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Energy Levels of Light Nuclei
$A = 6$

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Abstract: An evaluation of $A = 5$–10 was published in *Nuclear Physics* 78 (1966), p. 1. This version of $A = 6$ 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 TUNL/NNDC format.

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^{6}He

(Figs. 4 and 7)

GENERAL:

See (1960PH1A, 1960TA1C, 1961AH1A, 1961BA1E, 1962IN02, 1962IN1A, 1963BO1K, 1963MO1F, 1963VL1A, 1964GR1J, 1964WA1E, 1965BO1C, 1965LO1G).

$Ground\ state : J = 0$ (1958CO68).

1. ^{6}He(β^-)^{6}Li $\qquad Q_{\rm m} = 3.510$

The decay proceeds to the ground state of ^{6}Li(1^+) and is a super-allowed Gamow-Teller transition. Recently reported end points are: $E_\beta = 3.50 \pm 0.05$ (1952WU22), 3.50 ± 0.02 (1956SC40), 3.508 ± 0.015 (1963VI06), 3.508 ± 0.004 MeV (1963JO04). The weighted mean decay energy, including recoil energy of 1.4 keV, leads to ^{6}He-^{6}Li $= 3509.8 \pm 3.8$ keV (1963JO04). Half lives are listed in Table 6.2. With a half life of 802 msec and E_{β^-}(max) $= 3508.4$ keV, $ft = 802$ (1965BA2C).

The electron-neutrino correlation has the form $W(\theta) = 1+\alpha(\nu/c)\cos\theta$ with $\alpha = -0.39\pm0.05$ (1958HE46, 1959AL10), $\alpha = -0.353^{+0.033}_{-0.053}$ (1961RI03), $\alpha = -0.319 \pm 0.028$ (1963VI06), $\alpha = -0.3343 \pm 0.0030$ (1963JO15), in good agreement with the expected value $\alpha = -\frac{1}{3}$ for pure axial vector interaction. An upper limit to the possible contribution of tensor interaction is 0.4% (1963JO15). See also (1958CS88, 1959AL1E, 1959UB1A, 1961KO1H, 1961YU01, 1963CA1H, 1963DA04, 1963KI1D, 1964DE1G, 1965LO1H).

2. (a) ^{3}H(t, n)^{5}He $\qquad Q_{\rm m} = 10.374 \qquad E_{\rm b} = 12.302$

(b) ^{3}H(t, α)2n $\qquad Q_{\rm m} = 11.332$

At $E_{\rm t} = 1.9$ MeV, the α-spectrum observed at $30°$ extends from 1 to 7 MeV, with peaks at $E_\alpha = 2$ and 5 MeV. The same general shape is observed at other angles and for $E_{\rm t} = 0.95$ to 2.1 MeV. These peaks are attributed to a two-stage process involving formation and breakup of ^{5}He in the P$_{\frac{3}{2}}$ and P$_{\frac{1}{2}}$ states and are superposed on the three-body spectrum, reaction (b). Structure observed near the end point may indicate a correlation between the two neutrons (1958JA06). Alpha spectra observed at $\theta = 90°$, $E_{\rm t} = 0.2$ to 1.0 MeV, likewise exhibit a structure indicating appreciable contribution of ^{5}He$_{\rm g.s.}$; a peak ascribed to $\alpha +$ n^2 is reported (1961GO18).

At $E_{\rm t} = 1.48$ MeV, the neutron spectrum shows a continuum from 0 to 12 MeV with a broad peak at 11.3 MeV, corresponding to formation of ^{5}He in the ground state (1957BA10).

The cross section for neutron production rises monotonically from 0.1 to 2.2 MeV (1951AG30, 1957JA37, 1958JA06). The total cross section rises monotonically from 10 mb at $E_{\rm t} = 60$ keV to 82 mb at 1.14 MeV (1962GO1Q). At $E_{\rm t} = 1.90$ MeV, the total cross section for production

Table 6.1: Energy levels of ^{6}He

E_x (MeV $\pm$ keV)	$J^\pi; T$	Γ (keV)	Decay	Reactions
g.s.	$0^+; 1$		β^-	1, 5, 7, 8, 9, 10, 11, 12
1.797 ± 25	$(2)^+$	113 ± 20	n	9, 10, 11, 12
(≈ 15)	$(1^-, 2^-)$			9

of α-particles is 106 ± 5 mb (1958JA06). The zero-energy cross section factor $S_0 \approx 300$ keV · b (1964PA1A). See also (1964BA2B).

3. ^{3}H(t, t)^{3}H $E_b = 12.302$

Differential scattering cross sections have been measured at $E_t = 1.58$ to 2.01 MeV by (1956HO12). At $E_t = 1.90$ MeV, $\theta = 30°$, $\sigma(\theta) = 286$ mb/sr ($\pm$5%) (1958AL05). A phase shift analysis shows only ^{1}S hard-sphere scattering, with $R = 2.35$ fm (1955FR1C).

4. ^{4}He(t, p)^{6}He $Q_m = -7.512$

Not reported.

5. ^{6}Li(n, p)^{6}He $Q_m = -2.727$

See ^{7}Li and (1960VA1D).

6. ^{6}Li(t, ^{3}He)^{6}He $Q_m = -3.491$

Not reported.

7. ^{6}Li(γ, p)^{6}He $Q_m = -9.980$

See (1954TI16) and ^{7}Li.

Table 6.2: Half life of ^{6}He [a]

$\tau_{1/2}$ (msec)	Reference	$\tau_{1/2}$ (msec)	Reference
850 ± 50	(1946SO05)	799 ± 3	(1954KL36)
870 ± 60	(1947CA15)	850 ± 30	(1955RU06)
820 ± 60	(1948KN13)	852 ± 16	(1956VE10)
823 ± 13	(1949HO24)	830 ± 20	(1958HE46)
860 ± 30	(1952SH44)	797 ± 3 [a]	(1962BI14)
840 ± 30	(1952VE1A)	862 ± 17	(1962MA38)
830 ± 30	(1953BA04)	830 ± 20	(1963VI06)

[a] It is suggested that the longer half lives found in the older measurements may be due to impurities (1962BI14). We adopt here the mean of all cited values, weighted by the square of stated errors: 802 ± 3 msec.

8. ^{7}Li(n, d)^{6}He $\quad Q_{\rm m} = -7.755$

See ^{8}Li.

9. ^{7}Li(p, 2p)^{6}He $\quad Q_{\rm m} = -9.980$

The summed proton spectrum at $E_{\rm p} = 155$ to 450 MeV shows two peaks with $Q \approx -11.6$ and -25.4 MeV corresponding to ^{6}He*(0, 1.80), and an excited state with $J = 1^{-}$ or 2^{-} at $E_{\rm x} \approx 15$ MeV: see Table 6.3. Angular distributions indicate that the higher energy peak corresponds to ejection of a p-proton while the lower results from removal of an s-proton: see (1957TY35, 1958MA1B, 1958TY49, 1961GA09, 1961PU1A, 1962GA09, 1962GA23, 1962GO1P, 1962TI01, 1964TI02, 1965RI1A, 1965TY1A). See also ^{7}Li.

10. ^{7}Li(d, ^{3}He)^{6}He $\quad Q_{\rm m} = -4.486$

At $E_{\rm d} = 14.4$ MeV, the ground state and the 1.80 MeV level are observed. The angular distributions analyzed by pick-up theory indicate even parity for both states (1955LE24); $\theta^{2} = 0.025$ and 0.008 (1960MA32). See also (1960HA14).

11. ^{7}Li(t, α)^{6}He $\quad Q_{\rm m} = 9.834$

Table 6.3: ^{6}He levels from ^{7}Li(p, 2p)^{6}He

Q ($l = 1$) (MeV)	Γ (MeV)	Q ($l = 0$) (MeV)	Γ (MeV)	Reference
10.5 ± 1.6		24.9 ± 1.6		(1958TY49)
10.2 ± 1.6		23 ± 1.5		(1962GA09)
11.5 ± 2.5		25 ± 2.5		(1962GO1P)
10.1 ± 1.4		24.1 ± 1.5		(1961PU1A)
11.8 ± 0.3		25.5 ± 0.4		(1965TY1A)
11.3 ± 0.5	5.0	25.8 ± 0.6	5.5	(1964TI02)
11.6 ± 0.2		25.4 ± 0.3		mean

The energy of the first excited state is 1.71 ± 0.01 MeV, $\Gamma \lesssim$ 100 keV (1954AL35, 1960AL10); 1.797 ± 0.025 MeV, $\Gamma = 113 \pm 20$ keV (1965AJ01). Evidence gas also been reported for states at 3.4 ± 0.2 MeV (1960AL10), (6.0 ± 0.9) and for one or more states at 9.3 ± 0.7 MeV (1956MA1R, 1956MA50): see, however (1965AJ01). The width of the proton group corresponding to the 1.8 MeV state and the absence of ^{6}He* recoils implies that this state decays predominantly into ^{4}He $+$ 2n (1954AL35, 1963MA1P, 1965AJ01). The branching ratio Γ_γ/Γ_n is $< 4 \times 10^{-4}$ (1964HU1A). Angular distributions at $E_t = 0.24$ keV are consistent with $J = 0$ and 2 for the ground state and 1.8 MeV level, respectively (1954AL38). At $E_t = 13$ MeV, the two angular distributions are strongly peaked forward (1965AJ01). See also (1956MA09, 1961HO01, 1961HO23) and ^{10}Be.

12. ^{9}Be(n, α)^{6}He $\qquad Q_m = -0.601$

(1964GA11) report α-groups to excited states at $E_x = 1.66 \pm 0.26, 3.29 \pm 0.38$ and 6.05 ± 0.26 MeV. See also (1963AL18) and ^{10}Be.

^{6}Li

(Figs. 5 and 7)

GENERAL:

See (1955AU1A, 1955LA1C, 1956ME1A, 1957FR1B, 1957HU1C, 1957LE1E, 1958PI1A, 1959BA1M, 1959BR1E, 1959FE1B, 1959SK1A, 1959UB1A, 1960AN1B, 1960JA1G, 1960KO1D, 1960PH1A, 1960TA1C, 1960WA1F, 1961BA1E, 1961KO1G, 1961SH1B, 1961TA05, 1961VA1G, 1962CO1D, 1962CR09, 1962DI1B, 1962FO08, 1962GA09, 1962IN02, 1962IN1C, 1962IN1A, 1962JA06, 1962ME1C, 1962NA1B, 1962SA1F, 1962ST1E, 1962WA1E, 1963BO1K, 1963BU1C, 1963DA04, 1963EL1D, 1963HA1H, 1963JA1C, 1963JO07, 1963KL1A, 1963KU03, 1963KU1B, 1963MO1F, 1963OL1B, 1963SA1F, 1963SC1J, 1963SC30, 1963VL1A, 1963WA1H, 1964GR1J, 1964JI1A, 1964MA1G, 1964MI16, 1964NE1E, 1964OL1A, 1964SA1F, 1964SH05, 1964ST1B, 1964WA1E, 1965BE1R, 1965BE1H, 1965BO1C, 1965DA1H, 1965EL1B, 1965GO1L, 1965HA1L, 1965JA04, 1965JA1L, 1965LO1G, 1965LO1H, 1965MA1N, 1965MU1A, 1965NE1C, 1965RA1E, 1965SA1J).

Ground state :

$\mu = +0.82201$ nm (1965FU1G: see also (1962SC15)).

$Q = (-)0.5$ mb (1958TO34);

$Q = -(0.80 \pm 0.08)$ mb (1964WH01).

1. (a) ^{3}He(^{3}H, γ)^{6}Li	$Q_{\rm m} = 15.793$	$E_{\rm b} = 15.793$
(b) ^{3}He(^{3}H, p)^{5}He	$Q_{\rm m} = 11.138$	
(c) ^{3}He(^{3}H, p)^{4}He + n	$Q_{\rm m} = 12.096$	
(d) ^{3}He(^{3}H, n)^{5}Li	$Q_{\rm m} = 10.131$	
(e) ^{3}He(^{3}H, d)^{4}He	$Q_{\rm m} = 14.321$	
(f) ^{3}He(^{3}H, ^{3}H)^{3}He		

Capture γ-rays (reaction (a)) to the first three states of ^{6}Li have been observed for $E(^{3}\text{He}) = 1$ to 3 MeV: the differential cross section for the ground state transition ($90°$) varies from 1.4 μb/sr at $E(^{3}\text{He}) = 1.1$ MeV to 8 μb/sr at 3.0 MeV. At $E(^{3}\text{He}) = 1.1$ MeV the transitions to the 2.18 and 3.56 MeV states each have intensities $\approx 15\%$ that of the ground-state transition (1963KO04).

Angular distributions and total cross sections for reactions (b), (c) and (e) are given by (1963KU18) for $E_{\rm t} = 0.46$ to 1.09 MeV. The total cross section has also been determined for $E(^{3}\text{He}) = 0.1$ to 0.8 MeV (1953MO61), $E_{\rm t} = 0.15$ to 0.97 MeV (1960YO06), and at $E_{\rm t} = 1.9$ MeV (1963SM03). In the range $E_{\rm t} = 0.46$ to 1.09 MeV, the cross section increases from 27 to 53 mb (1963KU18). At

Table 6.4: Energy levels of ^{6}Li

E_x (MeV $\pm$ keV)	$J^\pi; T$	Γ (keV)	Decay	Reactions
g.s.	1^+; 0		stable	1, 4, 5, 6, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 23, 24
2.184 ± 2	3^+; 0	25 ± 1	γ, d, α	1, 4, 5, 8, 9, 10, 12, 13, 14, 15, 17, 18, 19, 21
3.562 ± 4	0^+; 1	< 5	γ	1, 4, 7, 9, 12, 17, 18, 19, 21
4.57 ± 34	2^+; 0	350 ± 150	d, α	4, 9, 12, 14, 19
5.36 ± 15	; (1)	320 ± 50		9, 12, 18, 19, 21
6.0 ± 200	1^+; 0		d, α	4
(6.77)	(2^-); 0		d, α	4, 8, 12
(7.8)	(1^-); 0		d, α	4, 8, 12
(9)	(0^-); 0		d, α	4, 9
(12.5)			γ, n	8
(14.0)	$+$			9
(15.8)	$+$			9

$E_t = 1.9$ MeV, it is 53 mb (1963SM03). The zero-energy cross section factor $S_0 \approx 1000$ keV $\cdot$ b (1964BA2B, 1964PA1A). See also (1961BA40).

The angular distribution of deuterons is isotropic at $E_t = 360$ keV (1953MO61), but from 0.5 to 1 MeV it shows an increasingly strong maximum at $90°$. It is suggested that the reaction proceeds via compound nucleus formation and that $l = 1$ is required (1963KU18).

For reaction (d), see (1963SM03). For reaction (f), see (1965LE02). See also (1963IN1A, 1963KU1H).

2. ^{4}He(d, γ)^{6}Li $\qquad Q_m = 1.472$

An upper limit for capture radiation at $E_d = 1.06$ MeV (^{6}Li* $= 2.18$ MeV) is 0.1 mb (1954SI07). A search for resonant capture radiation at $E_d = 3.1$ MeV (^{6}Li* $= 3.56$ MeV) yields $\Gamma_{d\alpha} < 0.2$ eV. It is concluded that the intensity of parity non-conserving parts of the wave functions, $F^2 \lesssim 10^{-7}$ (1958WI15).

3. (a) ^{4}He(d, n)^{5}Li $Q_{\rm m} = -4.190$ $E_{\rm b} = 1.472$

(b) ^{4}He(d, p)^{5}He $Q_{\rm m} = -3.182$

(c) ^{4}He(d, pn)^{4}He $Q_{\rm m} = -2.225$

Neutron spectra have been measured at $0°$ for $E_{\rm d} = 7.9$, 8.9 and 9.9 MeV, and at several angles at the higher energy. The neutrons show forward peaking, indicative of stripping via reaction (a). The differential cross section ($0°$) plotted for $E_{\rm d} = 4.5$ to 18.6 MeV shows a monotonic rise from 0.5 to 150 mb/sr (1962LE12: see also (1964RO1D)). Neutron spectra at $E_{\rm d} = 18.6$ MeV ($\theta = 0°$ and $180°$) indicate participation of reactions (a) ($0°$) and (b) ($180°$) (1961RY01). The proton spectra are also forward peaked at $E_{\rm d} = 20.2$ MeV (1960AR1A) and 24 and 27 MeV (1963ER02). The proton yield over the range from 6.5 to 8.7 MeV excitation in ^{6}Li gives no evidence of a 7.4 MeV, $T = 0$ state (see Table 6.8) (1964OH01).

At $E_{\rm d} = 20.2$ MeV, the (d, pn) cross section is nearly as large as that for the elastic scattering at $\theta \approx 45°$ (1960AR1A). Reaction (c) is presumably forbidden by isospin selection rules near threshold (1955HE90). See also (1965TO01).

4. ^{4}He(d, d)^{4}He $E_{\rm b} = 1.472$

Elastic scattering studies have been carried out by (1949BL66: 0.9 to 3.5 MeV), (1953LA28: 1.0 to 1.2 MeV), (1955GA26: 0.3 to 4.6 MeV), (1947GU1A: 6.5 MeV), (1951BU1C: 7.9 MeV), (1964SE07, 1964SE1G: 2.9 to 11.5 MeV), (1964OH02: 3.5 to 10 MeV), (1962ST19: 6.0 to 13.7 MeV), (1963RO23, 1964RO1D: 5.7 to 14.3 MeV), (1951AL26: 10.3 MeV), (1954FR22: 13.7 and 19.0 MeV), (1960AR1A: 20.2 MeV), (1964BR43: 21 MeV), (1963VA14: 24.9 MeV), (1963ER02: 21.3 to 27.3 MeV).

Phase shift analyses have been carried out for the range $E_{\rm d} = 0.3$ to 4.2 MeV by (1955GA74) and for 3 to 10 MeV by (1964SE07); see also (1964MC1F). Extrapolated phase shifts based on an optical model have been calculated by (1960GA08). The experimental s-wave phase shift decreases monotonically from $E_{\rm d} = 0.3$ to 10 MeV: in the range 0 to 4 MeV it can be accounted for by hard-sphere scattering with $r = 5$ fm; if a radius of 3.5 fm is chosen, a contribution from the ground state is required, with θ^2_α(g.s.) $= 0.51$ (1955GA74, 1960GA08). The d-wave phase shifts are split and exhibit resonance at $E_{\rm x} = 2.18$ (^{3}D$_3$), 4.87 (^{3}D$_2$) and 6.24 MeV (^{3}D$_1$): see Table 6.5 (1955GA74, 1964SE07). Single level analysis of the p-wave phase shifts indicate the possible presence of 2^-, 1^- and 0^- levels at 6.8, 7.8 and 9 MeV (1964SE07: see, however, (1964MC1F)). Preliminary analysis of data in the range $E_{\rm d} = 5.6$ to 12.5 MeV shows no effect from the presumptive $T = 1$ levels at $E_{\rm x} = 5.35$, 6.63 and 8.37 MeV (1963RO23), nor from the suggested $T = 0$ state at 7.4 MeV (1964MC1F). At $E_{\rm d} = 21$ to 27 MeV, increasing complexity of the angular distributions suggest $l = 3$ wave contributions (1963ER02). See also (1964MC1F).

A (d+α) model has been constructed by (1960GA08) to reproduce the phase shifts of (1955GA74); with this model, phase shifts and polarization parameters have been extrapolated to 14 MeV. Polarization parameters have also been calculated for $E_{\rm d} = 1.07$ MeV (1959GO1H, 1959PO1C),

Table 6.5: Levels of ^{6}Li from ^{4}He(d, d)^{4}He

$E_{\rm res}$ (MeV)	Γ (keV)	$l_{\rm d}$	J^{π}	$E_{\rm x}$ [a] (MeV)	$\theta_{\rm d}^{2}$ [b]	Reference
		0	1^{+}	0	0.51	1955GA74
1.070 ± 0.003	35 ± 5	2	3^{+}	2.184	0.80	1955GA74
4.57 ± 0.08 }				4.6	1.0	1955GA74
5.10 }		2	2^{+}	4.87	1.59	1964SE07
$5.1 - 6.5$ }				5.7		1955GA74
7.16 }		2	1^{+}	6.24	1.59	1964SE07
7.95		1	2^{-}	6.77	0.27	1964SE07
9.5		1	1^{-}	7.8	0.21	1964SE07
11.6		1	0^{-}	9	0.21	1964SE07

[a] See also (1964MC1F).
[b] $R = 3.5$ fm.

at 2 and 3.5 MeV by (1959PH1B). A measurement at $E_{\rm d} = 1.07$ MeV is consistent with expectation (1961PO01). Tensor polarization parameters for $E_{\rm d} = 4$ to 7.5 MeV, measured by (1964MC1E, 1964SE1F), are in fair agreement with calculations of (1960GA08, 1964SE07). See also (1960DU1C, 1965GR1Q, 1965SE1E).

5. ^{4}He(^{3}He, p)^{6}Li $\qquad Q_{\rm m} = -4.021$

Differential cross sections for formation of the ground and 2.18 MeV states of ^{6}Li have been measured for $E_{\alpha} = 27.5$ to 41 MeV. Protons to the 3.56 MeV state were not observed: intensity $< \frac{1}{5}$ of ground state group (1961CH09).

6. ^{6}He(β^{-})^{6}Li $\qquad Q_{\rm m} = 3.510$

See ^{6}He.

7. ^{6}Li(γ, γ)^{6}Li

The width, Γ_{γ}, of the 3.56 MeV state is in good agreement with that expected from the intermediate coupling shell model (8.7 eV): see Table 6.6 (1959CO67, 1963SK02). See also (1961VA1G, 1962BO17, 1962SE02).

Table 6.6: Levels of ^{6}Li from ^{6}Li(e, e′) and ^{6}Li(γ, γ)

E_x (MeV)	J^π	Γ_γ (eV)	B(E2↑) [a] (fm^4)	Reference
2.18	3^+	$4^{+3}_{-1.5} \times 10^{-4}$	32 ± 3	(1960BA47)
		3×10^{-5}		(1959DA04) [b]
3.56 [e]	0^+	6.2 ± 0.6		(1960BA47)
		4.7 ± 0.9		(1963BA19) [c]
		9 ± 2		(1963BE25)
		$9.1^{+2.0}_{-1.5}$		(1959CO67) [d]
		$8.8^{+1.9}_{-1.3}$		(1963SK02) [d]
4.52	2^+		18.2 ± 1.5	
5.35	(2^+)	0.16	7 ± 2	(1963BA19)
(7.40)	(1^+)		6 ± 2	
(8.37)	(1^+)		4 ± 2	
(9.3)	$0^+/1^+/2^+$	15/5/3		(1963BA19)
(14.0)	$0^+/1^+/2^+$	24/8/5		(1963BA19)
(15.8)	$0^+/1^+/2^+$	37.5/12.5/7.5		(1963BA19)

[a] (1963BE25, 1963BE53): E2 transition assumed; preliminary values.

[b] From ^{6}Li(γ, d).

[c] (1963BA19): M1 transitions assumed.

[d] From ^{6}Li(γ, γ).

[e] See also (1964GO15).

8. (a) ^{6}Li(γ, n)^{5}Li $Q_m = -5.662$
   (b) ^{6}Li(γ, p)^{5}He $Q_m = -4.655$
   (c) ^{6}Li(γ, d)^{4}He $Q_m = -1.472$
   (d) ^{6}Li(γ, t)^{3}He $Q_m = -15.793$

The total cross section for photoneutrons, measured with E(brems) $= 5$ to 20 MeV exhibits a peak at $E_\gamma = 12.5$ MeV, $\sigma = 2.8 \pm 0.53$ mb (1959RO62). Measurements with monochromatic γ-rays have been made for $E_\gamma = 5.4$ to 9.0 MeV by (1964GR40) and from 10 to 32 MeV by (1965BE42). The former work shows a smooth rise, with a possible peak at 6.75 MeV, while the latter yields a maximum at ≈ 12 MeV, $\sigma \approx 1.6$ mb and a gentle decrease to 0.6 mb at 32 MeV. See also (1951TI06, 1956ED15, 1964SH27). Another peak, at $E_\gamma \approx 26$ MeV is reported by (1963CO15): it is suggested that this peak corresponds to giant resonance excitation of the α-particle core (see also (1963BI10, 1963CO1D)); however, (1965BE42) find no evidence for this peak. At E(brems) $= 17.3$ MeV, 58% of the neutrons are ascribed to reaction (a), 31% to (b). A search for n-p correlations expected on the quasi-deuteron model for (γ, np) yielded a negative result (1960PR06). The integrated cross section (total neutrons) to 40 MeV is about 40 MeV · mb (1963CO15). See also (1964ER1B).

Photoprotons have been observed with E_γ up to 90 MeV: see (1959AJ76) and (1960BA45, 1962CH26, 1962VO1C). A peak in the proton spectrum corresponding to $E_x = 6.63$ or $E_x = 7.94$ MeV is reported by (1965SH1F). See also (1960KO14, 1961MA29, 1964BA2C, 1964ER1B, 1964MA1X).

The cross section for reaction (c) is $\lesssim 5$ μb in the range $E_\gamma = 2.6$ to 17 MeV (see (1959AJ76)) consistent with the expected inhibition of dipole absorption by isospin selection rules. In common with other (γ, d) reactions in light nuclei, an effective threshold first appears when sufficient energy is available to release at least one particle in addition to the deuteron (1962CH26, 1962VO1C, 1962VO1D). Resonant capture at the 2.18 MeV state is observed by (1959DA04): a value $\Gamma_\gamma = 30$ μeV is obtained. See also (1964KO1F).

For reaction (d), see (1962VO1C, 1964KO1F, 1965SH1F).

9. (a) ^{6}Li(e, e)^{6}Li

(b) ^{6}Li(e, p)^{5}He $\qquad Q_m = -4.655$

(c) ^{6}Li(e, d)^{4}He $\qquad Q_m = -1.472$

Elastic scattering has been studied at $E_e = 187$ (1955ST85, 1956HO93) and 426 MeV (1958BU17). Several different charge distributions provide acceptable fits to the observed form factors. The maximum charge density is 0.064 protons · fm^{-3}, $R_{rms} = 2.70 \pm 0.15$ fm (1958BU17, 1959ME24, 1960JA1G: see also (1958CA1B, 1963BO1K, 1963SC1J)). Magnetic elastic scattering at $E_e = 41.5$ MeV, $\theta = 180°$, has been studied by (1963GO04).

Inelastic spectra have been reported by (1960BA47: $E_e = 40$ MeV; $\theta = 132°, 160°$), (1963BA19: $E_e = 41.5$ MeV; $\theta = 180°$), (1964GO15: 75 MeV), (1963BI10: 101.4 MeV; $\theta = 60°$) and (1963BE25: 180 MeV). Table 6.6 summarizes the results. [For a review of the inelastic work to 1962, see (1962BA1D).] The inelastic spectrum of (1963BI10) shows two major absorption regions, from 9 to 17.5 MeV and from 17.5 to 32 MeV. Analysis of form factors on the assumption of E1 transitions leads to quite different values of $\langle r^2 \rangle$ for the two regions, supporting an α + d model. Fine structure is observed in both regions, possibly corresponding to discrete ^{6}Li levels (1963BE25, 1963BI10, 1964BI04). Form factors for ^{6}Li*(2.2) and (3.6) have been studied as a function of momentum transfer by (1963BE25, 1963BE53, 1964GO15). Interpretation in terms of nuclear models is discussed by (1963BE53, 1964KU1G, 1965DA1H). See also (1959ME1D, 1959UB1A, 1961PA1A, 1962JA06, 1965LO1J, 1965RA1D).

For reactions (b) and (c), see (1957KE1A).

10. ^{6}Li(n, n$'$)^{6}Li*

Inelastic neutron groups have been observed corresponding to the 2.18 MeV state with incident neutron energies up to 14 MeV. Differential cross sections are reported from $E_n = 3.4$ to 7.5 MeV (1963BA1V, 1963BA50), and at 14 MeV (1962WO07, 1964AR25, 1965ME05). Angular distributions up to $E_n = 7.5$ MeV show no obvious indication of direct interaction; at $E_n = 14$ MeV, both elastic and inelastic neutrons (n_0 and n_1) show sharp forward peaking. At both energies, the excitation of ^{6}Li*(3.56) is weak (1962WO07, 1963BA50). See also (1960KO1C, 1962EL1D, 1962JA1B, 1963EL1C, 1964PE20, 1965WE1E).

11. ^{6}Li(n, t)^{4}He $\qquad Q_m = 4.785$

(1956LI37) calculates $\theta_d^2 = 0.5$ for ^{6}Li$_{g.s.}$ from the data of (1954FR03). See also ^{7}Li.

12. (a) ^{6}Li(p, p)^{6}Li
(b) ^{6}Li(p, 2p)^{5}He $\qquad Q_m = -4.655$
(c) ^{6}Li(p, pd)^{4}He $\qquad Q_m = -1.472$
(d) ^{6}Li(p, ^{3}He)^{4}He $\qquad Q_m = 4.021$

Elastic scattering has been studied at $E_p = 31$ MeV by (1963DE01), at 40 MeV by (1960CH1B), and at 155 MeV by (1964TA02). At the latter energy, the polarization at high momentum transfers, $q > 1.7$ fm^{-1} is strikingly different for ^{6}Li and ^{7}Li (1964TA02). Optical model analysis is discussed by (1963DE01, 1963JA1C). See also (1960SA28). Polarization of the scattered protons has been studied by (1962RO20, 1963HW01, 1964MA1Y).

Inelastic groups corresponding to several ^{6}Li states are observed: see Table 6.7. Angular distributions have been determined for $E_p = 4$ to 9 MeV (1963HA49), 31 MeV (1963DE01), 39.8 MeV (1959CH1B: see also (1963JA1C)), 155 MeV (1964JA03) and 185 MeV (1965HA17). The distributions at $E_p = 155$ to 185 MeV indicate dominant E2 transitions to ^{6}Li*(2.2, 4.6, 5.4) and M1 to ^{6}Li*(3.6) (1964JA03, 1965HA17). At $E_p = 149$ MeV, a 3.56 MeV γ-ray is observed with a cross section of 0.7 ± 0.3 mb (1961CL09). See also (1957LE1E, 1959SY1A).

Reaction (b) has been studied at $E_p = 155$ MeV (1961GA09, 1962GA09, 1962GA23), 185 MeV (1962TI01, 1964TI02) and 460 MeV (1965TY1A). The spectra of summed proton energies ($E_{p1} + E_{p2}$) show two peaks, with $Q = -4.8$ and $Q = -22.4$ MeV. As a function of angle of emission $\theta_1 = -\theta_2$, the higher energy peak exhibits a maximum at the angle corresponding to zero momentum of the target proton ($\theta_1 + \theta_2 \approx 90°$), while the lower has a minimum at this point. The higher peak is thus interpreted as a quasi-free scattering from an $l = 1$ proton ^{6}Li $\rightarrow$ ^{5}He$_{g.s.}$ + p and the lower corresponding to a $l = 0$ proton, leaving ^{5}He* in a positive parity configuration with an excitation of about $16 - 17$ MeV (see ^{5}He* $= 16.70$ MeV).

Calculations of expected momentum distributions with various wave functions are discussed by (1962BE1J, 1962BE1K, 1962DI1A, 1962IN1A, 1962IN1C, 1962SA1F, 1963BE42, 1963EL1C, 1963JO07, 1963RI1B, 1964LI1D, 1965JA04, 1965JA1J, 1965JA1M, 1965MC1F, 1965RI1A, 1965WI1G).

Table 6.7: Levels of ^{6}Li from (p, p′), (d, d′), ^{9}Be(p, α), ^{7}Li(d, t)

Reaction	E_x (MeV)	$\Gamma_{c.m.}$ (keV)	Reference
^{6}Li(p, p′)^{6}Li*	2.188	25.4	(1957BR12)
^{6}Li(d, d′)^{6}Li*	2.186	24.5	(1957BR12)
^{9}Be(p, α)^{6}Li	2.192	29	(1957BR12)
^{9}Be(p, α)^{6}Li	2.19 ± 0.02	< 35	(1963GR29)
^{7}Li(d, t)^{6}Li	(2.18)	< 27	(1957BR12)
mean	2.188 ± 0.006	26.3	(1957BR12)
^{6}Li(p, p′)^{6}Li*	3.559	< 5	(1957BR12)
^{9}Be(p, α)^{6}Li	3.561		(1957BR12)
^{9}Be(p, α)^{6}Li	3.55 ± 0.02	< 35	(1963GR29)
mean	3.560 ± 0.006	< 5	(1957BR12)
^{9}Be(p, α)^{6}Li	4.40 ± 0.12	350 ± 150	(1963GR29)
^{6}Li(p, p′)^{6}Li*	4.4 ± 0.2	≈ 600	(1965HA17)
^{9}Be(p, α)^{6}Li	5.32 ± 0.06	280 ± 60	(1963GR29)
^{6}Li(p, p′)^{6}Li*	5.4 ± 0.2	≈ 1000	(1965HA17)
^{6}Li(p, p′)^{6}Li*	≈ 6.5		(1965HA17)
^{6}Li(p, p′)^{6}Li*	≈ 7.5		(1965HA17)

As compared with the analogous case of ^{7}Li, there appears to be a difficulty here in accounting for the small width of the observed angular distribution.

At $E_{\rm p} = 155$ MeV, the angular correlation of outgoing protons and deuterons (reaction (c)) give evidence for a substructure ^{6}Li $=$ ^{4}He $+$ d in a relative $l = 0$ state with a probability of 20 to 31% (1963RU05). See also (1962RU04, 1963RI1B, 1963SA1F, 1963TA1D, 1964BA1P, 1964DE1F, 1964SA1H, 1965DE1Q, 1965JA1L).

For reaction (d) see (1963RU05, 1963TE1B) and ^{7}Be. (1956LI37) gives $\theta_{\rm d}^{2}$ for the ground state of ^{6}Li $= 0.30$ ($E_{\rm p} = 15$ MeV), 0.45 (18.5 MeV).

13. ^{6}Li(d, d′)^{6}Li*

Deuteron groups have been observed corresponding to the ground state and the 2.18 MeV level (1957BR12: $E_{\rm d} = 7.0$ and 7.5 MeV): see Table 6.7. The 3.56 MeV state is not observed at $E_{\rm d} = 7.5$ MeV, $\theta = 60°$, consistent with its $T = 1$ character. The shape of the angular distribution of the deuterons to the 2.18 MeV state ($E_{\rm d} = 14.7$ MeV) does not fit simple direct interaction theory (1960HA14: see also (1956HA90, 1964HA05, 1965JO09)). See also (1956SO21, 1956SO33, 1960EL09).

14. ^{6}Li(α, α)^{6}Li

Angular distributions of elastic and inelastic scattering (to the 2.18 MeV state) have been studied at $E_{\alpha} = 10.0$ and 12.5 MeV (1963BL20), at 24 MeV (1964GR39) and at 31.5 MeV (1956WA29). At $E_{\alpha} = 31.5$ MeV, a group is also observed to the 4.57 MeV state but not to the $T = 1$, 3.56 MeV level (1956WA29: see also (1964GR39)). See also (1962TE1D, 1963TE1B).

15. ^{6}Li(^{6}Li, ^{6}Li′)^{6}Li*

Angular distributions ($\theta_{\rm c.m.} = 12°$ to $40°$) to the ground and 2.18 MeV states have been measured at E(^{6}Li) $= 63$ MeV: they show diffraction-type structure. No evidence of the excitation of the 3.56 MeV $T = 1$ state is seen (1964GA01).

16. ^{7}Li(γ, n)^{6}Li $\qquad Q_{\rm m} = -7.253$

See ^{7}Li.

17. ^{7}Li(p, d)^{6}Li $\qquad Q_{\rm m} = -5.028$

At $E_p = 17.5$ MeV, angular distributions of deuteron groups corresponding to ^{6}Li(g.s.), (2.18) and (3.56), analyzed by Butler theory give $l_n = 1$ for all these states. The ratios of observed reduced widths (see ^{7}Li) are consistent with predictions of the shell model with pure, or nearly pure, LS coupling (1956RE04, 1959BE84, 1960MA32). See also (1961CL09). The bearing of this reaction and its inverse on tests of invariance under time reversal is discussed by (1959HE1C). See also (1964SH07).

18. ^{7}Li(d, t)^{6}Li $\qquad Q_m = -0.995$

At $E_d \approx 15$ MeV, the angular distributions of the tritons indicate $l_n = 1$ (even parity) for the first three states of ^{6}Li (1955LE24, 1957FR1B, 1959HA29, 1960HA14): reported reduced widths are listed in Table 7.7. (1960HA14) report a board asymmetric bump at $E_x \approx 5.4$ MeV, $\Gamma \approx 600$ keV; no sharp states are reported for $4.4 < E_x < 8.5$ MeV with $\sigma > 0.3$ mb/sr ($E_d = 14.9$ MeV, $\theta = 14°, 25°$). See also (1956SO21, 1956SO33, 1959KU1C, 1959VL24, 1961OG1A, 1961SL06, 1962SL04, 1963OG1A, 1964BL1C).

19. ^{7}Li(^{3}He, α)^{6}Li $\qquad Q_m = 13.325$

Alpha particle groups have been observed with $E(^3\text{He}) = 0.6$ to 0.9 MeV (1960AL10), 1.5 MeV (1963CA02), 0.8 to 3 MeV (1965PA03), 4 MeV (1961WO05, 1963KN1C), 0.8 to 5.1 MeV (1963LI16) and 1.3 to 5.5 MeV (1965FO07). (1963LI16) find no evidence for reported levels at 4.3 or 6.6 MeV; (1965CO1F) confirms the levels at 4.3 and 5.35 MeV but finds no evidence for the higher states reported by (1960AL10). The results are summarized in Table 6.8.

20. ^{9}Be(γ, t)^{6}Li $\qquad Q_m = -17.688$

See (1955AJ61).

21. ^{9}Be(p, α)^{6}Li $\qquad Q_m = 2.126$

$Q_0 = 2.1254 \pm 0.0018$ (1965BR28).

Alpha particle groups have been observed with $E_p = 7.2$ to 7.5 MeV (1957BR12), 10 MeV (1963GR29), 3.50 to 12.50 MeV (1963BL20), 15.6 and 18.6 MeV (1962MA40). The results are summarized in Table 6.7. Angular distributions of the α_0 and α_1 groups are reported for $E_p = 6$ to 11.5 MeV (1963BL20, 1963TE1B), 5.9 and 7 MeV (1964YA1A) and 15.6 and 18.6 MeV (1962MA40). See also ^{9}Be. The 3.56 MeV state is observed to decay by γ-radiation: $E_\gamma =$

Table 6.8: States in ^{6}Li from ^{7}Li(^{3}He, α)^{6}Li

(1960AL10)		(1963LI16)		(1963CA02, 1965MA1E)	(1965CO1F)	
E_x (MeV $\pm$ keV)	Γ (keV)	E_x (MeV $\pm$ keV)	Γ (keV)	E_x (MeV $\pm$ keV)	E_x (MeV $\pm$ keV)	Γ (keV)
0		0		0	0	≤ 30
2.19		2.179 ± 8	< 40	2.184 ± 10	2.17 ± 20	≤ 30
3.56 ± 60		3.568 ± 8	< 40	3.564 ± 11	3.55 ± 20	≤ 30
4.3 ± 200				4.59 ± 40	4.3 ± 150	≈ 500
5.35 ± 70	< 100	5.47 ± 40	≈ 600	5.34 ± 30	5.35 ± 20	360 ± 40
(5.6 ± 200)	(2000)					
6.63 ± 800	200					
7.40 ± 100	600					
(8.37 ± 80)	(200)					
(9.3 ± 200)	(≈ 600)					

3.572 ± 0.012 MeV; the internal pair spectrum is consistent with an M1 transition (1954MA26: see also (1960GO13)).

The γ-ray angular distribution and the ($\alpha - \gamma$) correlation are isotropic at $E_p = 2.56$ MeV, consistent with $J = 0$ for ^{6}Li*(3.56) (1956ST93). See also (1959LE1B, 1962HA23, 1963ED1A, 1964BA1C) and ^{10}B.

22. ^{9}Be(d, ^{5}He)^{6}Li $\qquad Q_m = -1.056$

Not reported: see (1964BL1C).

23. (a) ^{10}B(γ, α)^{6}Li $\qquad Q_m = -4.461$
(b) ^{10}B(p, pα)^{6}Li $\qquad Q_m = -4.461$
(c) ^{10}B(α, 2α)^{6}Li $\qquad Q_m = -4.461$
(d) ^{10}B(n, dn2α) $\qquad Q_m = -5.933$
(e) ^{10}B(d, ^{6}Li)^{6}Li $\qquad Q_m = -2.989$

For reaction (a) see ^{10}B; for (b) see (1964BA1C); for (c) see (1963ME01); for (d) see (1956FR18); for (e) see (1964GE10).

24. (a) ^{11}B(d, ^{7}Li)^{6}Li $\quad Q_{\rm m} = -7.192$

(b) ^{11}B(^{3}He, ^{8}Be)^{6}Li $\quad Q_{\rm m} = 4.566$

Reaction (a) has not been reported: see (1964BL1C). For reaction (b), see (1964YO06).

Table 6.9: Energy levels of ^{6}Be

E_x (MeV)	J^π	Γ (keV)	Decay	Reactions
g.s.		92 ± 6	α, p	3, 4
(1.5 ± 0.2)				2, 3
$(18 - 24)$	$(^-)$		^{3}He	1

^{6}Be

(Figs. 6 and 7)

GENERAL:

See (1960TA1C, 1961GO1D, 1964GR1J, 1965BO1C, 1965JA1C, 1965LO1G).

Mass of ^{6}Be : From the Q-values of the ^{6}Li(p, n)^{6}Be reaction ($Q_0 = -5.069 \pm 0.010$ MeV) and the ^{6}Li(^{3}He, t)^{6}Be reaction ($Q_0 = -4.306 \pm 0.006$ MeV), we adopt ^{6}Be-^{6}Li $= 4.2872 \pm 0.005$ MeV. The mass excess of ^{6}Be is then 18.376 ± 0.005 MeV, based on ^{12}C $\equiv 0$.

1. (a) ^{3}He(^{3}He, 2p)^{4}He $Q_m = 12.860$ $E_b = 11.487$
   (b) ^{3}He(^{3}He, p)^{5}Li $Q_m = 10.895$
   (c) ^{3}He(^{3}He, ^{3}He)^{3}He

The total cross section for proton production shows a monotonic increase for $E(^{3}\text{He}) = 100$ to 800 keV (1954GO18). The zero-energy cross section factor $S_0 \approx 1100$ keV $\cdot$ b (1964PA1A). The elastic yield (reaction (c)) does not show any structure for $E(^{3}\text{He}) = 3$ to 12 MeV: the yields at $\theta = 31°$, $55°$, $70°$ and $90°$ all decrease with increasing energy in a smooth fashion. The angular distributions at $E(^{3}\text{He}) = 3.0$, 5.9, 7.9, 9.9 and 11.9 MeV disagree with the theoretical predictions based on the resonating group structure method (1963TO03). The $90°$ and $45°$ cross sections continue to decrease smoothly up to $E(^{3}\text{He}) = 18$ MeV, implying that an odd-parity partial wave (probably $l = 3$) is beginning to contribute strongly to the cross section in a region corresponding to ^{6}Be* ($E_x > 18$ MeV) ((1965BA2B) and private communication). The $65°$ differential cross section increases by a factor of 2.6 between $E(^{3}\text{He}) = 12$ and 18 MeV (1965BA2B). This sharp upward trend is continued to $E(^{3}\text{He}) = 25$ MeV (1960GA1C). Elastic $\sigma(\theta)$ have also been obtained at $E(^{3}\text{He}) = 12$, 16, 19, 22 and 25 MeV (1965LE02), 29 MeV (1960BR19) and 30 MeV (1960MC1E). See also (1960BR27, 1964AR08, 1965BA1E, 1965TO01).

2. ^{4}He(^{3}He, n)^{6}Be $Q_m = -9.091$

At $E(^3\text{He}) = 24.2 \pm 0.3$ MeV, two groups are reported corresponding to the ground state of ^{6}Be and to an excited state at ≈ 1.5 MeV (1964BR13).

3. ^{6}Li(p, n)^{6}Be $\quad Q_m = -5.070$

$Q_0 = -5.2 \pm 0.2$ MeV (1957BO1F);
$Q_0 = -5.05 \pm 0.2$ MeV (1959AJ81);
$Q_0 = -5.05 \pm 0.05$ MeV (1964BA16);
$Q_0 = -5.08 \pm 0.04$ MeV (1963GU07);
$Q_0 = -5.074 \pm 0.013$ MeV (1964HOZZ);
$Q_0 = -5.061 \pm 0.017$ MeV (1963FR1E).

At $E_p = 9$ (1957BO1F), 10 (1963GU07) and 10.5 MeV (1959AJ81), the ground-state neutron group is observed: $\Gamma < 300$ keV (1957BO1F), $\lesssim 150$ keV (1959AJ81), 140 ± 40 keV (1963GU07). The ground-state neutron threshold function indicates participation of both s- and p-wave neutrons (1964HOZZ). The ground-state width is 126 ± 15 keV (1963FR1E), 95 ± 28 keV (1964HOZZ). (1959AJ81) report evidence for an excited state at $E_x = 1.5 \pm 0.2$ MeV, $\Gamma < 100$ keV. However (1964HOZZ) does not observe any but the ground-state threshold up to $E_x \approx 3.8$ MeV.

4. ^{6}Li(^{3}He, t)^{6}Be $\quad Q_m = -4.306$

At $E(^3\text{He}) = 12$ MeV ($\theta = 2°, 10°$), a triton group is observed corresponding to the ground state of ^{6}Be ($\Gamma = 89 \pm 6$ keV, $Q_0 = -4.306 \pm 0.006$ MeV). No other states of ^{6}Be are seen with $\Gamma < 1$ MeV up to $E_x = 2.8$ MeV (1964WH06).

References

(Closed July 01, 1965)

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.

1946SO05 H.S. Sommers Jr. and R. Sherr, Phys. Rev. 69 (1946) 21

1947CA15 J.M. Cassels and R. Latham, Nature 159 (1947) 367

1947GU1A Guggenheimer, Heitler and Powell, Proc. Roy. Soc. A190 (1947) 196

1948KN13 W.J. Knox, Phys. Rev. 74 (1948) 1192

1949BL66 J.M. Blair, G. Freier, E.E. Lampi and W. Sleator Jr., Phys. Rev. 75 (1949) 1678

1949HO24 J.E.R. Holmes, Proc. Phys. Soc. (London) A62 (1949) 293

1951AG30 H.M. Agnew, W.T. Leland, H.V. Argo, R.W. Crews, A.H. Hemmendinger, W.E. Scott and R.F. Taschek, Phys. Rev. 84 (1951) 862

1951AL26 J.C. Allred, D.K. Froman, A.M. Hudson and L. Rosen, Phys. Rev. 82 (1951) 786

1951BU1C Burge, Burrows, Gibson and Rotblat, Proc. Roy. Soc. A210 (1951) 534

1951TI06 E.W. Titterton and T.A. Brinkley, Proc. Phys. Soc. (London) A64 (1951) 212

1952SH44 R.K. Sheline, Phys. Rev. 87 (1952) 557

1952VE1A Vendryes, Thesis, Univ. of Paris (1952)

1952WU22 C.S. Wu, B.M. Rustad, V. Perez-Mendez and L. Lidofsky, Phys. Rev. 87 (1952) 1140

1953BA04 M.E. Battat and F.L. Ribe, Phys. Rev. 89 (1953) 80

1953LA28 T. Lauritsen, T. Huus and S.G. Nilsson, Phys. Rev. 92 (1953) 1501

1953MO61 C.D. Moak, Phys. Rev. 92 (1953) 383

1954AL35 K.W. Allen, E. Almqvist, J.T. Dewan and T. Pepper, Phys. Rev. 96 (1954) 684

1954AL38 E. Almqvist, T.P. Pepper and P. Lorrain, Can. J. Phys. 32 (1954) 621

1954FR03 G.M. Frye Jr., Phys. Rev. 93 (1954) 1086

1954FR22 R.G. Freemantle, T. Grotdal, W.M. Gibson, R. McKeague, D.J. Prowse and J. Rotblat, Phil. Mag. 45 (1954) 1090

1954GO18 W.M. Good, W.E. Kunz and C.D. Moak, Phys. Rev. 94 (1954) 87

1954KL36 R.M. Kline and D.J. Zaffarano, Phys. Rev. 96 (1954) 1620

1954MA26 R.J. Mackin Jr., Phys. Rev. 94 (1954) 648

1954SI07 R.M. Sinclair, Phys. Rev. 93 (1954) 1082

1954TI16 E.W. Titterton and T.A. Brinkley, Proc. Phys. Soc. (London) A67 (1954) 469

1955AJ61 F. Ajzenberg and T. Lauritsen, Rev. Mod. Phys. 27 (1955) 77

1955AU1A T. Auerbach and J.B. French, Phys. Rev. 98 (1955) 1276

1955FR1C Frank and Gammel, Phys. Rev. 100 (1955) 973A

1955GA26 A. Galonsky, R.A. Douglas, W. Haeberli, M.T. McEllistrem and H.T. Richards, Phys. Rev. 98 (1955) 586

1955GA74 A. Galonsky and M.T. McEllistrem, Phys. Rev. 98 (1955) 590

1955HE90 R.L. Henkel, J.E. Perry, Jr. and R.K. Smith, Phys. Rev. 99 (1955) 1050

1955LA1C Lane and Wilkinson, Phys. Rev. 97 (1955) 1199

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

1955RU06 B.M. Rustad and S.L. Ruby, Phys. Rev. 97 (1955) 991

1955ST85 J.F. Streib, Phys. Rev. 100 (1955) 1797A

1956ED15 R.D. Edge, Aust. J. Phys. 9 (1956) 429

1956FR18 G.M. Frye Jr. and J.H. Gammel, Phys. Rev. 103 (1956) 328

1956HA90 J.W. Haffner, Phys. Rev. 103 (1956) 1398

1956HO12 D.M. Holm and H.V. Argo, Phys. Rev. 101 (1956) 1772

1956HO93 R. Hofstadter, Rev. Mod. Phys. 28 (1956) 214

1956LI37 J.G. Likely and F.P. Brady, Phys. Rev. 104 (1956) 118

1956MA09 D. Magnac-Valette, Compt. Rend. 242 (1956) 760

1956MA1R D. Magnac-Valette and P. Cuer, Physica 22 (1956) 1156A

1956MA50 D. Magnac-Valette and P. Cuer, J. Phys. Rad. 17 (1956) 553

1956ME1A Meshkov and Ufford, Phys. Rev. 101 (1956) 734

1956RE04 J.B. Reynolds and K.G. Standing, Phys. Rev. 101 (1956) 158

1956SC40 A. Schwarzschild, B.M. Rustad and C.S. Wu, Bull. Amer. Phys. Soc. 1 (1956) 336, N4

1956SO21 I.L. Sokolov, M.M. Sulkovskaia, E.I. Karpushkina and E.A. Albitskaia, Zh. Eksp. Teor. Fiz. 30 (1956) 1007; JETP (Sov. Phys.) 3 (1956) 740

1956SO33 I.L. Sokolov, M.M. Sulkovskaia, E.A. Albitskaia and E.I. Karpushkina, Dokl. Akad. Nauk SSSR 111 (1956) 1219; Sov. Phys. Dokl. 1 (1957) 773

1956ST93 J. Stoltzfus, J. Friichtenicht and E.B. Nelson, Bull. Amer. Phys. Soc. 1 (1956) 329, J2; Oral Report

1956VE10 N. Veeraraghavan, Proc. Ind. Acad. Sci. A43 (1956) 319

1956WA29 H.J. Watters, Phys. Rev. 103 (1956) 1763

1957BA10 S.J. Bame Jr. and W.T. Leland, Phys. Rev. 106 (1957) 1257

1957BO1F Bogdanov, Vlasov, Kalinin, Rybakov and Sidorov, Sov. J. At. Energy 3 (1957) 987

1957BR12 C.P. Browne and C.K. Bockelman, Phys. Rev. 105 (1957) 1301

1957FR1B French and Fujii, Phys. Rev. 105 (1957) 652

1957HU1C Huper, Z. Naturforsch. A12 (1957) 295

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

1957KE1A Kendall and Meyer-Berkhout, Bull. Amer. Phys. Soc. 2 (1957) 378

1957LE1E Levinson and Banerjee, Ann. Phys. 2 (1957) 471

1957TY35 H. Tyren, T.A.J. Maris and P. Hillman, Nuovo Cim. 6 (1957) 1507

1958AL05 R.C. Allen and N. Jarmie, Phys. Rev. 111 (1958) 1129

1958BU17 G.R. Burleson and R. Hofstadter, Phys. Rev. 112 (1958) 1282

1958CA1B Cazzola and Foglia, Nuovo Cim. 10 (1958) 913

1958CO68 E.D. Commins and P. Kusch, Phys. Rev. Lett. 1 (1958) 208

1958CS88 J. Csikai and A. Szalay, Zh. Eksp. Teor. Fiz. 35 (1958) 1074; JETP (Sov. Phys.) 8 (1959) 749

1958HE46 W.B. Herrmannsfeldt, R.L. Burman, P. Stahelin, J.S. Allen and T.H. Braid, Phys. Rev. Lett. 1 (1958) 61

1958JA06 N. Jarmie and R.C. Allen, Phys. Rev. 111 (1958) 1121

1958MA1B Th.A.J. Maris, P. Hillman and H. Tyren, Nucl. Phys. 7 (1958) 1

1958PI1A Pinkston and Brennan, Phys. Rev. 109 (1958) 499

1958TO34 C.H. Townes, Handbuch der Physik 38-1; Ed. S. Flugge (Springer Verlag, Gottingen, 1958) 377

1958TY49 H. Tyren, P. Hillman and T.A.J. Marris, Nucl. Phys. 7 (1958) 10

1958WI15 D.H. Wilkinson, Phys. Rev. 109 (1958) 1603

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

1959AJ81 F. Ajzenberg-Selove, C.F. Osgood and C.P. Baker, Phys. Rev. 116 (1959) 1521

1959AL10 J.S. Allen, R.L. Burman, W.B. Hermannsfeldt, P. Stahelm and T.H. Braid, Phys. Rev. 116 (1959) 134

1959AL1E Allen, Rev. Mod. Phys. 31 (1959) 791

1959BA1M Balashov, Zh. Eksp. Teor. Fiz. 36 (1959) 1123; JETP (Sov. Phys.) 9 (1959) 798

1959BE84 E.F. Bennett and D.R. Maxson, Phys. Rev. 116 (1959) 131

1959BR1E Brink and Kerman, Nucl. Phys. 12 (1959) 314

1959CH1B Chen and Hintz, Congres Int. de Phys. Nucl., Paris, 1958 (Dunod, Paris, 1959) 387

1959CO67 L. Cohen and R.A. Tobin, Nucl. Phys. 14 (1959) 243

1959DA04 F. Daublin, F. Berthold and P. Jensen, Z. Naturforsch. A14 (1959) 208

1959FE1B Feingold, Phys. Rev. 114 (1959) 540

1959GO1H Goldfarb, Nucl. Phys. 12 (1959) 494

1959HA29 E.W. Hamburger, Thesis, Univ. of Pittsburgh (1959)

1959HE1C Henley and Jacobsohn, Phys. Rev. 113 (1959) 225

1959KU1C Kurepin and Neudachin, Zh. Eksp. Teor. Fiz. 36 (1959) 1725; JETP (Sov. Phys.) 9 (1959) 1229

1959LE1B Levin and MacDonald, Bull. Amer. Phys. Soc. 4 (1959) 58

1959ME1D Meyer-Berkhout, Phys. Rev. 115 (1959) 1300

1959ME24 U. Meyer-Berkhout, K.W. Ford and A.E.S. Green, Ann. Phys. (N.Y.) 8 (1959) 119

1959PH1B Phillips, Phys. Rev. Lett. 3 (1959) 101

1959PO1C Pondrom, Phys. Rev. Lett. 2 (1959) 346

1959RO62 T.A. Romanowski and W.H. Voelker, Phys. Rev. 113 (1959) 886

1959SK1A Skyrme, Nucl. Phys. 9 (1959) 641

1959SY1A Sytenko and Kharchenko, Ukr, Fiz. Zh. USSR 4 (1959) 569; Phys. Abs. 13780 (1961)

1959UB1A Uberall, Phys. Rev. 116 (1959) 218

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

1960AL10 K.W. Allen, E. Almqvist and C.B. Bigham, Proc. Phys. Soc. (London) 75 (1960) 913

1960AN1B Anderson, Knox and Quinton, Bull. Amer. Phys. Soc. 5 (1960) 292

1960AR1A Artemov and Vlasov, Zh. Eskp. Teor. Fiz. 39 (1960) 1612; JETP (Sov. Phys.) 12 (1961) 1124

1960BA45 E.B. Bazhanov and L.A. Kulchitskii, Zh. Eksp. Teor. Fiz. 38 (1960) 1685; JETP (Sov. Phys.) 11 (1960) 1215

1960BA47 W.C. Barber, F. Berthold, G. Fricke and F.E. Gudden, Phys. Rev. 120 (1960) 2081

1960BR19 D.J. Bredin, J.B.A. England, D. Evans, J.S. McKee, P.V. March, E.M. Mosinger and W.T. Toner, Proc. Roy. Soc. A258 (1960) 202

1960BR27 B.H. Bransden and R.A.H. Hamilton, Proc. Phys. Soc. (London) 76 (1960) 987

1960CH1B Chen and Hintz, Nucl. Forces and the Few Nucleon Problem (Pergamon, 1960) 683

1960DU1C Dul-Kova, Zh. Eksp. Teor. Fiz. 39 (1960) 1008; JETP (Sov. Phys.) 12 (1961) 701

1960EL09 M. El-Nadi and M. Wafik, Proc. Phys. Soc. (London) 76 (1960) 185

1960GA08 J.L. Gammel, B.J. Hill and R.M. Thaler, Phys. Rev. 119 (1960) 267

1960GA1C Gammel, Brolley, Rosen and Stewart, Proc. Int. Conf. on Nucl. Structure (1960) 215

1960GO13 S. Gorodetzky, G. Sutter, F. Scheibling, P. Mennrath, P. Chevallier and R. Armbruster, Compt. Rend. 250 (1960) 3308

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

1960JA1G Jackson, Proc. Phys. Soc. (London) 76 (1960) 949

1960KO14 A.P. Komar and E.D. Makhnovskii, Dokl. Akad. Nauk SSSR 135 (1960) 52; Sov. Phys. Dokl. 5 (1960) 1229

1960KO1C Kotin, Rev. Mex. Fisica 9 (1960) 73

1960KO1D Kopaleishvili, Vashakidez, Mamasakhlisov and Chilashvili, Zh. Eksp. Teor. Fiz. 38 (1960) 1758; JETP (Sov. Phys.) 11 (1960) 1268

1960MA32 R.D. Macfarlane and J.B. French, Rev. Mod. Phys. 32 (1960) 567

1960MC1E McKee, Nucl. Forces and the Few Nucleon Problem (Pergamon, 1960) 609

1960PH1A Phillips and Tombrello, Nucl. Phys. 19 (1960) 555

1960PR06 D.G. Proctor and W.H. Voelker, Phys. Rev. 118 (1960) 217

1960SA28 Y. Sakamoto and T. Takemiya, Prog. Theor. Phys. 23 (1960) 172

1960TA1C Talmi and Unna, Ann. Rev. Nucl. Sci. 10 (1960) 353

1960VA1D Vashakidze, Kopaleishvili and Chilashvili, Zh. Eksp. Teor. Fiz. 39 (1960) 393; JETP (Sov. Phys.) 12 (1961) 278

1960WA1F Wackman, Thesis, Univ. of Pittsburgh (1960)

1960YO06 L.G. Youn, G.M. Osetinskii, N. Sodnom, A.M. Govorov, I.V. Sizov and V.I. Salatskii, Zh. Eksp. Teor. Fiz. 39 (1960) 225; JETP (Sov. Phys.) 12 (1961) 163

1961AH1A Ahrens, J. Inorg. Nucl. Chem. 16 (1961) 368

1961BA1E Balashov, Neudachin and Smirnov, Izv. Akad. Nauk SSSR Ser. Fiz. 25 (1961) 170; Bull. Acad. Sci. USSR Phys. 25 (1961) 165

1961BA40 J.F. Barry, R. Batchelor and B.E.F. Macefield, Proc. Rutherford Jub. Int. Conf., Manchester, England; Ed. J.B. Birks (Academic Press, New York, 1961) 543

1961CH09 R. Chiba, H.E. Conzett, H. Morinaga, N. Mutsuro, K. Shoda and M. Kimura, J. Phys. Soc. Jpn. 16 (1961) 1077

1961CL09 A.B. Clegg, K.J. Foley, G.L. Salmon and R.E. Segel, Proc. Phys. Soc. (London) 78 (1961) 681

1961GA09 J.P. Garron, J.C. Jacmart, M. Riou, C. Ruhla, J. Teillac, C. Caverzasio and K. Strauch, Phys. Rev. Lett. 7 (1961) 261

1961GO18 A.M. Govorov, L.H. Youn, G.M. Osetinskii, V.I. Salatskii and I.V. Sizov, Zh. Eksp. Teor. Fiz. 41 (1961) 703; JETP (Sov. Phys.) 14 (1962) 508

1961GO1D Golsansky, Nucl. Phys. 27 (1961) 648

1961HO01 H.D. Holmgren and L.M. Cameron, Bull. Amer. Phys. Soc. 6 (1961) 36, MA2

1961HO23 H.D. Holmgren and L.M. Cameron, Proc. Rutherford Jub. Int. Conf., Manchester, England; Ed. J.B. Birks (Academic Press Inc., New York, 1961) 537

1961KO1G Kopaleishvili, Vashakidze, Mamasakhlisov and Chilashvili, Nucl. Phys. 23 (1961) 430

1961KO1H Kolos, Acta Phys. Pol. 20 (1961) 175

1961MA29 M. Masuda, J. Phys. Soc. Jpn. 16 (1961) 1801

1961OG1A Ogloblin and Chuen, Instr. Expt. Tech. 5 (1962) 859; Pribory Tekhnika Eksp. 5 (1961) 37

1961PA1A Patel and Bhavsar, Current Sci. (India) 30 (1961) 51

1961PO01 L.G. Pondrom and J.W. Daughtry, Phys. Rev. 121 (1961) 1192

1961PU1A Pugh and Riley, Proc. Rutherford Jub. Int. Conf., Manchester, England; Ed. J.B. Birks (Academic Press Inc., New York, 1961) 195

1961RI03 B.W. Ridley, Nucl. Phys. 25 (1961) 483

1961RY01 B.V. Rybakov, V.A. Sidorov and N.A. Vlasov, Nucl. Phys. 23 (1961) 491

1961SH1B Shah and Pandya, Proc. Rutherford Jub. Int. Conf., Manchester, England; Ed. J.B. Birks (Academic Press Inc., New York, 1961) 393

1961SL06 R.J. Slobodrian, Bol. Acad. Nac. Cienc. (Cordoba, Rep. Arg.) 42 (1961) 75; Phys. Abs. 67, 1989, Phys. Abs. 22164 (1964)

1961TA05 Y.C. Tang, K. Wildermuth and L.D. Pearlstein, Phys. Rev. 123 (1961) 548

1961VA1G Vashakidze, Kopaleishvili and Chilashvili, Nucl. Phys. 23 (1961) 694

1961WO05 E.A. Wolicki and A.R. Knudson, Bull. Amer. Phys. Soc. 6 (1961) 415, B2

1961YU01 T. Yuasa, J. Phys. Rad. 22 (1961) 169

1962BA1D Barber, Ann. Rev. Nucl. Sci. 12 (1962) 1

1962BE1J Berggren and Jacob, Phys. Lett. 1 (1962) 258

1962BE1K Berggren, Brown and Jacob, Phys. Lett. 1 (1962) 88

1962BI14 J.K. Bienlein and F. Pleasonton, Nucl. Phys. 37 (1962) 529; Erratum Nucl. Phys. 40 (1963) 694

1962BO17 E.C. Booth and K.A. Wright, Nucl. Phys. 35 (1962) 472

1962CH26 V.P. Chizhov, et al., Nucl. Phys. 34 (1962) 562

1962CO1D Cohen, Nucl. Phys. 33 (1962) 52

1962CR09 C.L. Critchfield, LA-2714 (1962)

1962DI1A Dietrich, Phys. Lett. 2 (1962) 139

1962DI1B Dietrich, Z. Phys. 167 (1962) 563

1962EL1D Elton and Jackson, Nucl. Phys. 35 (1962) 209

1962FO08 W.F. Ford, Nucl. Phys. 37 (1962) 119

1962GA09 J.P. Garron, J.C. Jacmart, M. Riou, C. Ruhla, J. Teillac and K. Strauch, Nucl. Phys. 37 (1962) 126

1962GA23 J.P. Garron, Ann. Phys. (Paris) 7 (1962) 301

1962GO1P Gottschalk, Unpublished Thesis, Harvard Univ. (1962)

1962GO1Q Govorov, Ka-Yeng, Osetinsky, Salatsky and Sizov, Zh. Eksp. Teor. Fiz. 42 (1962) 383; JETP (Sov. Phys.) 15 (1962) 266

1962HA23 S.S. Hanna, Bull. Amer. Phys. Soc. 7 (1962) 470, LA4

1962IN02 D.R. Inglis, Nucl. Phys. 30 (1962) 1

1962IN1A Inglis, Rev. Mod. Phys. 34 (1962) 165

1962IN1C Inglis, Phys. Rev. 126 (1962) 1789

1962JA06 D.F. Jackson, Proc. Phys. Soc. (London) 79 (1962) 1041

1962JA1B Jackson, Nucl. Phys. 35 (1962) 194

1962LE12 H.W. Lefevre, R.R. Borchers and C.H. Poppe, Phys. Rev. 128 (1962) 1328

1962MA38 S. Malmskog and J. Konijn, Nucl. Phys. 38 (1962) 196

1962MA40 D.R. Maxson, Phys. Rev. 128 (1962) 1321

1962ME1C Meshkov, Nucl. Phys. 35 (1962) 485

1962NA1B Narasimhan, Shah and Pandya, Nucl. Phys. 33 (1962) 529

1962RO20 L. Rosen and W.T. Leland, Phys. Rev. Lett. 8 (1962) 379

1962RU04 C. Ruhla, M. Riou, J.P. Garron, J.C. Jacmart and L. Massonnet, Phys. Lett. 2 (1962) 44

1962SA1F Sakamoto, Phys. Lett. 1 (1962) 256; Nuovo Cim. 26 (1962) 461

1962SC15 R. Schlecht, D. McColm and I. Maleh, Bull. Amer. Phys. Soc. 7 (1962) 604, G1

1962SE02 F.D. Seward, Phys. Rev. 125 (1962) 335

1962SL04 R.J. Slobodrian, Phys. Rev. 126 (1962) 1059

1962ST19 L. Stewart, J.E. Brolley Jr. and L. Rosen, Phys. Rev. 128 (1962) 707

1962ST1E Strnad, Phys. Rev. 125 (1962) 1639

1962TE1D Temmer, Bull. Amer. Phys. Soc. 7 (1962) 569

1962TI01 G. Tibell, O. Sundberg and U. Miklavzic, Phys. Lett. 1 (1962) 172

1962VO1C Volkov and Kulchitskii, Zh. Eksp. Teor. Fiz. 42 (1962) 108; JETP (Sov. Phys.) 15 (1962) 77

1962VO1D Volkov, Kulikov and Chizhov, Zh. Eksp. Teor. Fiz. 42 (1962) 61; JETP (Sov. Phys.) 15 (1962) 42

1962WA1E Wackman and Austern, Nucl. Phys. 30 (1962) 529

1962WO07 C. Wong, J.D. Anderson and J.W. McClure, Nucl. Phys. 33 (1962) 680

1963AL18 D.E. Alburger, Phys. Rev. 132 (1963) 328

1963BA19 W.C. Barber, J. Goldemberg, G.A. Peterson and Y. Torizuka, Nucl. Phys. 41 (1963) 461; Erratum Nucl. Phys. 47 (1963) 527

1963BA1V Batchelor and Towle, AWRE NR 6/63 (1963)

1963BA50 R. Batchelor and J.H. Towle, Nucl. Phys. 47 (1963) 385

1963BE25 M. Bernheim and G.R. Bishop, Phys. Lett. 5 (1963) 270

1963BE42 T. Berggren and G. Jacob, Nucl. Phys. 47 (1963) 481

1963BE53 M. Bernheim and G.R. Bishop, J. Phys. 24 (1963) 970

1963BI10 G.R. Bishop and M. Bernheim, Phys. Lett. 5 (1963) 140

1963BL20 H.R. Blieden, G.M. Temmer and K.L. Warsh, Nucl. Phys. 49 (1963) 209

1963BO1K Bodmer and Ali, Nucl. Phys. 40 (1963) 463

1963BU1C Bunakov, Phys. Lett. 7 (1963) 14

1963CA02 J.A. Careaga and M. Mazari, Bull. Amer. Phys. Soc. 8 (1963) 124, U5, and Private Communication (1963)

1963CA1H Carlson, Pleasonton and Johnson, Phys. Rev. 129 (1963) 2220

1963CO15 S. Costa, S. Ferroni, V. Wataghin and R. Malvano, Phys. Lett. 4 (1963) 308

1963CO1D Costa et al., Phys. Lett. 6 (1963) 226

1963DA04 J.F. Dawson and J.D. Walecka, Ann. Phys. 22 (1963) 133

1963DE01 D.W. Devins and H.H. Forster, Bull. Amer. Phys. Soc. 8 (1963) 12, BA13

1963ED1A Edwards, Padua (1963) 469

1963EL1C Elton, Padua (1963) 1093

1963EL1D El-Nadi, Rabie and Sherif, Nucl. Phys. 48 (1963) 569

1963ER02 H.J. Erramuspe and R.J. Slobodrian, Nucl. Phys. 49 (1963) 65

1963FR1E Freeman, West and Montague, AERE Prog. Rept. PR/NP 3, 4 (1963), and Private Communication (1963)

1963GO04 J. Goldemberg and Y. Torizuka, Phys. Rev. 129 (1963) 312

1963GR29 D.E. Groce and W. Whaling, Phys. Rev. 132 (1963) 2614

1963GU07 M. Gulyamov, B.V. Rybakov and V.A. Sidorov, Zh. Eksp. Teor. Fiz. 44 (1963) 1829; JETP (Sov. Phys.) 17 (1963) 1230

1963HA1H Hansteen adn Kanestrom, Nucl. Phys. 46 (1963) 303

1963HA49 W.D. Harrison, Bull. Amer. Phys. Soc. 8 (1963) 597, F2

1963HW01 C.F. Hwang, G. Clausnitzer, D.H. Nordby, S. Suwa and J.H. Williams, Phys. Rev. 131 (1963) 2602

1963IN1A Inopin, Nucl. Phys. 42 (1963) 666

1963JA1C Jackson and Elton, Nucl. Phys. 43 (1963) 136

1963JO04 C.H. Johnson, F. Pleasonton and T.A. Carlson, Nucl. Phys. 41 (1963) 167

1963JO07 A. Johansson and Y. Sakamoto, Nucl. Phys. 42 (1963) 625

1963JO15 C.H. Johnson, F. Pleasonton and T.A. Carlson, Phys. Rev. 132 (1963) 1149

1963KI1D Kim, Nucl. Phys. 49 (1963) 651

1963KL1A Klapisch, Rameau, Epherre and Gradsztajn, J. Phys. 24 (1963) 839

1963KN1C Knudson and Wolicki, Padua (1963) 981

1963KO04 D. Kohler and S.M. Austin, Bull. Amer. Phys. Soc. 8 (1963) 290, A2

1963KU03 D. Kurath, Phys. Rev. 130 (1963) 1525

1963KU18 B. Kuhn and B. Schlenk, Nucl. Phys. 48 (1963) 353

1963KU1B Kunz, Can. J. Phys. 41 (1963) 2187

1963KU1H Kuhn and Schlenk. Joint. Inst. Nucl. Res., Lab. Neutron Phys. USSR Rept. No. P1197 (1963)

1963LI16 J. Linck, I. Nicolas-Linck, R. Bilwes and D. Magnac-Valette, J. Phys. 24 (1963) 983

1963MA1P Magnac-Valette, Seltz, Bilwes and Spyns, Padua (1963) 1088A

1963ME01 J.B. Mead, L.B. Geesaman and H.B. Knowles, Bull. Amer. Phys. Soc. 8 (1963) 292, A15

1963MO1F Morpurgo, Nucl. Spectroscopy; Ed. Racah (Academic Press, 1962)

1963OG1A Ogloblin, Nucl. Phys. 47 (1963) 408

1963OL1B Ollerhead, Chasman and Bromley, Padua (1963) 984

1963RI1B Riou, Padua (1963) 18

1963RO23 R.E. Rothe, L. Jacobson and J. Jobst, Bull. Amer. Phys. Soc. 8 (1963) 537, S6

1963RU05 C. Ruhla, M. Riou, M. Gusakow, J.C. Jacmart, M. Liu and L. Valentin, Phys. Lett. 6 (1963) 282

1963SA1F Sakamoto, Nuovo Cim. 28 (1963) 206

1963SC1J Schmid, Tang and Wildermuth, Phys. Lett. 7 (1963) 263

1963SC30 R.G. Schlecht, UCRL-11047 (1963)

1963SK02 S.J. Skorka, R. Hubner, T.W. Retz-Schmidt and H. Wahl, Nucl. Phys. 47 (1963) 417

1963SM03 D.B. Smith, N. Jarmie and A.M. Lockett, Phys. Rev. 129 (1963) 785

1963TA1D Takemiya, Prrog. Theor. Phys. 30 (1963) 191

1963TE1B Temmer, Pauda (1963) 1013

1963TO03 T.A. Tombrello and A.D. Bacher, Phys. Rev. 130 (1963) 1108

1963VA14 W.T.H. Van Oers and K.W. Brockman Jr., Nucl. Phys. 44 (1963) 546

1963VI06 J.B. Vise and B.M. Rustad, Phys. Rev. 132 (1963) 2573

1963VL1A Vlasov, Zh. Eksp. Teor. Fiz. 45 (1963) 160; JETP (Sov. Phys.) 18 (1964) 160

1963WA1H Wackman and Austern, Bull. Amer. Phys. Soc. 8 (1963) 56

1964AR08 K.P. Artjomov, V.J. Chuev, V.Z. Goldberg, A.A. Ogloblin, V.P. Rudakov and I.N. Serikov, Phys. Lett. 12 (1964) 53

1964AR25 A.H. Armstrong, J. Gammel, L. Rosen and G.M. Frye, Jr., Nucl. Phys. 52 (1964) 505

1964BA16 J.K. Bair, C.M. Jones and H.B. Willard, Nucl. Phys. 53 (1964) 209

1964BA1C Balashov, Boyarkina and Rotter, Nucl. Phys. 59 (1964) 417

1964BA1P Balashov and Boyarkina, Izv. Akad. Nauk SSSR Ser. Fiz. 26 (1964) 359

1964BA2B Bahcall and Wolf, Astrophys. J. 139 (1964) 622

1964BA2C Bazhanov, Komar and Kulikov, Zh. Eksp. Teor. Fiz. 46 (1964) 1497; JETP (Sov. Phys.) 19 (1964) 1014

1964BI04 G.R. Bishop and M. Bernheim, Phys. Lett. 8 (1964) 128

1964BL1C Blieden, Phys. Lett. 9 (1964) 176

1964BR13 H.C. Bryant, J.G. Beery, E.R. Flynn and W.T. Leland, Nucl. Phys. 53 (1964) 97

1964BR43 H.W. Broek and J.L. Yntema, Phys. Rev. 135 (1964) B678

1964DE1F Devins, Forster, Bunch and Kim, Phys. Lett. 9 (1964) 35

1964DE1G Delorme, Congres Int. de Phys. Nucl., Paris (1964)

1964ER1B Eramjian, Izv. Akad. Nauk SSSR Ser. Fiz. 28 (1964) 1181

1964GA01 G.T. Garvey and J.C. Hiebert, Bull. Amer. Phys. Soc. 9 (1964) 44, DC9

1964GA11 N. Gangas, S. Kossionides, R. Rigopoulos and M.L. Ahmad, Phys. Lett. 12 (1964) 233

1964GE10 D.S. Gemmell, J.R. Erskine and J.P. Schiffer, Phys. Rev. 134 (1964) B110

1964GO15 J. Goldemberg, W.C. Barber, F.H. Lewis Jr. and J.D. Walecka, Phys. Rev. 134 (1964) B1022

1964GR1J Green, Nucl. Phys. 54 (1964) 505

1964GR39 G. Gregoire and P.C. Macq, Phys. Lett. 8 (1964) 328

1964GR40 L. Green and D.J. Donahue, Phys. Rev. 135 (1964) B701

1964HA05 E.W. Hamburger, Nucl. Phys. 50 (1964) 66

1964HOZZ J.L. Honsaker, Unpublished Thesis, Cal Tech (1964)

1964HU1A Hunchen, Kropf and Waffler, Nucl. Phys. 58 (1964) 477

1964JA03 J.C. Jacmart, J.P. Garron, M. Riou and C. Ruhla, Phys. Lett. 8 (1964) 269

1964JI1A Jibuti, Kopaleishvili and Mamasakhlisov, Nucl. Phys. 52 (1964) 345

1964KO1F Komar and Makhnovskii, Dokl. Akad. Nauk SSSR 156 (1964) 774

1964KU1G Kurath, Phys. Rev. 134 (1964) B1025

1964LI1D Lim and McCarthy, Phys. Rev. 133 (1964) B1006

1964MA1G Mamasakhlisov, Izv. Akad. Nauk SSSR Ser. Fiz. 28 (1964) 1550

1964MA1X Makhnovskii, Zh. Eksp. Teor. Fiz. 46 (1964) 1136; JETP (Sov. Phys.) 19 (1964) 769

1964MA1Y Marty, Geoffrion, Rolland, Tatischeff anf Willis, Congres Int. de Phys. Nucl., Paris (1964)

1964MC1E McIntyre and Haeberli, Bull. Amer. Phys. Soc. 9 (1964) 390

1964MC1F McIntyre and Haeberli, Bull. Amer. Phys. Soc. 9 (1964) 627

1964MI16 F.C. Michel, Phys. Rev. 133 (1964) B329

1964NE1E Neudachin, Shevchenko and Yudin, Phys. Lett. 10 (1964) 180

1964OH01 G.G. Ohlsen and P.G. Young, Phys. Rev. 136 (1964) B1632

1964OH02 G.G. Ohlsen and P.G. Young, Nucl. Phys. 52 (1964) 134

1964OL1A Ollerhead, Chasman and Bromley, Phys. Rev. 134 (1964) B74

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

1964PE20 J.L. Perkin, Nucl. Phys. 60 (1964) 561

1964RO1D Rothe, Private Communication (1964)

1964SA1F Sandulescu and Dumitrescu, Phys. Lett. 11 (1964) 420

1964SA1H Sakamoto, Phys. Rev. 134 (1964) B1211

1964SE07 L.S. Senhouse Jr. and T.A. Tombrello, Nucl. Phys. 57 (1964) 624

1964SE1F Seiler, Darden, Mcintyre and Weitakmp, Nucl. Phys. 53 (1964) 65

1964SE1G Senhouse, Thesis, Cal Tech (1964)

1964SH05 J.H. Shafer, Phys. Rev. 133 (1964) B920

1964SH07 T.H. Short and N.M. Hintz, Bull. Amer. Phys. Soc. 9 (1964) 391, BA16

1964SH27 A.K. Shardanov, V.G. Shevchenko and B.A. Yurev, Izv. Akad. Nauk SSSR Ser. Fiz. 28 (1964) 60; Bull. Acad. Sci. USSR Phys. Ser. 28 (1965) 60

1964ST1B Stovall, Phys. Rev. 133 (1964) B268

1964TA02 B. Tatischeff, N. Marty, X. De Bouard, J.G. Fox, B. Geoffrion and C. Rolland, Phys. Lett. 8 (1964) 54

1964TI02 G. Tibell, O. Sundberg and P.U. Renberg, Ark. Fys. 25 (1964) 433

1964WA1E Walecka, Congres Int. de Phys. Nucl., Paris (1964)

1964WH01 L.Wharton, L.P.Gold and W. Klemperer, Phys. Rev. 133 (1964) B270

1964WH06 W. Whaling, Bull. Amer. Phys. Soc. 9 (1964) 627, E7

1964YA1A Yanabu et al., J. Phys. Soc. Jpn. 19 (1964) 1818

1964YO06 F.C. Young, P.D. Forsyth, M.L. Roush, W.F. Hornyak and J.B. Marion, Phys. Lett. 13 (1964) 50

1965AJ01 F. Ajzenberg-Selove, J.W. Watson and R. Middleton, Phys. Rev. 139 (1965) B592

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

1965BA2B Bacher and Tombrello, Bull. Amer. Phys. Soc. 10 (1965) 423

1965BA2C Bahcall, Nucl. Phys. (1965)

1965BE1H Beregi, Zelenskaja, Neudatchin and Smirnov, Nucl. Phys. 66 (1965) 513

1965BE1R Bernas, Epherre, Gradsztajn, Klapisch and Yiou, Phys. Lett. 15 (1965) 147

1965BE42 B.L. Berman, R.L. Bramblett, J.T. Caldwell, R.R. Harvey and S.C. Fultz, Phys. Rev. Lett. 15 (1965) 727

1965BO1C Bodmer and Murphy, Nucl. Phys. 73 (1965) 664

1965BR28 C.P. Browne, W.E. Dorenbusch and F.H. O'Donnell, Nucl. Phys. 72 (1965) 194

1965CO1F Cocke, Private Communication (1965)

1965DA1H Da Providencia and Shakin, Nucl. Phys. 65 (1965) 54

1965DE1Q Devins, Forster and Scott, Rev. Mod. Phys. 37 (1965) 396

1965EL1B Elton and Lodhi, Nucl. Phys. 66 (1965) 209

1965FO07 P.D. Forsyth and R.R. Perry, Nucl. Phys. 67 (1965) 517

1965FU1G Fuller and Cohen, Appendix I, Nucl. Data Sheets 6-5 (1965)

1965GO1L Gogny and Jean, Compt. Rend. 260 (1965) 510

1965GR1Q Griffith and Roman, Phys. Lett. 14 (1965) 42

1965HA17 D. Hasselgren, P.U. Renberg, O. Sundberg and G. Tibell, Nucl. Phys. 69 (1965) 81

1965HA1L Hansteen and Wittern, Phys. Rev. 137 (1965) B524

1965JA04 D.F. Jackson and J. Mahalanabis, Nucl. Phys. 64 (1965) 97

1965JA1C Janecke, Nucl. Phys. 61 (1965) 383

1965JA1J Jackson and Berggren, Nucl. Phys. 62 (1965) 353

1965JA1L Jackson and Elton, Proc. Phys. Soc. (London) 85 (1965) 659

1965JA1M Jackson, Rev. Mod. Phys. 37 (1965) 393

1965JO09 G. Johnson, H. Langevin-Joliot and P. Roussel, J. Phys. (Paris) 26 (1965) 161

1965LE02 W.T. LeLand, J.E. Brolley Jr. and L. Rosen, Bull. Amer. Phys. Soc. 10 (1965) 51, DC7

1965LO1G Lovitch, Nucl. Phys. 62 (1965) 653

1965LO1H Lodder and Jonker, Phys. Lett. 15 (1965) 245

1965LO1J Lodhi, Bull. Amer. Phys. Soc. 10 (1965) 583

1965MA1E Mazari, Private Communication (1965)

1965MA1N Malvano and Ricco, Nuovo Cim. 35 (1965) 484

1965MC1F McCarthy, Rev. Mod. Phys. 37 (1965) 388

1965ME05 F. Merchez, N. Van Sen, V. Regis and R. Bouchez, Compt. Rend. 260 (1965) 3922

1965MU1A Murphy and Rosati, Nucl. Phys. 63 (1965) 625

1965NE1C Neudatchin and Smirnov, Nucl. Phys. 66 (1965) 25

1965PA03 P. Paul, S.L. Blatt and D. Kohler, Phys. Rev. 137 (1965) B499

1965RA1D Rand, Frosch and Yearian, Bull. Amer. Phys. Soc. 10 (1965) 542

1965RA1E Rahman, Proc. Phys. Soc. (London) 85 (1965) 653

1965RI1A Riou, Rev. Mod. Phys. 37 (1965) 375

1965SA1J Sakamoto, Nuovo Cim. 37 (1965) 774

1965SE1E Sergeev, Izv. Akad. Nauk 29 (1965) 105

1965SH1F Sherman, Morrison and Stewart, Bull. Amer. Phys. Soc. 10 (1965) 541

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

1965TY1A Tyren, Kullander, Sundberg, Ramachandran, Isacsson and Berggren (1965), Unknown source

1965WE1E Weidenmuller, Nucl. Phys. (1965)

1965WI1G Wittern and Hansteen, Bull. Amer. Phys. Soc. 10 (1965) 424