p = 43.7$ MeV, a triton group is observed to ^{5}Li(0) ($\Gamma = 1.55 \pm 0.15$ MeV): the angular distribution is consistent with a substantial mixing of $L = 0$ and 2 transfer. There is some evidence for a very broad excited state between $E_x = 2$ and 5 MeV. ^{5}Li*(16.7, 20.0) were not observed. The formation of ^{5}Li*(16.7) ($^4S_{3/2}$) would be S-forbidden: the absence of ^{5}Li*(20.0) would indicate that this state(s) is also of quartet character [see reaction 19 in ^{5}He] (1966CE05). See also (1966BA1L, 1967PO1C). Weak, broad states at $E_x = 22.0 \pm 0.5$ MeV and 25.0 ± 0.5 MeV and possibly 34 MeV are reported by (1968MC02) in a coincidence experiment in which 3- and 4-particle breakup was analyzed. The t_0 angular distribution has also been studied at $E_p = 16.6$ MeV (1965OG03) and 30.3 MeV (1969DE04).

For reaction (b) see (1967JO1C).

16. ^{10}B(^{3}He, pα)^{4}He^{4}He $\quad Q_m = 12.420$

At $E(^3\text{He}) = 2.45$ and 6.00 MeV the reaction proceeds in part via the first two states of ^{5}Li (1966WA16).

17. ^{12}C(p, 2α)^{5}Li $\quad Q_m = -9.24$

Not observed: see (1972MA62).

^{5}Be

(Fig. 3)

The absence of any group structure in the neutron spectrum in the reaction ^{3}He(^{3}He, n)^{5}Be at $E(^3\text{He}) = 18.0$ to 26.0 MeV indicates that ^{5}Be(0) is at least 4.2 MeV unstable with respect to ^{3}He + 2p [$(M - A) > 33.7$ MeV]. With Coulomb corrections adjusted to match the 16.7 MeV states of ^{5}He–^{5}Li, this observation places the first $T = \frac{3}{2}$ level in these nuclei above $E_x = 21.4$ MeV (1967AD05). [With the "conventional" correction (1966LA04, p.2) $E_x > 20.3$ MeV].

See also (1968CE01, 1970WA1G).

References

(Closed December 31, 1973)

References are arranged and designated by the year of publication followed by the first two letters of the first-mentioned author's name and then by two additional characters. Most of the references appear in the National Nuclear Data Center files (Nuclear Science References Database) and have NNDC key numbers. Otherwise, TUNL key numbers were assigned with the last two characters of the form 1A, 1B, etc. In response to many requests for more informative citations, we have, when possible, included up to ten authors per paper and added the authors' initials.

1949CR1A Critchfield and Dodder, Phys. Rev. 76 (1949) 602

1952AR30 H.V. Argo, R.F. Taschek, H.M. Agnew, A. Hemmendinger and W.T. Leland, Phys. Rev. 87 (1952) 612

1952BO68 T.W. Bonner, J.P. Conner and A.B. Lillie, Phys. Rev. 88 (1952) 473

1952CO35 J.P. Conner, T.W. Bonner and J.R. Smith, Phys. Rev. 88 (1952) 468

1952DO30 D.C. Dodder and J.L. Gammel, Phys. Rev. 88 (1952) 520

1953BE14 J. Benveniste and B. Cork, Phys. Rev. 89 (1953) 422

1953JA1A Jarvis and Roaf, Proc. Roy. Soc. 218 (1953) 432

1954AR02 W.A. Arnold, J.A. Phillips, G.A. Sawyer, E.J. Stovall, Jr. and J.L. Tuck, Phys. Rev. 93 (1954) 483

1954BL89 J.M. Blair, N.M. Hintz and D.M. Van Patter, Phys. Rev. 96 (1954) 1023

1954BR05 R.J.S. Brown, K.F. Famularo, H.D. Holmgren, D. Rankin and T.F. Stratton, Phys. Rev. 96 (1954) 80

1954BU06 W.H. Burke, J.R. Risser and G.C. Phillips, Phys. Rev. 93 (1954) 188

1955KU03 W.E. Kunz, Phys. Rev. 97 (1955) 456

1955LE24 S.H. Levine, R.S. Bender and J.N. McGruer, Phys. Rev. 97 (1955) 1249

1955LI09 J.G. Likely, Phys. Rev. 98 (1955) 1538

1957JA37 N. Jarmie, J.D. Seagrave et al., LA-2014 (1957)

1957WI22 A.F. Wickersham, Jr., Phys. Rev. 107 (1957) 1050

1958HU18 D.J. Hughes and R.B. Schwartz, BNL 325, 2nd Edition (1958); BNL 325, 2nd Edition, Suppl. Vol. I (1960)

1958SE74 W. Selove and J.M. Teem, Phys. Rev. 112 (1958) 1658

1959AJ76 F. Ajzenberg and T. Lauritsen, Nucl. Phys. 11 (1959) 1

1959BO54 T.W. Bonner, F.W. Prosser, Jr. and J. Slattery, Phys. Rev. 115 (1959) 398

1959VL24 N.A. Vlasov and A.A. Ogloblin, Zh. Eksp. Teor. Fiz. 37 (1959) 54; JETP (Sov. Phys.) 10 (1960) 39

1960HA14 E.W. Hamburger and J.R. Cameron, Phys. Rev. 117 (1960) 781

1960HU08 Hughes, Magurno and Brussel, BNL 325, 2nd Ed., Suppl. 1 (1960)

1960ST25 L. Stewart, J.E. Brolley, Jr. and L. Rosen, Phys. Rev. 119 (1960) 1649

1960VA04 F.J. Vaughn, W.L. Imhof, R.G. Johnson and M. Walt, Phys. Rev. 118 (1960) 683

1961PE13 R.B. Perkins and J.E. Simmons, Phys. Rev. 124 (1961) 1153

1961RU1A Rudin, Streibel, Baumgartner, Brown and Huber, Helv. Phys. Acta 34 (1961) 58

1961TR05 I.S. Trostin, V.A. Smotryaev and I.I. Levintov, Zh. Eksp. Teor. Fiz. 41 (1961) 725; JETP (Sov. Phys.) 14 (1962) 524

1962SE09 F. Seiler, E. Baumgartner, W. Haeberli, P. Huber and H.R. Striebel, Helv. Phys. Acta 35 (1962) 385

1963BI14 O.M. Bilaniuk and R.J. Slobodrian, Phys. Lett. 7 (1963) 77

1963BR10 R.I. Brown and W. Haeberli, Phys. Rev. 130 (1963) 1163

1963BU07 W. Buss, H. Waffler and B. Ziegler, Phys. Lett. 4 (1963) 198

1963MA29 T.H. May, R.L. Walter and H.H. Barschall, Nucl. Phys. 45 (1963) 17

1964AL1E Alekseev, Arifkhanov, Vlasov, Davidiv and Samoilov, Zh. Eksp. Teor. Fiz. 47 (1964) 433; JETP (Sov. Phys.) 20 (1965) 287

1964BI06 O.M. Bilaniuk and R.J. Slobodrian, Nucl. Phys. 50 (1964) 585

1964BU16 S.M. Bunch, H.H. Forster and C.C. Kim, Nucl. Phys. 53 (1964) 241

1964CA1B Cairns, Griffith, Lush, Metheringham and Thomas, Nucl. Phys. 60 (1964) 369

1964CO1A Conzett, Shield, Slobodrian and Yamabe, Phys. Rev. Lett. 13 (1964) 625

1964DE1B De Facio, UCRL-7961 T (1964)

1964FE01 P. Fessenden and D.R. Maxson, Phys. Rev. 133 (1964) B71

1964HA13 S. Hayakawa, N. Horikawa, R. Kajikawa, K. Kikuchi, H. Kobayakawa, K. Matsuda, S. Nagata and Y. Sumi, Phys. Lett. 8 (1964) 333

1964HA1P S. Hayakawa, N. Horikawa, R. Kajikawa, K. Kikuchi, H. Kobayakawa, K. Matsuda, S. Nagata and Y. Sumi, Phys. Lett. 8 (1964) 330

1964HA49 S. Hayakawa, N. Horikawa, R. Kajikawa, K. Kikuchi, H. Kobayakawa, K. Matsuda, S. Nagata and Y. Sumi, J. Phys. Soc. Jpn. 19 (1964) 2004

1964MA57 M. Mazari, A. Jaidar, G. Lopez, A. Tejera, J. Careaga, R. Dominguez and F. Alba, Proc. 2nd Int. Conf. on Nucl. Masses, Vienna, Austria, 1963; Ed., W.H. Johnson, Jr. (1964) 305

1964PA1A Parker, Bahcall and Fowler, Astrophys. J. 139 (1964) 602

1964PE14 R.B. Perkins and C. Glashausser, Nucl. Phys. 60 (1964) 433

1964SH30 R.E. Shamu and J.G. Jenkin, Phys. Rev. 135 (1964) B99

1964ST25 J.R. Stehn, M.D. Goldberg, B.N. Magurno and R. Wiener-Chasman, BNL 325, 2nd Edition, Suppl. Vol. 1 (1964)

1964WA22 R.L. Walter, W. Benenson, T.H. May and C.A. Kelsey, Nucl. Phys. 59 (1964) 235

1965AR04 P.E. Argan, L. Meneghetti and S. Vitale, Nuovo Cim. 38 (1965) 1489

1965AR08 P.E. Argan, G.C. Mantovani, P. Marazzini, A. Piazzoli and D. Scannicchio, Suppl. Nuovo Cim. 3 (1965) 245

1965AR10 U.R. Arifkhanov, N.A. Vlasov, V.V. Davydov and L.N. Samoilov, Yad. Fiz. 2 (1965) 239; Sov. J. Nucl. Phys. 2 (1966) 170

1965AS06 P.A. Assimakopoulos, N.H. Gangas, S. Kossionides and N.R.C. Democritus, Phys. Lett. 19 (1965) 316

1965BA16 E.B. Bazhanov, A.P. Komar, A.V. Kulikov and E.D. Makhnovsky, Nucl. Phys. 68 (1965) 191

1965BA1D Bacher and Tombrello, Rev. Mod. Phys. 37 (1965) 433

1965BA1E Bacher and Tombrello, Bull. Amer. Phys. Soc. 10 (1965) 693

1965BE1C Berkowitz, Carlson and Carpenter, Bull. Amer. Phys. Soc. 10 (1965) 694

1965BL02 R.A. Blue and W. Haeberli, Phys. Rev. 137 (1965) B284

1965BO13 F. Boreli, V. Lazarevic and N. Radisic, Nucl. Phys. 66 (1965) 301

1965CH12 G. Charpak, G. Gregoire, L. Massonnet, J. Saudinos, J. Favier, M. Gusakow and M. Jean, Phys. Lett. 16 (1965) 54

1965CH15 J. Christiansen, F.W. Busser, F. Niebergall and G. Sohngen, Nucl. Phys. 67 (1965) 133

1965CO1D Cohen, Kanaris, Margulies and Rosen, Phys. Lett. 14 (1965) 242

1965CO1E Cortellessa, Suppl. Nuovo Cim. 3 (1965) 820

1965DA05 S.E. Darden and A.J. Froelich, Phys. Rev. 140 (1965) B69

1965DU1A Dumitrescu and Sandalescu, Rev. Phys. 10 (1965) 77

1965FL1A Fleischmann, Fritsch and Graw, Z. Physik 186 (1965) 485

1965GO1B Goldfarb and Hug, Helv. Phys. Acta 38 (1965) 541

1965HE1A Henley, Richards and Yu, Phys. Lett. 15 (1965) 331

1965HI1B Hiura and Shimodaya, Prog. Theor. Phys. 34 (1965) 861

1965HO1A Holdeman and Thaler, Phys. Rev. 139 (1965) B1186

1965HO1B Horikawa and Kanada, J. Phys. Soc. Jpn. 20 (1965) 1758

1965JA1B Jarmie et al., Bull. Amer. Phys. Soc. 10 (1965) 1204

1965KU13 V.N. Kuzmin and R.M. Yakovlev, Izv. Akad. Nauk SSSR Ser. Fiz. 29 (1965) 1242; Bull. Acad. Sci. USSR Phys. Ser. 29 (1966) 1245

1965KU1B Kudo, Prog. Theor. Phys. 34 (1965) 942

1965KU1C Kuzmin and Yakovlev, Izv. Akad. Nauk SSSR Ser. Fiz. 29 (1965) 236

1965NE1B Neudachin and Smirnov, At. Energy Rev. 3 (1965) 157

1965OG03 A.A. Ogloblin and V.I. Chuev, Yad. Fiz. 2 (1965) 670; Sov. J. Nucl. Phys. 2 (1966) 480

1965RO15 J.C. Roynette, C. Ruhla, M. Arditi, J.C. Jacmart and M. Riou, Phys. Lett. 19 (1965) 497

1965RO22 L. Rosen, J.G. Beery, A.S. Goldhaber and E.H. Auerbach, Ann. Phys. 34 (1965) 96

1965TO01 T.A. Tombrello and A.D. Bacher, Phys. Lett. 17 (1965) 37

1965TR01 W. Trachslin, H. Burgisser, P. Huber, G. Michel and H.R. Striebel, Helv. Phys. Acta 38 (1965) 523

1965VA05 V. Valkovic, G. Paic, I. Slaus, P. Tomas, M. Cerineo and G.R. Satchler, Phys. Rev. 139 (1965) B331

1965WO03 C. Wong, J.D. Anderson and J.W. McClure, Nucl. Phys. 71 (1965) 106

1965YA02 T. Yanabu, S. Yamashita, K. Takimoto and K. Ogino, J. Phys. Soc. Jpn. 20 (1965) 1303

1965ZU02 R.W. Zurmuhle, Nucl. Phys. 72 (1965) 225

1966AS04 P.A. Assimakopoulos, N.H. Gangas and S. Kossionides, Nucl. Phys. 81 (1966) 305

1966BA1H Baumgartner et al., Phys. Rev. Lett. 16 (1966) 105

1966BA1J Balashko, Proc. Conf. Nucl. Reactions, Rossendorf, 1966; Ed., J. Schintlmeister, ZFK-122 (1966) 398

1966BA1K Barschall, Proc. 2nd Int. Symp. on Polarization Phenom. of Nucleons, Karlsruje,1965 (1966) 393

1966BA1L Bachelier et al., J. Phys. (Paris) 27 (1966) C1-70

1966BA1M Balashko, Trudy of the P.N. Lebedev Phys., 1965, Vol. 33 (1966) 51

1966BE1B Berggren and Tyren, Ann. Rev. Nucl. Sci. 16 (1966) 153

1966BI1A Bilwes, Bourotte and Magnac-Valette, J. Phys. (Paris) 27 (1966) C1-68

1966BL02 E.W. Blackmore and J.B. Warren, Phys. Rev. Lett. 16 (1966) 520

1966BL1B Blue and Stout, Proc. 2nd Int. Symp. on Polarization Phenom. of Nucleons, Karlsruhe, 1965 (1966) 149

1966BO1A Boschitz, Chabre, Conzett and Slobodrian, Proc. 2nd Int. Symp. on Polarization Phenom. of Nucleons, Karlsruhe, 1965 (1966) 354

1966BR02 L. Brown, H.A. Christ and H. Rudin, Nucl. Phys. 79 (1966) 459

1966BR1E Bruning et al., Proc. 2nd Int. Symp. on Polarization Phenom. of Nucleons, Karlsruhe, 1965 (1966) 146

1966BR1F Breunlich, Acta Phys. Aust. 23 (1966) 517

1966BU09 F.W. Busser, F. Niebergall, G. Sohngen and J. Christiansen, Nucl. Phys. 88 (1966) 593

1966CE05 J. Cerny, C. Detraz and R.H. Pehl, Phys. Rev. 152 (1966) 950

1966CS1A Csonka, Moravcsik and Scadron, Phys. Rev. 143 (1966) 775

1966DE1D De Facio, Umberjee and Gammel, Phys. Lett. 21 (1966) 666

1966DE1E Detraz, J. Phys. (Paris) 27 (1966) C1-64

1966DE1F De Facio, Umberjee and Gammel, Phys. Rev. 151 (1966) 819

1966DR01 L. Drigo, C. Manduchi, G.C. Nardelli, M.T. Russo-Manduchi, G. Tornielli and G. Zannoni, Nuovo Cim. B42 (1966) 363

1966DU1A Duck, Nucl. Phys. 80 (1966) 617

1966FR1B Fraser and Spicer, Aust. J. Phys. 19 (1966) 893

1966GR08 T.C. Griffith, D.C. Imrie, G.J. Lush and L.A. Robbins, Phys. Rev. 146 (1966) 626

1966HA1F Hanna, Proc. 2nd Int. Symp. on Polarization Phenom. of Nucleons, Karlsrhue, 1965 (1966) 280

1966HE1B Henneberg, Z. Physik 193 (1966) 23

1966HI1A Hiura and Shimodaya, Prog. Theor. Phys. Jpn. 36 (1966) 977

1966HO06 T.D. Hoang and R.C. Smith, Nucl. Phys. 83 (1966) 9

1966HO07 B. Hoop, Jr. and H.H. Barschall, Nucl. Phys. 83 (1966) 65

1966HU16 A. Huq, Helv. Phys. Acta 39 (1966) 507

1966JE01 R.W. Jewell, W. John, J.E. Sherwood and D.H. White, Phys. Rev. 142 (1966) 687

1966KO19 A.P. Kobzev, V.I. Salatskii and S.A. Telezhnikov, Yad. Fiz. 3 (1966) 1060; Sov. J. Nucl. Phys. 3 (1966) 774

1966LA04 T. Lauritsen and F. Ajzenberg-Selove, Nucl. Phys. 78 (1966) 1

1966LO10 T. Lorenz, Z. Naturforsch. A21 (1966) 1196

1966ME03 D.F. Measday, Phys. Lett. 21 (1966) 62

1966ME14 D.F. Measday and J.N. Palmieri, Nucl. Phys. 85 (1966) 129

1966MI09 C. Milone and R. Potenza, Nucl. Phys. 84 (1966) 25

1966PE1C W.A. Pearce and P. Swan, Nucl. Phys. 78 (1966) 433

1966PO1D Potenza, Proc. Int. School Enrico Fermi, Course 36; Ed., C. Bloch (1966) 584

1966RA1B Rahman, Khan and Sen Gupta, Nuovo Cim. 44 (1966) 36

1966RO1B Rosen, Proc. 2nd Int. Symp. on Polarization Phenom. of Nucleons, Karlsruhe, 1965 (1966) 253

1966SE1C Seifert, NYO GEN 72 48 (1966)

1966TO04 T.A. Tombrello, Phys. Lett. 23 (1966) 134

1966TY01 H. Tyren, S. Kullander, O. Sundberg, R. Ramachandran, P. Isacsson and T. Berggren, Nucl. Phys. 79 (1966) 321; Erratum Nucl. Phys. A119 (1968) 692

1966VA1A Vasilev et al., Atomn. Energ. (USSR) 20 (1966) 341

1966WA16 M.A. Waggoner, J.E. Etter, H.D. Holmgren and C. Moazed, Nucl. Phys. 88 (1966) 81

1966WA18 N. Wang, V.N. Novatskii, G.M. Osetinskii, N. Chien and I.A. Chepurchenko, Yad. Fiz. 3 (1966) 1064; Sov. J. Nucl. Phys. 3 (1966) 777

1966WE03 W.G. Weitkamp and W. Haeberli, Nucl. Phys. 83 (1966) 46

1966WE1B Weinberg, Antwerp 1965 Neutron Conf. (1966) 37

1967AD05 E.G. Adelberger, A.B. McDonald, T.A. Tombrello, F.S. Dietrich and A.V. Nero, Phys. Lett. B25 (1967) 595

1967AD1B Adyasevich, Antonenko, Polunin and Fomenko, Yad. Fiz. 5 (1967) 933

1967AU1A Audouze, Epherre and Reeves, High Energy Nucl. Reactions in Astrophys.; Ed., B.S.P. Shen (1967) 255

1967BA1E Bang, Zelemskaya, Magzumov and Neudachin, Sov. J. Nucl. Phys. 4 (1967) 688

1967BA1F Baz, Sov. J. Nucl. Phys. 4 (1967) 182

1967BA1G R.H. Bassel and C. Wilkin, Phys. Rev. Lett. 18 (1967) 871

1967BE13 M. Berrada, J.-P. Laugier, C. Lemeille, N. Saunier and L. Marquez, J. Phys. (Paris) 28 (1967) 135

1967BE1G H.C. Benoehr and K. Wildermuth, Phys. Lett. B26 (1967) 68

1967BE35 M. Bernas, J.K. Lee, D. Bachelier, I. Brissaud, C. Detraz, P. Radvanyi and M. Roy, Phys. Lett. B25 (1967) 260

1967BO1B Boyd et al., Bull. Amer. Phys. Soc. 12 (1967) 465

1967BO1C M. Bouten, P. Van Leuven, H. Depuydt and L. Schotsmans, Nucl. Phys. A100 (1967) 90

1967BO1D Bodart and Deconninck, Ann. Soc. Sci. (Brussels) 81 (1967) 137

1967BR02 L. Brown and W. Trachslin, Nucl. Phys. A90 (1967) 334

1967BR03 L. Brown, W. Haeberli and W. Trachslin, Nucl. Phys. A90 (1967) 339

1967BU11 W. Busse, J. Christiansen, D. Hilscher, U. Morfeld, J.A. Scheer and W.U. Schroder, Nucl. Phys. A100 (1967) 490

1967CA1E Cameron et al., Bull. Amer. Phys. Soc. 12 (1967) 1140

1967CZ1A W. Czyz and L. Lesniak, Phys. Lett. B24 (1967) 227

1967DA08 B.W. Davies, M.K. Craddock, R.C. Hanna, Z.J. Moroz and L.P. Robertson, Nucl. Phys. A97 (1967) 241

1967DE1G B. Defacio, R.K. Umerjee and J L. Gammel, Phys. Lett. B25 (1967) 449

1967EL03 J.P. Elliott, H.A. Mavromatis and E.A. Sanderson, Phys. Lett. B24 (1967) 358

1967FL12 Y. Flamant, Y. Chanut and R. Ballini, J. Phys. (Paris) 28 (1967) 622

1967FU1D Fukunaga et al., J. Phys. Soc. Jpn. 22 (1967) 28

1967HE1B E.M. Henley, F.C. Richards and D.U.L. Yu, Nucl. Phys. A103 (1967) 361

1967HO1C Holmgren, Nucl. Research with Low Energy Accelerators; Eds., Marion and van Patter (1967) 213

1967HO1D Hoop and Huber, Helv. Phys. Acta 40 (1967) 710

1967IG1A G.J. Igo, J.L. Friedes, H. Palevsky, R. Sutter, G. Bennett, W.D. Simpson, D.M. Corley and R.L. Stearns, Nucl. Phys. B3 (1967) 181

1967JA07 N. Jarmie, R.H. Stokes, G.G. Ohlsen and R.W. Newsome, Jr., Phys. Rev. 161 (1967) 1050

1967JA09 M.F. Jahns and E.M. Bernstein, Phys. Rev. 162 (1967) 871

1967JE01 H. Jeremie, P. Martin and A. Calamand, Nucl. Phys. A105 (1967) 689

1967JO1B Joseph et al., Bull. Amer. Phys. Soc. 12 (1967) 189

1967JO1C Joseph et al., Bull. Amer. Phys. Soc. 12 (1967) 465

1967KO1B Kolybasov and Smorodinskaya, Yad. Fiz. 5 (1967) 777

1967KU10 L.A. Kull, Phys. Rev. 163 (1967) 1066

1967MC01 L.C. McIntyre and W. Haeberli, Nucl. Phys. A91 (1967) 369

1967ME11 D.F. Measday and J.N. Palmieri, Phys. Rev. 161 (1967) 1071

1967ME14 H. Meiner, E. Baumgartner, S.E. Darden, P. Huber and G.R. Plattner, Helv. Phys. Acta 40 (1967) 483

1967ME1C Meboniya, Bull. Moscow Univ., Phys. Astron. 1 (1967) 114

1967MO08 B.J. Morton, E.E. Gross, J.J. Malanify and A. Zucker, Phys. Rev. Lett. 18 (1967) 1007

1967MO1E Morton, ORNL TM 1914 (1967)

1967NA1D H. Nakamura, Phys. Lett. B24 (1967) 509

1967NE1B Newsome, Bull. Amer. Phys. Soc. 12 (1967) 17

1967OH1A G.G. Ohlsen, Phys. Rev. 164 (1967) 1268

1967PA25 H. Palevsky, J.L. Friedes, R.J. Sutter, G.W. Bennett, G.J. Igo, W.D. Simpson, G.C. Phillips, D.M. Corley, N.S. Wall, R.L. Stearns et al., Phys. Rev. Lett. 18 (1967) 1200

1967PO1C Portner and Moore, Bull. Amer. Phys. Soc. 12 (1967) 632

1967RE03 M.A. Reimann, P.W. Martin and E.W. Vogt, Phys. Rev. Lett. 18 (1967) 246

1967RO06 J.C. Roynette, M. Arditi, J.C. Jacmart, F. Mazloum, M. Riou and C. Ruhla, Nucl. Phys. A95 (1967) 545

1967RO07 D.C. Robinson, Nucl. Phys. A95 (1967) 663

1967SA1C Sannes and Stairs, Can. J. Phys. 45 (1967) 1497

1967SC1E Schenter, Bull. Amer. Phys. Soc. 12 (1967) 11

1967SH1C Shapiro, Proc. Prob. Symp. on Nucl. Phys., Tbilisi, 1967 (1967) 307

1967SL01 R.J. Slobodrian, J.S.C. McKee, W.F. Tivol, D.J. Clark and T.A. Tombrello, Phys. Lett. B25 (1967) 19

1967SW1B Swan, Private Communication (1967)

1967TA1B B. Tatischeff, Nucl. Phys. A98 (1967) 384

1967TO02 T.A. Tombrello, R.J. Spiger and A.D. Bacher, Phys. Rev. 154 (1967) 935

1967TR05 A. Trier and W. Haeberli, Phys. Rev. Lett. 18 (1967) 915

1967VA11 V. Valkovic, W.R. Jackson, Y.S. Chen, S.T. Emerson and G.C. Phillips, Nucl. Phys. A96 (1967) 241

1967VA12 V. Valkovic, I. Slaus, P. Tomas and M. Cerineo, Nucl. Phys. A98 (1967) 305

1967WA08 R.E. Warner and R.W. Bercaw, Phys. Lett. B24 (1967) 517

1967WI1C Wise, Knowles and Bunch, Bull. Amer. Phys. Soc. 12 (1967) 633

1967YA1A Yazaki, Prog. Theor. Phys. 37 (1967) 353

1968AJ02 F. Ajzenberg-Selove and T. Lauritsen, Nucl. Phys. A114 (1968) 1

1968AL1B Allison and Smythe, Nucl. Phys. A121 (1968) 97

1968BA1K R.H. Bassel and C. Wilkin, Phys. Rev. 174 (1968) 1179

1968BA1N Bacher and Tombrello, Bull. Amer. Phys. Soc. 13 (1968) 564

1968BA1U Barashenkov and Eliseev, Joint Inst. Nucl. Res., Lab. Theor. Phys., USSR, Rept. P2 4333 (1969)

1968BE05 A.F. Behof, T.H. May and W.I. McGarry, Nucl. Phys. A108 (1968) 250

1968BE72 M. Bernas and D. Smet, Ann. Phys. (Paris) 3 (1968) 213

1968BL06 E.W. Blackmore and J.B. Warren, Can. J. Phys. 46 (1968) 233

1968BO1K E.T. Boschitz, W.K. Roberts, J.S. Vincent, K. Gotow, P.C. Gugelot, C.F. Perdrisat and L.W. Swenson, Phys. Rev. Lett. 20 (1968) 1116

1968BO1M Bonbright et al., Bull. Amer. Phys. Soc. 13 (1968) 1367

1968BO32 N.E. Booth, A. Beretvas, R.E.P. Davis, C. Dolnick, R.E. Hill, M. Raymond and D. Sherden, Nucl. Phys. A119 (1968) 233

1968BO35 D.C. Bonar, C.W. Drake, R.D. Headrick and V.W. Hughes, Phys. Rev. 174 (1968) 1200

1968BU09 W. Buss, W. Del Bianco, H. Waffler and B. Ziegler, Nucl. Phys. A112 (1968) 47

1968CE01 J. Cerny, Ann. Rev. Nucl. Sci. 18 (1968) 27

1968CH35 J.S. Chalmers and A.M. Saperstein, Phys. Rev. 168 (1968) 1145; Addendum Phys. Rev. C2 (1970) 2034

1968DA04 P. Darriulat, D. Garreta, A. Tarrats and J. Testoni, Nucl. Phys. A108 (1968) 316

1968DE14 W. Del Bianco, F. Lemire, R.J.A. Levesque and J.M. Poutissou, Can. J. Phys. 46 (1968) 1585

1968DE1K de Alba, Jaidar and Martinez Negrete, Rev. Mex. Fis. 17 (1968) 143

1968EL1A Elliott, 3rd Symp. on the Struct. of Low-Medium Mass Nucl.; Ed., Davidson (1968) 48

1968EN1A J. Engler, K. Horn, J. Konig, F. Monnig, P. Schludecker, H. Schopper, P. Sievers, H. Ullrich and K. Runge, Phys. Lett. B28 (1968) 64

1968FI1D Findley, Baker, Carter and Hatfield, Bull. Amer. Phys. Soc. 13 (1968) 558

1968FR1F V. Franco, Phys. Rev. Lett. 21 (1968) 1360

1968GA1E Gagne, Lambert and Teado, Bull. Amer. Phys. Soc. 13 (1968) 698

1968GL1A Glauber, Proc. Symp. on Use of Nimrod, 1968, RHEL/R166 (1968) 41, 60

1968GO01 P. Goldhammer, J.R. Hill and J. Nachamkin, Nucl. Phys. A106 (1968) 62

1968GO1M K. Gotow, E.T. Boschitz, W.K. Roberts, J.S. Vincent, P.C. Gugelot, C.F. Perdrisat and L.W. Swenson, Phys. Rev. Lett. 21 (1968) 1816

1968GO1N Gofman et al., Izv. Akad. Nauk SSSR Ser. Fiz. 32 (1968) 690

1968GO36 G.S. Gogsadze and T.I. Kopaleishvili, Yad. Fiz. 8 (1968) 875; Sov. J. Nucl. Phys. 8 (1969) 509

1968HA1F R.M. Haybron, Nucl. Phys. A112 (1968) 594

1968HE16 G. Hentschel, G. Mack and G. Mertens, Z. Naturforsch. A23 (1968) 1401

1968HE1D R.C. Herndon and Y.C. Tang, Phys. Rev. 165 (1968) 1093

1968HO29 C. Hojvat and G. Jones, Nucl. Instrum. Meth. 66 (1968) 13

1968IV01 M. Ivanovich, P.G. Young and G.G. Ohlsen, Nucl. Phys. A110 (1968) 441

1968JA1D Jackson, Adv. Phys. 17 (1968) 481

1968KO1F Komarov and Savchenko, Joint Inst. Nucl. Res., Lab. Nucl. Problems, USSR, Rept. P1 3720 (1968)

1968KR03 L. Kraus, M. Suffert and D. Magnac-Valette, Nucl. Phys. A109 (1968) 593

1968LE15 J.C. Legg, W.D. Simpson and S.T. Emerson, Nucl. Phys. A119 (1968) 209

1968MC02 R.L. McGrath, J. Cerny and S.W. Cosper, Phys. Rev. 165 (1968) 1126

1968ME03 W.E. Meyerhof and T.A. Tombrello, Nucl. Phys. A109 (1968) 1

1968MO10 B.J. Morton, E.E. Gross, E.V. Hungerford, J.J. Malanify and A. Zucker, Phys. Rev. 169 (1968) 825

1968MO26 G.L. Morgan and R.L. Walter, Phys. Rev. 168 (1968) 1114; Erratum Phys. Rev. 185 (1969) 1598

1968NE1D Newsome, LA 3997 (1968)

1968OH1A Ohlsen, McKibben and Lawrence, Bull. Amer. Phys. Soc. 13 (1968) 1443

1968PA1J Palevsky, Proc. of Symp. on Use of Nimrod, 1968, RHEL-R166 (1968) 19

1968PL02 D.J. Plummer, T.A. Hodges, K. Ramavataram, D.G. Montague and N.S. Chant, Nucl. Phys. A115 (1968) 253

1968RE10 M.A. Reimann, P.W. Martin and E.W. Vogt, Can. J. Phys. 46 (1968) 2241

1968RO19 P.G. Roos, H.G. Pugh, M. Jain, H.D. Holmgren, M. Epstein and C.A. Ludemann, Phys. Rev. 176 (1968) 1246

1968SA1B G.R. Satchler, L.W. Owen, A.J. Elwyn, G.L. Morgan and R.L. Walter, Nucl. Phys. A112 (1968) 1

1968SA1C Saito, Hiura and Tanaka, Prog. Theor. Phys. 39 (1968) 635

1968SA25 J.R. Sawers, Jr., G.L. Morgan, L.A. Schaller and R.L. Walter, Phys. Rev. 168 (1968) 1102

1968SC1D L.I. Schiff, Phys. Rev. 176 (1968) 1390

1968SE1A Sergeev, Geradin, Wery and Magnac-Valette, Compt. Rend. 261 (1965) 291

1968SI1B Simmons and Malanify, Bull. Amer. Phys. Soc. 13 (1968) 564

1968SL1A Slabospitskii et al., Sov. J. Nucl. Phys. 6 (1968) 723

1968ST1H Starkovich et al., Bull. Amer. Phys. Soc. 13 (1968) 1448

1968TA11 T. Tanabe, J. Phys. Soc. Jpn. 25 (1968) 21

1968TA1E B. Tatischeff and A. Willis, Nucl. Phys. A115 (1968) 593

1968TA1J Tanifuji and Yazaki, Prog. Theor. Phys. 40 (1968) 1023

1968TO01 T.A. Tombrello and R.J. Slobodrian, Nucl. Phys. A111 (1968) 236

1968TO1F Tombrello, Proc. Int. Conf. Nucl. Struct., Tokyo, Japan (1967); Suppl. J. Phys. Soc. Jpn. 24 (1968) 63

1968VA02 V. Valkovic, C. Joseph, S.T. Emerson and G.C. Phillips, Nucl. Phys. A106 (1968) 138

1968VA12 V. Valkovic, C. Joseph, A. Niiler and G.C. Phillips, Nucl. Phys. A116 (1968) 497

1968VI03 B. Vignon, J.-F. Cavaignac and J.-P. Longequeue, Compt. Rend. B266 (1968) 878

1968WA01 R.E. Warner and R.W. Bercaw, Nucl. Phys. A109 (1968) 205

1968WI1E Wise, Thesis, Washington State Univ. (1968)

1968YA02 T. Yanabu, S. Yamashita, K. Hosono, S. Matsuki, T. Tanabe, K. Takimoto, Y. Okuma, K. Ogino, S. Okumura and R. Ishiwari, J. Phys. Soc. Jpn. 24 (1968) 667

1968YO06 P.G. Young, R.H. Stokes and G.G. Ohlsen, Phys. Rev. 173 (1968) 949

1968ZA1A Zaika, Mokhnach, Shmarin and Yasnogorodskii, Izv. Akad. Nauk SSSR Ser. Fiz. 32 (1968) 257

1968ZU1A Zupancic, Proc. Symp. on Use of Nimrod, 1968, RHEL/R166 (1968) 67

1969AD05 B.P. Adyasevich and V.G. Antonenko, Yad. Fiz. 10 (1969) 485; Sov. J. Nucl. Phys. 10 (1970) 278

1969BA05 D. Bachelier, M. Bernas, I. Brissaud, C. Detraz and P. Radvanyi, Nucl. Phys. A126 (1969) 60

1969BE1M H. C. Benohr and K. Wildermuth, Nucl. Phys. A128 (1969) 1

1969BE56 V.M. Bezotosnyi, V.A. Zhmailo, L.M. Surov and M.S. Shvetsov, Yad. Fiz. 10 (1969) 225; Sov. J. Nucl. Phys. 10 (1970) 127

1969BR22 H. Bruckmann and F.K. Schmidt, Nucl. Phys. A136 (1969) 81

1969BU10 S.N. Bunker, J.M. Cameron, M.P. Epstein, G. PaiImage, J.R. Richardson, J.G. Rogers, P. TomaImage and J.W. Verba, Nucl. Phys. A133 (1969) 537

1969BU19 F.W. Busser, H. Dubenkropp, F. Niebergall and K. Sinram, Nucl. Phys. A129 (1969) 666

1969CO1E G. Cocho, A. Mondragon and M. Colon-Vela, Nucl. Phys. A125 (1969) 425

1969CR1A A.H. Cromer, Nucl. Phys. B11 (1969) 152

1969CR1B Cramer, Thesis, Univ. of Virginia (1969)

1969DA1F Dauchy et al., Lett. Nuovo Cim. 2 (1969) 263

1969DE04 D.W. Devins, S.M. Bunch, H.H. Forster, J. Hokhikian and C.C. Kim, Nucl. Phys. A126 (1969) 261

1969DO1G Dolinski and Turovtsev, Sov. J. Nucl. Phys. 9 (1969) 445

1969EL1B Elliott, Proc. Int. Conf., Montreal (1969) 277

1969ER1B Ericson and Locher, Nucl. Struct. Dubna Symp. 1968, IAEA (1968) 389

1969GA12 D. Garreta, J. Sura and A. Tarrats, Nucl. Phys. A132 (1969) 204

1969GE1A George and Shamu, Bull. Amer. Phys. Soc. 14 (1969) 535

1969GI1A B.F. Gibson, A. Goldberg and M.S. Weiss, Phys. Rev. 181 (1969) 1486

1969GO1C Golovanova and Zelenskaya, Sov. J. Nucl. Phys. 8 (1969) 158

1969HA16 S.A. Harbison, R.J. Griffiths, F.G. Kingston, A.R. Johnston and G.T.A. Squier, Nucl. Phys. A130 (1969) 513

1969HA1M Halbleib and Scott, Nucl. Sci. Eng. 37 (1969) 271

1969HE15 P. Heiss and H.H. Hackenbroich, Phys. Lett. B30 (1969) 373

1969HE1H Hentschel, Z. Phys. 219 (1969) 32

1969HE1K Henley, Isospin in Nucl. Phys.; Ed., D.H. Wilkinson (1969) 15

1969HE1L Heiss, BMWF FBK 69 38 (1969)

1969KO1M Komarov, Kosarev and Savchenko, Joint. Inst. Nucl. Res., Lab. Nucl. Problems, USSR, Rept. P1 4876 (1969)

1969KO30 T.I. Kopaleishvili and I.Z. Machabeli, Izv. Akad. Nauk SSSR Ser. Fiz. 33 (1969) 69; Bull. Acad. Sci. USSR Phys. Ser. 33 (1970) 65

1969KU1D Kujawski, Tech. Rept. No. 70-048, Univ. of Maryland (1969)

1969LE03 L. Lesniak and H. Wolek, Nucl. Phys. A125 (1969) 665

1969LI02 T.Y. Li and S.K. Mark, Nucl. Phys. A123 (1969) 147

1969MA1H Manduchi, Moschini, Tornielli and Zannoni, Nucl. Instrum. Meth. 67 (1969) 267

1969ME1B Meiner et al., Bull. Amer. Phys. Soc. 14 (1969) 512

1969ME1C Meyer, Amer. J. Phys. 37 (1969) 296

1969MI10 R.C. Minehart, L. Coulson, W.F. Grubb, III and K. Ziock, Phys. Rev. 177 (1969) 1455, 1464

1969NA09 H. Nakamura, Nucl. Phys. A137 (1969) 51

1969NA1F Nagatani, Herling and Kolltveit, Bull. Amer. Phys. Soc. 14 (1969) 511

1969PE01 V. Perez-Mendez, J.M. Sperinde and A.W. Stetz, Phys. Lett. B28 (1969) 648

1969PL01 G.R. Plattner and L.G. Keller, Phys. Lett. B29 (1969) 301

1969RO16 D.C. Rorer, B.M. Ecker and R.O. Akyuz, Nucl. Phys. A133 (1969) 410

1969RO1L Rogers, UCLA P-84 (1969)

1969RO20 L.P. Robertson, R.C. Hanna, K. Ramavataram, D.W. Devins, T.A. Hodges, Z.J. Moroz, S.J. Hoey and D.J. Plummer, Nucl. Phys. A134 (1969) 545

1969RO24 J.G. Rogers, J.M. Cameron, M.B. Epstein, G. Paic, P. Tomas, J.R. Richardson, J.W. Verba and P. Doherty, Nucl. Phys. A136 (1969) 433

1969RU1A Ruhla, Proc. Enrico Fermi School of Phys., Course XL, Lake Como, 1967 (1969) 701

1969SC1J R. Schrills and H.M. Darley, Phys. Lett. B29 (1969) 291

1969SE1B Seiler, Baumgartner, Huber and Leeman, Helv. Phys. Acta 42 (1969) 567

1969ST1F Starkovich, LA 4191 (1969)

1969TH02 G. Thievent, J. Lang, R. Muller and P. Marmier, Phys. Lett. B30 (1969) 23

1969TH06 D.R. Thompson, I. Reichstein, W. McClure and Y.C. Tang, Phys. Rev. 185 (1969) 1351

1969TO1A I.S. Towner, Nucl. Phys. A126 (1969) 97

1969VI05 B. Vignon, E. Ligeon and J.P. Longequeue, J. Phys. (Paris) 30 (1969) 913

1969VO1E Vogt, Proc. Int. Conf., Montreal (1969) 5

1969WI1C Wildermuth, Bochum Conf. STI/PUB/232 IAEA (1969) 3

1969WI1D Wilhelmi et al., Contrib., Montreal (1969) 284

1969YA1B Yamashita et al., J. Phys. Soc. Jpn. 26 (1969) 1078

1970AR1B R.A. Arndt and L.D Roper, Phys. Rev. C1 (1970) 903

1970AS02 P.A. Assimakopoulos, E. Beardsworth, D.P. Boyd and P.F. Donovan, Nucl. Phys. A144 (1970) 272

1970BA1F Barashenkov and Toneev, Uspekhi Fiz. Nauk 100 (1970) 425

1970BE49 M. Bernas, D. Bachelier, J.K. Lee, P. Radvanyi, M. Roy-Stephan, I. Brissaud and C. Detraz, Nucl. Phys. A156 (1970) 289

1970BO1P Boschitz, Proc. 3rd Int. Conf. on High Energy Phys. and Nucl. Struct., New York, 1969 (1970) 288

1970BR1L Bruno and Duck, Bull. Amer. Phys. Soc. 15 (1970) 1652

1970BR30 W.B. Broste, G.P. Lawrence, J.L. McKibben, G.G. Ohlsen and J.E. Simmons, Phys. Rev. Lett. 25 (1970) 1040

1970CA1K Carlton, Thesis, Univ. of Georgia (1970)

1970CO1M Cominos, Crawford and Li, Bull. Amer. Phys. Soc. 15 (1970) 768

1970DE41 P.A. Deutchman, Lett. Nuovo Cim. 4 (1970) 61

1970ER1A Ericson and Locher, Nucl. Phys. A148 (1970) 1

1970FE1C H. Federsel, E.-J. Kanellopoulos, W. Sunkel and K. Wildermuth, Phys. Lett. B33 (1970) 140

1970GA1A Garber et al., BNL 400, 3rd Edition, Vol. 1 (1970)

1970GA1G Gagne, Lambert and Treado, Bull. Amer. Phys. Soc. 15 (1970) 1695

1970GN1A Gnedin, Dolginov, Silantyev and Shibanov, Yad. Fiz. 12 (1970) 815

1970GO12 B. Gottschalk and S.L. Kannenberg, Phys. Rev. C2 (1970) 24

1970GO36 N.P. Goldstein, A. Held and D.G. Stairs, Can. J. Phys. 48 (1970) 2629

1970GR17 E.E. Gross, E.V. Hungerford, J.J. Malanify and R. Woods, Phys. Rev. C1 (1970) 1365

1970HA1L Haussen, Schweitzer, Seeliger and Seidel, Nucl. Instrum. Meth. 88 (1970) 251

1970HA1M Hardy, Thesis, Rice Univ. (1970)

1970HA36 S.A. Harbison, R.J. Griffiths, N.M. Stewart, A.R. Johnston and G.T.A. Squier, Nucl. Phys. A152 (1970) 503

1970HE1C Heiss and Hackenbroich, Z. Phys. 231 (1970) 230

1970HE1D Heiss and Hackenbroich, Z. Phys. 235 (1970) 422

1970HO1L Hojvat, Thesis, Univ. of British Columbia (1970)

1970HO32 H.M. Hofmann and D. Fick, Z. Phys. 240 (1970) 420

1970IR01 J.M. Irvine and V.F.E. Pucknell, Nucl. Phys. A159 (1970) 513

1970KH03 V.A. Khangulyan, Yad. Fiz. 11 (1970) 967; Sov. J. Nucl. Phys. 11 (1970) 538

1970KO09 A. Kosiara and H.B. Willard, Phys. Lett. B32 (1970) 99

1970KU1C E. Kujawski, Phys. Rev. C1 (1970) 1651

1970KU1D Kull, Thesis, Michigan State Univ. (1970)

1970LA10 H.T. Larson, A.D. Bacher, K. Nagatani and T.A. Tombrello, Nucl. Phys. A149 (1970) 161

1970LA1K Larson, Thesis, California Institute of Technology (1970)

1970LI06 W.-K. Lin, F. Scheibling and R.W. Kavanagh, Phys. Rev. C1 (1970) 816

1970MI05 D. Miljanic, M. Furic and V. Valkovic, Nucl. Phys. A148 (1970) 312

1970MO31 G.L. Morgan and R.L. Walter, Phys. Rev. C2 (1970) 2034; Addendum to 1968CH35

1970OM1A Omojola, J. Phys. A3 (1970) 630

1970PO1A Porter, Thesis, Yale Univ. (1970)

1970RA1D K. Ramavataram and S. Ramavataram, Nucl. Phys. A147 (1970) 293

1970RA1J Rao, Swami, Gurtu and Singh, Proc. Indian Acad. Sci. A71 (1970) 257

1970RE1A Reichstein and Tang, Nucl. Phys. A158 (1970) 529

1970RO17 J.G. Rogers, G. Paic, J.R. Richardson and J.W. Verba, Phys. Rev. C2 (1970) 828

1970RO1L Rohrer et al., Helv. Phys. Acta 43 (1970) 746

1970RO1M Roberts et al., Rept. NASA-TN-D-5961 (1970)

1970SA01 T. Sawada, G. Paic, M.B. Epstein and J.G. Rogers, Nucl. Phys. A141 (1970) 169

1970SC18 H. Schroder and W. Mausberg, Z. Phys. 235 (1970) 234

1970SE1B F. Seiler and E. Baumgartner, Nucl. Phys. A153 (1970) 193

1970SL1A Slobodrian et al., Proc. 1st Int. Conf. on Three Body Problems in Nucl. Particle Phys., Birmingham, England, 1969 (1970) 390

1970SL1B Slaus, Theory of Nucl. Struct., Trieste, 1969, IAEA STI/PUB/249 (1970) 17

1970ST15 T. Stammbach, J. Taylor, G. Spalek and R.L. Walter, Phys. Rev. C2 (1970) 434

1970SU1B Sukhoruchkin, Sov. J. Nucl. Phys. 10 (1970) 144

1970TH1D Thompson, Epstein and Sawada, Nucl. Phys. A142 (1970) 571

1970VA1L Valkovic, Furic, Miljanic and Tomas, Proc. 1st Int. Conf. on Three Body Problem in Nucl. Particle Phys., Birmingham, England, 1969 (1970) 436

1970WA15 R.E. Warner, B.E. Corey, E.L. Petersen, R.W. Bercaw and J.E. Poth, Nucl. Phys. A148 (1970) 503

1970WA1G Walker and Stokes, LA-DC 11224 (1970)

1970WA1L B.E. Watt and W.T. Leland, Phys. Rev. C2 (1970) 1680

1970WA32 B.E. Watt and W.T. Leland, Phys. Rev. C2 (1970) 1677

1970WI1G Willmes, Shadoan and Cahill, Bull. Amer. Phys. Soc. 15 (1970) 1694

1970ZO1A Zofka, Czech. J. Phys. 20 (1970) 926

1971AL1B Allas et al., Bull. Amer. Phys. Soc. 16 (1971) 512

1971AR20 R.A. Arndt, L.D. Roper and R.L. Shotwell, Phys. Rev. C3 (1971) 2100

1971BA1U Baker, Polarization, Madison, 1970 (1971) 899

1971BA1Y Baguil et al., Nuovo Cim. A1 (1971) 285

1971BA2Y Baus-Baghdikian, Univ. libre Bruxelles, Bull. No. 45 (1971)

1971BA61 A.G. Baryshnickov and L.D. Blokhintsev, Phys. Lett. B36 (1971) 205

1971BA74 C.J. Batty, E. Friedman and D.F. Jackson, Nucl. Phys. A175 (1971) 1

1971BR12 K.H. Bray, S.N. Bunker, M. Jain, K.S. Jayaraman, G.A. Moss, W.T.H. van Oers, D.O. Wells and Y.I. Wu, Phys. Rev. C3 (1971) 1771

1971CH1T Chamberlin, Thesis, Texas A&M Univ. (1971)

1971CH31 G. Chenevert, N.S. Chant, I. Halpern, C. Glashausser and D.L. Hendrie, Phys. Rev. Lett. 27 (1971) 434

1971CH50 N.S. Chant and E.M. Henley, Phys. Rev. Lett. 27 (1971) 1657

1971DE20 B. De Facio and R.K. Umerjee, Nucl. Phys. A169 (1971) 257

1971DO1C Dodder et al., Polarization, Madison, 1970 (1971) 520

1971EF01 V.D. Efros and M.V. Zhukov, Phys. Lett. B37 (1971) 18

1971FE10 H. Feshbach, A. Gal and J. Hufner, Ann. Phys. 66 (1971) 20

1971FO1J Forssmann, Graf, Schober and Jochim, Polarization, Madison, 1970 (1971) 537

1971GI1B B. Giraud and D. Zaikine, Phys. Lett. B37 (1971) 25

1971GR12 E.E. Gross, E.V. Hungerford and J.J. Malanify, Nucl. Phys. A164 (1971) 376

1971GR15 W. Gruebler, V. Konig, A. Ruh, R.E. White, P.A. Schmelzbach, R. Risler and P. Marmier, Nucl. Phys. A165 (1971) 505

1971GR32 H. Grunder, R. Gleyvod, G. Lietz, G. Morgan, H. Rudin, F. Seiler and A. Stricker, Helv. Phys. Acta 44 (1971) 662

1971GR45 R. Grotzschel, B. Kuhn, K. Moller, J. Mosner and G. Schmidt, Nucl. Phys. A176 (1971) 261

1971GR47 W. Gruebler, V. Konig, A. Ruh, P.A. Schmelzbach, R.E. White and P. Marmier, Nucl. Phys. A176 (1971) 631

1971HA02 D.M. Hardy, S.D. Baker, D.H. McSherry and R.J. Spiger, Nucl. Phys. A160 (1971) 154

1971HA1L Hale, Dodder and Witte, Polarization, Madison, 1970 (1971) 573

1971HA2G Haeberli, Proc. 2nd Int. Conf. on Polarized Targets, LBL 500 (1971) 329

1971HE05 P. Heiss and H.H. Hackenbroich, Nucl. Phys. A162 (1971) 530

1971HE1M Hertzog, Thesis, Brown Univ. (1971)

1971HI07 D. Hilscher, P.A. Quin and J.C. Davis, Nucl. Phys. A173 (1971) 216

1971HU1B Huber et al., Polarization, Madison, 1970 (1971) 546

1971HU1H Hudomalj, Valkovic and Tomas, Fizika 4 (1971) 36

1971IK01 M. Ikeda, Prog. Theor. Phys. 46 (1971) 1088

1971IN1C Ingalls, Thesis, Princeton Univ. (1971)

1971KE16 L.G. Keller and W. Haeberli, Nucl. Phys. A172 (1971) 625

1971KH03 V.A. Khangulyan, Yad. Fiz. 13 (1971) 525; Sov. J. Nucl. Phys. 13 (1971) 295

1971KI02 K. Kilian, H. Treiber, R. Strausz and D. Fick, Phys. Lett. B34 (1971) 283

1971KL02 W. Klinger, F. Dusch and R. Fleischmann, Nucl. Phys. A166 (1971) 253

1971KL04 J.T. Klopcic and S.E. Darden, Phys. Rev. C3 (1971) 2171; Erratum Phys. Rev. C4 (1971) 1494

1971KO09 V. Konig, W. Gruebler, A. Ruh, R.E. White, P.A. Schmelzbach, R. Risler and P. Marmier, Nucl. Phys. A166 (1971) 393

1971KR1A Kraus, Linck and Magnac-Valette, Polarization, Madison, 1970 (1971) 564

1971LE02 C.W. Lewis, D.P. Saylor and L.C. Northcliffe, Phys. Rev. C3 (1971) 28

1971LE13 C. Leemann, H. Burgisser, P. Huber, U. Rohrer, H. Schieck and F. Seiler, Helv. Phys. Acta 44 (1971) 141

1971LE1G Leemann et al., Polarization, Madison, 1970 (1971) 548

1971LE1N Leclercq-Villain, Conf. on Certain Microscopic Aspects of Nucl. Reactions, La Toursinei, 1971 (1971)

1971LE27 C. Leemann, H. Burgisser, P. Huber, U. Rohrer, H. Paetz gen.Schieck and F. Seiler, Ann. Phys. 66 (1971) 810

1971LI04 W.-K. Lin and F. Scheibling, Phys. Rev. C3 (1971) 20

1971LO24 W.G. Love and L.W. Owen, Phys. Lett. B37 (1971) 463

1971MC1L McKibben, Proc. 2nd Int. Conf. on Polarized Targets, LBL 500 (1971) 307

1971MI12 D. Miljanic and V. Valkovic, Nucl. Phys. A176 (1971) 110

1971MU04 G.S. Mutchler, W.B. Broste and J.E. Simmons, Phys. Rev. C3 (1971) 1031

1971MU1H Mullensiefen, Nucl. Phys. B28 (1971) 368

1971NI06 A. Niiler, M. Drosg, J.C. Hopkins, J.D. Seagrave and E.C. Kerr, Phys. Rev. C4 (1971) 36

1971OH04 G.G. Ohlsen, J.L. McKibben, G.P. Lawrence, P.W. Keaton, Jr. and D.D. Armstrong, Phys. Rev. Lett. 27 (1971) 599

1971OH1A Ohlsen, Keaton and Simmons, Polarization, Madison, 1970 (1971) 415

1971OH1B Ohlsen, McKibben and Lawrence, Polarization, Madison, 1970 (1971) 503

1971OH1C Ohlsen, Keaton and Gammel, Polarization, Madison, 1970 (1971) 512

1971PI04 J. Pigeon, J. Barguil, C. Fayard, G-H. Lamot and E. El Baz, Phys. Rev. C4 (1971) 704

1971PL06 G.R. Plattner and A.D. Bacher, Phys. Lett. B36 (1971) 211

1971PL07 D.J. Plummer, K. Ramavataram, T.A. Hodges, D.G. Montague, A. Zucker and N.K. Ganguly, Nucl. Phys. A174 (1971) 193

1971PO1C Poutissou and Jeremie, Bull. Amer. Phys. Soc. 16 (1971) 133

1971RA15 S. Ramavataram and K. Ramavataram, Can. J. Phys. 49 (1971) 1798

1971RA27 K. Ramavataram, D.J. Plummer, T.A. Hodges and D.G. Montague, Nucl. Phys. A174 (1971) 204

1971RE19 D. Rendic, N.D. Gabitzsch, V. Valkovic, W. von Witsch and G.C. Phillips, Nucl. Phys. A178 (1971) 49

1971RH1A Rhea, Stammbach and Walter, Polarization Phenom. in Nucl. Reactions, Madison, 1970; Eds., H.H. Barscahll and W. Haeberli (1971) 556

1971RO35 U. Rohrer, P. Huber, C. Leemann, H. Meiner and F. Seiler, Helv. Phys. Acta 44 (1971) 846

1971RU07 R.W. Rutkowski and E.E. Gross, Phys. Lett. B35 (1971) 151

1971RU1E Rutkowski, Thesis, Univ. of Tennessee (1971)

1971SC04 P. Schwandt, T.B. Clegg and W. Haeberli, Nucl. Phys. A163 (1971) 432

1971SC1L Schuster and Hagengruber, Polarization Phenom. in Nucl. Reactions, Madison, 1970; Eds., H.H. Barscahll and W. Haeberli (1971) 865

1971SE1G Seiler and Baumgartner, Polarization Phenom. in Nucl. Reactions, Madison, 1970; Eds., H.H. Barscahll and W. Haeberli (1971) 518

1971SI30 M. Sieminski, Z. Wilhelmi and P. Zupranski, Acta Phys. Pol. B2 (1971) 503

1971ST1J Striebel, Polarization Phenom. in Nucl. Reactions, Madison, 1970; Eds., H.H. Barschall and W. Haeberli (1971) 95

1971SW10 W.E. Sweeney, Jr., V. Valkovic, D. Rendic and G.C. Phillips, Phys. Lett. B37 (1971) 183

1971TH09 D.R. Thompson and Y.C. Tang, Phys. Rev. C4 (1971) 306

1971WA08 R.F. Wagner and C. Werntz, Phys. Rev. C4 (1971) 1

1971WA18 R.E. Warner, G.C. Ball, W.G. Davies, A.J. Ferguson and J.S. Forster, Phys. Rev. Lett. 27 (1971) 961

1971WA1D Walter, Polarization Phenom. in Nucl. Reactions, Madison, 1970; Eds., H.H. Barschall and W. Haeberli (1971) 317

1971WO07 W. Wolfli, J. Hall and R. Muller, Phys. Rev. Lett. 27 (1971) 271

1971ZA1C Zaika et al., Polarization Phenom. in Nucl. Reactions, Madison, 1970; Eds., H.H. Barscall and W. Haeberli (1971) 531

1971ZA1D D.A. Zaikin, Nucl. Phys. A170 (1971) 584

1971ZH05 M.V. Zhukov and V.D. Efros, Yad. Fiz. 14 (1971) 577; Sov. J. Nucl. Phys. 14 (1972) 322

1972AD02 M.L. Adelberg and A.M. Saperstein, Phys. Rev. C5 (1972) 1180

1972AG01 N.M. Agababyan, Y.A. Batusov, S.A. Bunyatov, G.P. Gulkanyan, V.M. Sidorov and V.A. Yarba, Yad. Fiz. 15 (1972) 18; Sov. J. Nucl. Phys. 15 (1972) 10

1972AL1P Allab, Beaumevielle and Dauchy, Bull. Amer. Phys. Soc. 17 (1972) 929

1972AN1P Anzelon et al., Few Particle Problems, UCLA, 1972 (1972) 54

1972AN1Q Antolkovic, Few Particle Problems, UCLA, 1972 (1972) 695

1972AN24 Y.N. Antufev, V.L. Agranovich, V.S. Kuzmenko, I.I. Miroshnichenko and P.V. Sorokin, Pisma Zh. Eksp. Teor. Fiz. 16 (1972) 77; JETP Lett. 16 (1972) 52

1972AN27 Y.P. Antoufiev, V.L. Agranovich, V.S. Kuzmenko and P.V. Sorokin, Phys. Lett. B42 (1972) 347

1972AN29 Y.P. Antufev, V.L. Agranovich, V.S. Kuzmenko and P.V. Sorokin, Pisma Zh. Eksp. Teor. Fiz. 16 (1972) 339; JETP Lett. 16 (1972) 240

1972AV1E Avida, Chang, Boyd and Glavish, Bull. Amer. Phys. Soc. 17 (1972) 562

1972AZ03 L.S. Azhgirei, Z. Cisek, Z.V. Krumstein, Y.P. Merekov, Z. Moroz, Ngo Quang Zui, V.I. Petrukhin, A.I. Ronzhin, G.A. Shelkov and O.D. Dalkarov, Nucl. Phys. A195 (1972) 581

1972BA24 A.D. Bacher, G.R. Plattner, H.E. Conzett, D.J. Clark, H. Grunder and W.F. Tivol, Phys. Rev. C5 (1972) 1147

1972BA30 M.P. Baker, J.M. Cameron, N.S. Chant and N.F. Mangelson, Nucl. Phys. A184 (1972) 97

1972BA32 D. Bachelier, M. Bernas, H.L. Harney, J.C. Jourdain, P. Radvanyi and M. Roy-Stephan, Nucl. Phys. A184 (1972) 641

1972BB19 A.G. Baryshnikov, L.D. Blokhintsev, A.N. Safronov and V.V. Turovtsev, Pisma Zh. Eksp. Teor. Fiz. 16 (1972) 414; JETP Lett. 16 (1972) 294

1972BL1F Blokhintsev and Safronov, Nucl. Phys. A180 (1972) 363

1972BO29 E.T. Boschitz, W.K. Roberts, J.S. Vincent, M. Blecher, K. Gotow, P.C. Gugelot, C.F. Perdrisat, L.W. Swenson and J.R. Priest, Phys. Rev. C6 (1972) 457

1972BR08 K.H. Bray, J.M. Cameron, G.C. Neilson and T.C. Sharma, Nucl. Phys. A181 (1972) 319

1972BR10 W.B. Broste, G.S. Mutchler, J.E. Simmons, R.A. Arndt and L.D. Roper, Phys. Rev. C5 (1972) 761

1972CA37 P. Camiz, E. Olivieri, M. Scalia and A. D'Andrea, Nuovo Cim. A12 (1972) 71

1972CH31 E. Cheifetz, B. Eylon, E. Fraenkel and A. Gavron, Phys. Rev. Lett. 29 (1972) 805

1972CR01 D.S. Cramer and L. Cranberg, Nucl. Phys. A180 (1972) 273

1972DE30 J. Deenen, Nucl. Phys. A189 (1972) 73

1972DE44 J. Decharge, G. Surget, G. Bruno and M.Y. Decharge, J. Phys. (Paris) 33 (1972) 485

1972DE46 M.L.V.L. de Slobodrian, B. Cujec, R. Roy and R.J. Slobodrian, Nucl. Phys. A194 (1972) 577

1972GA11 K. Gabathuler, J. Rohlin, J.J. Domingo, C.H.Q. Ingram, S. Rohlin and N.W. Tanner, Nucl. Phys. B40 (1972) 32

1972GA1N Garrett, 4th Ainse Nucl. Phys. Conf., Sydney, 1972 (1972) 445

1972GI10 P. Gil, L. Marquez, J.L. Quebert and H. Sztark, J. Phys. (Paris) 33 (1972) 315

1972GI11 B.F. Gibson, A. Goldberg and M.S. Weiss, Phys. Rev. C6 (1972) 741

1972GR06 A.M. Green and A. Prodon, Nucl. Phys. A183 (1972) 225

1972GU1D Guy, Eisenberg, Noble and Weber, Bull. Amer. Phys. Soc. 17 (1972) 918

1972HA57 H.H. Hackenbroich and T.H. Seligman, Phys. Lett. B41 (1972) 102

1972IK01 M. Ikeda, Phys. Rev. C6 (1972) 1608

1972JA07 O.N. Jarvis, C. Whitehead and M. Shah, Nucl. Phys. A184 (1972) 615

1972JA14 J. Janecke, Phys. Rev. C6 (1972) 467

1972KA38 N.I. Kassis, Nucl. Phys. A194 (1972) 205

1972KA44 S. Kato, H. Orihara, S. Kubono, J. Kasagi, H. Ueno, T. Nakagawa and T. Tohei, Nucl. Phys. A195 (1972) 534

1972KE17 P.W. Keaton, Jr., D.D. Armstrong, R.A. Hardekopf, P.M. Kurjan and Y.K. Lee, Phys. Rev. Lett. 29 (1972) 880

1972KI01 H.T. King, W.E. Meyerhof and R.G. Hirko, Nucl. Phys. A178 (1972) 337

1972KI02 T.R. King and R. Smythe, Nucl. Phys. A183 (1972) 657

1972KI1F Kisslinger, Few Particle Problems, UCLA, 1972 (1972) 593

1972KO07 V. Konig, W. Gruebler, R.E. White, P.A. Schmelzbach and P. Marmier, Nucl. Phys. A185 (1972) 263

1972KO13 V.M. Kolybasov and N.Y. Smorodinskaya, Yad. Fiz. 15 (1972) 483; Sov. J. Nucl. Phys. 15 (1972) 269

1972LA1L Lambert et al., Few Body Problems, UCLA, 1972 (1972) 725

1972LE1L Lee and Cusson, Ann. Phys. 72 (1972) 353

1972LO1K Locher, Nucl. Phys. B36 (1972) 634

1972MA57 H.A. Mavromatis and B. Singh, Phys. Lett. B41 (1972) 251

1972MA61 I.A. Mackenzie, S.K. Mark and T.Y. Li, Nucl. Phys. A195 (1972) 609

1972MA62 A.M. MacLeod and G.R. Milne, J. Phys. (London) A5 (1972) 1252

1972NA1D Nakamura, Prog. Theor. Phys. 48 (1972) 695

1972NI02 A. Niiler, R.J. Spiger, W. von Witsch and G.C. Phillips, Nucl. Phys. A179 (1972) 263

1972NI04 J.E. Nicholls, A. Craig, T.C. Griffith, D.C. Imrie, C.J. Lush and A.J. Metheringham, Nucl. Phys. A181 (1972) 329

1972OH1C Ohlsen and Mitchell, Bulll. Amer. Phys. Soc. 17 (1972) 153

1972OH1D Ohlsen, Few Particle Problems, UCLA, 1972 (1972) 585

1972OT05 I. Ots, Izv. Akad. Nauk Est. SSR Fiz. Mat. 21 (1972) 289

1972PL02 G.R. Plattner, A.D. Bacher and H.E. Conzett, Phys. Rev. C5 (1972) 1158

1972PN1A Pniewski, Few Particle Problems, UCLA, 1972 (1972) 145

1972QU01 J.R. Quinn, M.B. Epstein, S.N. Bunker, J.W. Verba and J.R. Richardson, Nucl. Phys. A181 (1972) 440

1972RI10 A.S. Rinat, L.P. Kok and M. Stingl, Nucl. Phys. A190 (1972) 328

1972RO1M Rohrig, Knutson, Goddard and Haeberli, Bull. Amer. Phys. Soc. 17 (1972) 153

1972RY01 N. Ryu, J. Sanada, H. Hasai, D.C. Worth, M. Nishi, T. Hasegawa, H. Ueno, M. Seki, K. Iwatani and Y. Nojiri, Nucl. Phys. A180 (1972) 657

1972SC1M Schwaller et al., CERN 72-13 (1972)

1972SC1R Schroder et al., Few Particle Problems, UCLA, 1972 (1972) 1002

1972SC1T Schmidt, Wiss. Z. Tech. Univ. Dres. (Germany) 21 (1972) 700

1972SE09 F. Seiler, Nucl. Phys. A187 (1972) 379

1972SI1F Simon, Mitchell and Ohlsen, Few Particle Problems, UCLA, 1972 (1972) 735

1972SM05 J.R. Smith and S.T. Thornton, Nucl. Phys. A187 (1972) 433

1972ST01 T. Stammbach and R.L. Walter, Nucl. Phys. A180 (1972) 225

1972ST08 L. Strauss and E. Friedland, Z. Phys. 250 (1972) 370

1972TA1E Tanifuji and Yazaki, Few Particle Problems, UCLA, 1972 (1972) 739

1972TH04 D.T. Thompson, G.E. Tripard and D.H. Ehlers, Phys. Rev. C5 (1972) 1174

1972TH06 D.R. Thompson, Y.C. Tang and R.E. Brown, Phys. Rev. C5 (1972) 1939

1972TH08 D.T. Thompson and G.E. Tripard, Phys. Rev. C6 (1972) 452

1972TH1B Thompson, Thesis, Washington State Univ. (1972)

1972WA22 R.E. Warner, G.R. Flierl, W.G. Davies, G.C. Ball, A.J. Ferguson, J.S. Forster and S.A. Gottlieb, Nucl. Phys. A192 (1972) 341

1972WO1E Wolfli et al., Few Particle Problems, UCLA, 1972 (1972) 96

1973AD01 M.L. Adelberg and A.M. Saperstein, Phys. Rev. C7 (1973) 63

1973AR1N Arndt, Long and Roper, Nucl. Phys. A209 (1973) 429

1973AR1P Arndt and Roper, Nucl. Phys. A209 (1973) 447

1973BA2P Baker, May, Hardekopf and Ohlsen, Bull. Amer. Phys. Soc. 18 (1973) 1394

1973BH1A Bhowmik, Chang and Holmgren, Bull. Amer. Phys. Soc. 18 (1973)78

1973BO1Y Bollen et al., Bull. Amer. Phys. Soc. 18 (1973) 1600

1973CH05 M. Chemarin, J.P. Burq, J.C. Cabrillat and B. Ille, Nucl. Phys. A202 (1973) 71

1973CH1Q Chang, Roos, Bhowik and Chant, Bull. Amer. Phys. Soc. 18 (1973) 1401

1973CH27 F.S. Chwieroth, R.E. Brown, Y.C. Tang and D.R. Thompson, Phys. Rev. C8 (1973) 938

1973CL01 B.C. Clark, R.L. Mercer, D.G. Ravenhall and A.M. Saperstein, Phys. Rev. C7 (1973) 466

1973CL13 J.F. Clare, Nucl. Phys. A217 (1973) 342

1973CO1Y Collaboration Clermont-FD-Lyon-Strasbourg, Contrib., Uppsala (1973) 36

1973DA1M Davison et al., Bull. Amer. Phys. Soc. 18 (1973) 553

1973DA1N Davison et al., Phys. in Canada 29 (1973) 3

1973DA1P Davison et al., Bull. Amer. Phys. Soc. 18 (1973) 1381

1973DE17 V.P. Denisov, L.A. Kulchitskii and I.Y. Chubukov, Izv. Akad. Nauk SSSR Ser. Fiz. 37 (1973) 107; Bull. Acad. Sci. USSR Phys. Ser. 37 (1973) 94

1973DE2B De Facio and Wuller, Bull. Amer. Phys. Soc. 18 (1973) 1392

1973DE51 A.A. Debenham, V. Konig, W. Gruebler, P.A. Schmelzbach, R. Risler and D.O. Boerma, Nucl. Phys. A216 (1973) 42

1973EI01 J.M. Eisenberg, R. Guy, J.V. Noble and H.J. Weber, Phys. Lett. B43 (1973) 20; Erratum Phys. Lett. B45 (1973) 93

1973EK1A Ekelof et al., Contrib., Uppsala (1973) 35

1973FE1H Feshbach and Ullo, Bull. Amer. Phys. Soc. 18 (1973) 22

1973FE1J Federsel, Schranner, Teufel and Wildermuth, in Munich, 1 (1973) 499

1973FI04 S. Fiarman and W.E. Meyerhof, Nucl. Phys. A206 (1973) 1

1973GA16 S.N. Gardiner, J.L. Matthews and R.O. Owens, Phys. Lett. B46 (1973) 186

1973GA17 R.B. Galloway and R.M.A. Maayouf, Nucl. Phys. A212 (1973) 182

1973GA1H Gari, Phys. Rept. C6 (1973) 317

1973GE1G Geisler et al., Bull. Amer. Phys. Soc. 18 (1973) 580

1973GO38 C.A. Goulding, P. Stoler and J.D. Seagrave, Nucl. Phys. A215 (1973) 253

1973GR1L Grotzschel et al., in Munich, 1 (1973) 6

1973GR22 A.P. Graevskii, B.A. Bochagov and Y.A. Chestnov, Pisma Zh. Eksp. Teor. Fiz. 17 (1973) 204; JETP Lett. 17 (1973) 145

1973HA46 R.D. Haracz and T.K. Lim, Phys. Rev. Lett. 31 (1973) 1263

1973HA49 P.S. Hauge and S. Maripuu, Phys. Rev. C8 (1973) 1609

1973HA50 M.L. Halbert, A. van der Woude and N.M. O'Fallon, Phys. Rev. C8 (1973) 1621

1973HA51 R.A. Hardekopf, D.D. Armstrong, W. Gruebler, P.W. Keaton, Jr. and U. Meyer-Berkhout, Phys. Rev. C8 (1973) 1629

1973HE06 J.C.P. Heggie and P.W. Martin, Phys. Lett. B43 (1973) 289

1973HE26 J.C.P. Heggie and P.W. Martin, Nucl. Phys. A212 (1973) 78

1973HO1U Houdayer and Van Oers, Phys. in Canada 29 (1973) 3

1973JA1M Jarmie, in Munich, 1 (1973) 332

1973JE02 H. Jeremie and R. Larose-Poutissou, Phys. Lett. B44 (1973) 68

1973JO1J John and Seigelman, in Munich, 1 (1973) 500

1973JU02 M. Jung, Y. Sakamoto, J.N. Suren, C. Jacquot, L. Girardin and R. Schmitt, Phys. Rev. C7 (1973) 2209

1973KA08 S. Kato and Y. Aoki, J. Phys. Soc. Jpn. 34 (1973) 1128

1973KA32 D. Kamke, Z. Phys. 263 (1973) 251

1973KI1L Kirkby et al., Contrib., Uppsala (1973) 176

1973LA14 E. Lambert and H. Feshbach, Ann. Phys. 76 (1973) 80

1973LI02 R.H. Lindsay, W. Toews and J.J. Veit, Nucl. Phys. A199 (1973) 513

1973LI19 T.K. Lim, Phys. Rev. Lett. 31 (1973) 1258

1973LI1K Lisowski et al., Bull. Amer. Phys. Soc. 18 (1973) 697

1973LI1L Lisowski, Trainor, Busch and Clegg, Bull. Amer. Phys. Soc. 18 (1973) 699

1973LI1M Ligatto de Slobodrian, Phys. in Canada 29 (1973) 4

1973LO1D Lovoi, Ohlsen, Salzman and Gruebler, Bull. Amer. Phys. Soc. 18 (1973) 699

1973LY02 G.I. Lykasov and A.V. Tarasov, Yad. Fiz. 17 (1973) 301; Sov. J. Nucl. Phys. 17 (1974) 153

1973MA20 H.A. Mavromatis, Nucl. Phys. A206 (1973) 477

1973MC05 D.K. McDaniels, M. Drosg, J.C. Hopkins and J.D. Seagrave, Phys. Rev. C7 (1973) 882

1973MU14 S.F. Mughabghab and D.I. Garber, BNL 325, 3rd Edition, Vol. 1 (1973)

1973NI1B Nisley et al., Bull. Amer. Phys. Soc. 18 (1973) 552

1973OH02 G.G. Ohlsen, G.C. Salzman, C.K. Mitchell, W.G. Simon and W. Gruebler, Phys. Rev. C8 (1973) 1639

1973PL02 G.R. Plattner, R.D. Viollier, D. Trautmann and K. Alder, Nucl. Phys. A206 (1973) 513

1973RA1E Rayet, Nucl. Phys. B57 (1973) 269

1973RO1R Robson, Nucl. Phys. A204 (1973) 523

1973RO1Z Roos et al., Bull. Amer. Phys. Soc. 18 (1973) 20

1973SA09 A.M. Saperstein, Phys. Rev. Lett. 30 (1973) 1257

1973SA1W Sagle et al., Bull. Amer. Phys. Soc. 18 (1973) 699

1973SL03 I. Slaus, R.G. Allas, L.A. Beach, R.O. Bondelid, E.L. Petersen, J.M. Lambert and D.L. Shannon, Phys. Rev. C8 (1973) 444

1973TO06 W. Tornow, G. Mack, G. Mertens and H. Spiegelhauer, Phys. Lett. B44 (1973) 53

1973TR04 P.A. Treado, J.M. Lambert, R.J. Kane, L.A. Beach, E.L. Petersen and R.B. Theus, Phys. Rev. C7 (1973) 1742

1973TR1H Treado et al., Bull. Amer. Phys. Soc. 18 (1973) 1381

1973UL1C Ullo and Feshbach, Contrib., Uppsala (1973) 95

1973VO1M Votta et al., Bull. Amer. Phys. Soc. 18 (1973) 19

1973WA13 R.E. Warner and E.W. Vogt, Nucl. Phys. A204 (1973) 433

1973YO1F Young and Redish, Bull. Amer. Phys. Soc. 18 (1973) 548

1974CH02 F.S. Chwieroth, Y.C. Tang and D.R. Thompson, Phys. Rev. C9 (1974) 56

1974PR1D P.P. Pronko and J.G. Pronko, Phys. Rev. B9 (1974) 2870