Revised Manuscript *23 June 2008*

Energy Levels of Light Nuclei
$A = 7$

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Abstract: An evaluation of $A = 5$–10 was published in *Nuclear Physics A*320 (1979), p. 1. This version of $A = 7$ 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.

(References closed 1978)

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).

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^{7}n

(Not illustrated)

See (1977DE08).

^{7}H

(Not illustrated)

A search for ^{7}H in ^{7}Li(π^-, π^+)^{7}H was unsuccessful (1965GI10). See also (1975BE31, 1977SP1B; theor.).

^{7}He

(Fig. 10)

GENERAL: (See also (1974AJ01).)

See (1974IR04, 1974TH01, 1975PN1A, 1976TR1A, 1977DO06, 1977SH1C, 1978DA06).

1. ^{7}Li(π^-, γ)^{7}He $\qquad Q_{\rm m} = 128.37$

The radiative capture has been observed to the ground state of ^{7}He. The (M1) transition is seen $E_\gamma = 126.6$ MeV (1976AL1F). See also (1976TR1A).

2. ^{7}Li(n, p)^{7}He $\qquad Q_{\rm m} = -10.42$

At $E_{\rm n} = 14.8$ MeV a proton group is reported corresponding to ^{7}He$_{\rm g.s.}$: $\Gamma < 0.2$ MeV (1973LI02). See also (1976KI1D).

Table 7.1: Energy levels of ^{7}He

$E_{\rm x}$ (MeV)	$J^\pi; T$	$\Gamma_{\rm c.m.}$ (keV)	Decay	Reactions
g.s.	$(\frac{3}{2})^-; \frac{3}{2}$	160 ± 30	n [a]	1, 2, 3, 4

[a] Q_0 for ^{7}Li(t, ^{3}He)^{7}He is -11.18 MeV. This leads to 26.11 ± 0.03 MeV for the atomic mass excess of ^{7}He: $Q_{\rm m}$ for ^{7}He$_{\rm g.s.} \rightarrow {}^6$He + n is then 0.44 ± 0.03 MeV (1969ST02).

3. ^{7}Li(t, ^{3}He)^{7}He $\qquad Q_{\rm m} = -11.18$

The ^{3}He particles to the ground state of ^{7}He have been observed at $E_{\rm t} = 22$ MeV. The width of the ground state is 160 ± 30 keV; for a radius of 2.2 fm and $l_{\rm n} = 1$, this width is 0.22 of the Wigner limit. The angular distribution is peaked in the forward direction. No other states of ^{7}He were observed for $E_{\rm x} < 2.4$ MeV (1967ST04, 1969ST02).

4. ^{9}Be(^{6}Li, ^{8}B)^{7}He $\qquad Q_{\rm m} = -23.60$

At E(^{6}Li) $= 80.0$ and 93.3 MeV the ground state of ^{7}He is strongly populated, indicating negative parity, as expected. There is no indication of relatively sharp states of ^{7}He with $E_{\rm x} \lesssim 10$ MeV (1977WE03, 1977WE1B). See also (1974CE1A).

^{7}Li
(Figs. 8 and 10)

GENERAL: (See also (1974AJ01).)

Shell model: (1974KA11, 1975DI04, 1977ST04, 1978BO31).

Collective, rotational or deformed models: (1974BO25, 1976BR26).

Cluster and α-particle models: (1973HO1A, 1974GR24, 1974KA11, 1975KU1H, 1975GR26, 1975MI09, 1975PA11, 1975RO1B, 1977BE50, 1977MI03, 1977SA22, 1978RA09).

Astrophysical questions: (1973BA1H, 1973CA1B, 1973CO1B, 1973IB1A, 1973SM1A, 1973TI1A, 1973TR1B, 1973WE1D, 1974AU1A, 1974CA1C, 1974JA11, 1974KO1C, 1974RE1A, 1974WI1F, 1975AR1E, 1975BR1B, 1975CU1A, 1975KI14, 1975ME1E, 1975NO1D, 1975PR1B, 1975SC1H, 1975TR1A, 1976AU1B, 1976AU1C, 1976BE1C, 1976BO1E, 1976CA1C, 1976CL1A, 1976CO1B, 1976EP1A, 1976GI1C, 1976HA1F, 1976NO1C, 1976RO1J, 1976RO12, 1976SC1E, 1976SI1C, 1976SI1D, 1976VI1A, 1977AU1C, 1977AU1B, 1977BE1P, 1977BO1F, 1977CA1B, 1977KO1J, 1977MA1H, 1977MO1D, 1977MO1E, 1977SC1D, 1977ST1H, 1978AU1C, 1978BY1A, 1978MA1H).

Electromagnetic transitions: (1974CH46, 1974KU06, 1974MU1B, 1976KU07, 1977DO06, 1977ST04, 1978KI08).

Special levels: (1974IR04, 1974KA11, 1974KU06, 1975DI04, 1975LI20, 1976IR1B, 1978BO31).

Applied work: (1976OV1A, 1976PO1C, 1977BR1H, 1977CO1F).

Special reactions: (1973SI38, 1974BA70, 1974BO08, 1974JA11, 1974LA18, 1974QU01, 1975AR14, 1975BA1G, 1975FE1A, 1975KU01, 1975RA14, 1975RA21, 1975ZE01, 1976BE1K, 1976BE67, 1976BO08, 1976BU16, 1976CH28, 1976JA1E, 1976LE1F, 1976MI13, 1976NA11, 1976OS04, 1976RA1C, 1976RO12, 1977FE1B, 1977GE08, 1977GO07, 1977GR1D, 1977KU1D, 1977MO1C, 1977RE08, 1977SH1D, 1977ST34, 1977ST1G, 1977YA1B, 1978BA1J, 1978BI08, 1978DI04, 1978GE1C, 1978GR1F, 1978OT1A, 1978WE1D).

Muon and neutrino capture and reactions: (1974DO1C, 1974EN10, 1974HA1E, 1975FE1B, 1975GE1E, 1977BA1R, 1977CA1E, 1977MU1A, 1978DE15, 1978LE04).

Pion and kaon capture and reactions: (1972BA1C, 1973AL1A, 1973BA1G, 1973GO41, 1973NA20, 1973WI1A, 1974BO1D, 1974CL04, 1974GO04, 1974HU14, 1974LI1D, 1974TA18, 1975BA1L, 1975BA1G, 1975BA1P, 1975BO1B, 1975BU1A, 1975CA19, 1975GI1B, 1975NI1B, 1975PN1A, 1975TA1C, 1975YA02, 1976AL1F, 1976AS1B, 1976BO32, 1976CA23, 1976DO1D, 1976DU1B, 1976DY1B, 1976EN02, 1976GI01, 1976JA1D, 1976NO1D, 1976PI1B, 1976SH01, 1976TR1A, 1977AB09, 1977AL1C, 1977AL21, 1977AM1A, 1977AP1A, 1977BA27, 1977BA51, 1977BA47, 1977BA1M, 1977DO06, 1977HO1B, 1977KI1F, 1977MA35, 1977MC1E, 1977NA08, 1977SH1C, 1977SI03, 1977SP02, 1977SP1B, 1977WA02, 1978AT01, 1978CO16, 1978DA06, 1978EI1A, 1978FI1E, 1978HA1J, 1978HE02, 1978KI08, 1978MA1J, 1978ME05, 1978MO01, 1978OT1A, 1978WA02).

Table 7.2: Energy levels of ^{7}Li

E_x (MeV $\pm$ keV)	$J^\pi; T$	τ_m or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
g.s.	$\frac{3}{2}^-; \frac{1}{2}$		stable	1, 6, 12, 13, 16, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 39, 41, 42, 43, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59
0.477611 ± 0.012	$\frac{1}{2}^-; \frac{1}{2}$	$\tau_m = 105 \pm 5$ fsec [a]	γ	1, 6, 12, 13, 17, 19, 20, 21, 22, 24, 28, 31, 33, 34, 35, 36, 39, 41, 45, 46, 48, 50, 52, 53, 54, 55, 56, 57, 58
4.630 ± 9	$\frac{7}{2}^-; \frac{1}{2}$	$\Gamma = 93 \pm 8$ keV	t, α	3, 12, 13, 19, 20, 21, 22, 24, 35, 36, 41, 45, 54
6.68 ± 50	$\frac{5}{2}^-; \frac{1}{2}$	875^{+200}_{-100}	t, α	3, 12, 19, 20, 21, 35, 45
7.456 ± 1.5	$\frac{5}{2}^-; \frac{1}{2}$	89 ± 7	n, t, α	2, 3, 7, 11, 12, 13, 19, 21, 24, 33, 36, 45
(9.5)	$(\frac{3}{2}^+); \frac{1}{2}$	(≈ 3700)	n	7
9.67 ± 100	$\frac{7}{2}^-; \frac{1}{2}$	≈ 400	n, t, α	2, 3, 7, 13, 21, 36
9.85	$\frac{3}{2}^-; \frac{1}{2}$	≈ 1200	n, α	7, 11
11.24 ± 30	$\frac{3}{2}^-; \frac{3}{2}$	260 ± 35	n, p	7, 8, 19, 35
17		broad	γ, n	7, 18

[a] See Table 7.4 in (1966LA04) and (1966PA11, 1967CA02, 1975GE1D).

Antiproton induced reactions: (1973GO41, 1977BA1W, 1977RO23, 1977WE1E).

Other topics: (1972BA1C, 1974IR04, 1974KU06, 1974SI04, 1975ER09, 1975KU01, 1975KU08, 1975LI20, 1975PN1A, 1976BR26, 1976ES1A, 1976IR1B, 1976KU07, 1976MA04, 1978DA06).

Ground state properties of ^{7}*Li:* (1974DE1E, 1974EN10, 1974KU06, 1974SHYR, 1975BE31, 1975JO1A, 1976BR26, 1976FU06, 1976HA1E, 1977AN21, 1977MA35, 1978AN07, 1978RA09, 1978ZA1D).

$\mu = +3.256424\ (2)$ nm (1974BE50) and (V. Shirley, private communication);

$Q = -36.6$ (3) mb (V. Shirley, private communication);

$B(\text{E2: } \frac{3}{2}^- \rightarrow \frac{1}{2}^-) = 8.3 \pm 0.6\ e^2 \cdot \text{fm}^4$ (1972HA06, 1973HA47);
$= 7.4 \pm 0.1\ e^2 \cdot \text{fm}^4$ (1972BA77) [see also (1973HA47)].

Table 7.3: ^{7}Li levels from ^{3}H + ^{4}He

E_x (MeV ± keV)	J^π	l_α	LS term	R (fm)	θ^2_α [a]	$\theta^2_{n_0}$	$\theta^2_{n_1}$ [b]	Refs.
4.65 ± 20	$\frac{7}{2}^-$	3	$^{2}F_{7/2}$	4.0	0.57 ± 0.04			(1967SP10, 1968IV01)
6.64 ± 100	$\frac{5}{2}^-$	3	$^{2}F_{5/2}$	4.0	1.36 ± 0.13	0.000 ± 0.002		(1967SP10)
6.79 ± 90	$\frac{5}{2}^-$	3	$^{2}F_{5/2}$	4.4	0.52			(1968IV01)
7.47 ± 30	$\frac{5}{2}^-$	3	$^{4}P_{5/2}$	4.0	0.011 ± 0.001	0.26 ± 0.02		(1967SP10)
9.67 ± 100	$\frac{7}{2}^-$	3	$^{4}D_{7/2}$	4.0	0.53 ± 0.22		2.3 ± 0.7	(1967SP10)

[a] $\gamma^2/(\frac{3}{2}\hbar^2/\mu a^2)$.
[b] To ^{6}Li*(2.19).

1. ^{3}H(α, γ)^{7}Li $\qquad Q_m = 2.467$

Excitation functions and angular distributions have been studied for $E_\alpha = 0.5$ to 1.9 MeV (1959HO03, 1961GR27). The cross section rises smoothly as expected for a direct capture process: at $E_\alpha = 1.32$ MeV, $\sigma = 3.58 \pm 0.60$ μb and the corresponding reduced cross section factor $S = 0.064 \pm 0.016$ keV · b (1961GR27). Cross sections of (1961GR27) are 2 to 2.5 times higher than those of (1959HO03). See (1966LA04) for further comments.

2. ^{3}H(α, n)^{6}Li $\qquad Q_m = -4.7839 \qquad E_b = 2.467$

The cross section for this reaction has been measured for $E_\alpha = 11$ to 18 MeV: the data show the effect of ^{7}Li*(7.46) and indicate a broad resonance near $E_\alpha = 16.8$ MeV [^{7}Li*(9.6)]. The level parameters derived from this reaction and from reaction 3 (1967SP10) are displayed in Table 7.3. The yield of ^{6}Li ions at 0°(lab) has also been measured for $E_\alpha = 11.310$ to 11.930 MeV with $2 - 3$% accuracy: the data were then reduced to obtain the c.m. differential cross sections at 0° and 180° for the inverse reaction in the energy region corresponding to formation of ^{7}Li*(7.46) (1977BR21). See also (1976HA1H, 1977BE1M; theor.) and (1975AL1A) for the breakup of ^{6}Li.

3. ^{3}H(α, α)^{3}H $\qquad E_b = 2.467$

The elastic scattering has been studied for $E_\alpha = 3.6$ to 18.2 MeV and $E_t = 7.6$ to 12 MeV. The excitation curves show the effects of ^{7}Li*(4.63, 6.68, 7.46, 9.67). The derived level parameters are displayed in Table 7.3 (1967SP10, 1968IV01). Angular distributions have been measured for $E_\alpha = 2.13$ to 2.98 MeV (1971CH42) and $E_t = 8.2$ to 12 MeV (1975JA1D). Very accurate differential cross sections are reported by (1977BR21) for $E_t = 8.507$ to 9.050 and by (1975JA1D; abstract) for $E_t = 7.6$ to 10 MeV. Polarization measurements are reported for $E_t = 6.0$ to 12.3 MeV (1968KE03) and for $E_{\vec{t}} = 10.2$ to 11.7 MeV (1976HA17) and 12 to 17 MeV (1978CO1G). (1976HA17) find a polarization extremum $(A_y = -1)$ near $E_t = 11.1$ MeV, $\theta_{c.m.} = 95°$ (1976HA17). See also (1974QU01), (1978BR1E) and (1974CL1D, 1974KO03, 1974TE05, 1975AB1C, 1975BA38, 1975CL1B, 1975HE07, 1975KU09, 1975NE1B, 1975PA1B, 1975TA1A, 1975WI1C, 1976HA1G, 1976HA1H, 1977BE50, 1977BE1M, 1978FR02, 1978LE1H; theor.).

4. ^{4}He(α, p)^{7}Li $\qquad Q_m = -17.347$

Angular distributions of the p_0 and p_1 groups are reported at $E_\alpha = 39.9 \rightarrow 49.5$ MeV (1977KI12) and 60.2, 92.4 and 140.0 MeV (1975KI14; p_{0+1}). See also (1974KO1C, 1975KI14; astrophysics) and ^{8}Be.

5. ^{6}He(p, t)^{4}He $\qquad Q_m = 7.509 \qquad E_b = 9.975$

See (1971PO1A).

6. ^{6}Li(n, γ)^{7}Li $\qquad Q_m = 7.251$

Two γ-rays with $E_\gamma = 7247 \pm 2$ and 6769 ± 2 keV are observed corresponding to transitions to ^{7}Li*(0, 0.48) with branching ratios of (61 ± 3) and (39 ± 2)%. ^{7}Li*(4.63) is not involved in the decay [$\lesssim$ 2%] (1967TH05). See (1974AJ01) for the earlier work on Q_0, for an unpublished measurement of $\sigma_{n,\gamma}$, and for more accurate values of E_γ and branching ratios which have, however, not been published. See also (1974KR1B).

7. ^{6}Li(n, n)^{6}Li $\qquad E_b = 7.251$

The total cross section has been measured from $E_n = 4$ eV to 29 MeV: see (1976GAYV). Recent measurements include those of (1975HA1J, 1975HA1M: $E_n = 10$ eV to 10 MeV; preliminary) and (1976KN1C: $E_n = 0.1$ to 3.0 MeV; abstract). See also (1976BI1B). A pronounced resonance occurs at $E_n = 244.5 \pm 1.0$ keV with a peak cross section of 11.20 ± 0.20 b (1977SM1B). [(1975HA1M) report $\sigma_{peak} = 10.85 \pm 0.10$ b at 244.1 keV.] The elastic contribution is 7.2 b (1961LA1A): see Table 7.4. No other clearly defined resonance is observed although the total cross section exhibits a broad maximum at $E_n \approx 5$ MeV (1976GAYV). The analyzing power is nearly constant for $E_{\vec{n}} = 2$ to 5 MeV: a multi-level R-matrix analysis suggests a $\frac{3}{2}^+$ state at

Table 7.4: Resonance parameters for $7.5 - 7.2$ MeV levels in ^{7}Li and ^{7}Be [a]

Reaction	^{6}Li + n [b]	^{6}Li + p [c]
E_r (keV, lab)	262 [d]	1840
$\Gamma(E_r)$ (keV, c.m.)	154	836
E_λ (keV above g.s.)	7700	7580
$\Gamma_{n,p}(E_r)$ (keV, c.m.)	118 [e]	798
radius (n, p) in fm	3.94	4.08
$\gamma^2_{n,p}$ (MeV · fm)	4.85	5.02
$\theta^2_{n,p}$	0.26	0.28
$\Gamma_\alpha(E_r)$ (keV, c.m.)	36 [e]	38
radius (α) in fm	4.39	4.39
γ^2_α (MeV · fm)	0.101	0.101
θ^2_α	0.012	0.012

[a] These states are believed to have a $^4P_{5/2}$ character, consistent with their large θ^2_n and θ^2_p (1959GA08, 1963MC09).

[b] (1959GA08). See also (1972ME17).

[c] (1963MC09).

[d] 245 keV (1974PO07), 241 keV (1977BR21), 244.5 ± 1.0 keV (1977SM1B), 240 keV [see (1978RE1B)].

[e] $\Gamma_n = 107$ keV, $\Gamma_\alpha = 43$ keV (1974FO1B, abstract).

$E_n = 2.8$ MeV ($\Gamma_n = 3.5$ MeV) and a $\frac{3}{2}^-$ state at $E_n = 3.5$ MeV ($\Gamma = 7.3$ MeV) (1975HO01). The coherent scattering length (thermal, bound) is $1.8 \pm 0.25i$ fm (1973MU14). The spin dependent capture cross section of slow neutrons ($\lambda = 1.074$ Å) is -1170 ± 50 b and the spin dependent scattering length is $(-0.38 \pm 0.05) \times 10^{-12}$ cm (1978GL01). For angular distributions see ^{6}Li and (1974HY01: σ_{el} at 14.1 MeV).

The excitation function for 3.56 MeV γ-rays exhibits an anomaly, also seen in the (n, p) reaction (reaction 8). The data are well fi tted assuming $E_{res} = 3.50$ and 4.60 MeV [$E_x = 10.25 \pm 0.10$ and 11.19 ± 0.05 MeV], $T = \frac{1}{2}$ and $\frac{3}{2}$, $\Gamma_{c.m.} = 1.40 \pm 0.10$ and 0.27 ± 0.05 MeV, respectively. Both states have $J^\pi = \frac{3}{2}^-$. The reduced widths for the $T = \frac{3}{2}$ state [^{7}Li*(11.19)] are $\theta^2_n = 2 \times 10^{-4}$, $\theta^2_{n''} = 0.16$ [to ^{6}Li*(3.56)] and $\theta^2_p = 0.09$ (1969PR04). However, an R-matrix study of ^{4}He(t, t), ^{6}Li(n, n), and ^{6}Li(n, α) data leads to the identifi cation of a $\frac{3}{2}^-$ state at $E_x = 9.85$ MeV, $\Gamma = 1.2$ MeV. The width of ^{7}Li*(9.67) is 0.4 MeV and there is preliminary evidence for a $\frac{3}{2}^+$ state at 9.5 MeV, $\Gamma = 3.7$ MeV (G.M. Hale, private communication). A broad resonance is suggested at $E_n = 11$ MeV in elastic and inelastic differential cross sections. It would correspond to a state at $E_x = 17$ MeV (1977NE1A; abstract): see also reaction 3 in ^{7}Be.

For other measurements see (1974AJ01). See also (1976KN1D, 1978LI1C), (1976LA1C) and (1974TE1B, 1976HA1G, 1977GU04, 1978MA37, 1978ST05; theor.).

8. ^{6}Li(n, p)^{6}He $\qquad Q_m = -2.725 \qquad E_b = 7.251$

The excitation function, measured from threshold to $E_n = 8.9$ MeV, exhibits an anomaly at $E_n = 4.6$ MeV (1969PR04). The excitation function, at forward angles, of p_0 is approximately constant for $E_n = 4.4$ to 7.25 MeV (1977RO01). See also ^{6}He, (1977RI07: $E_n = 800$ MeV) and (1974BO1E, 1976GO12, 1976SL2A).

9. ^{6}Li(n, d)^{5}He $\qquad Q_m = -2.37 \qquad E_b = 7.251$

The excitation function, at forward angles, of deuterons increases monotonically for $E_n = 5.4$ to 6.8 MeV (1977RO01). See also (1976SL2A) and ^{5}He.

10. ^{6}Li(n, 2n)^{5}Li $\qquad Q_m = -5.66 \qquad E_b = 7.251$

See (1974KO35, 1976GO12).

11. ^{6}Li(n, α)^{3}H $\qquad Q_m = -4.7839 \qquad E_b = 7.251$

The isotopic thermal cross section is 940 ± 4 b: see (1973MU14). Below 5 keV, the total cross section is given by $\sigma = (149.5/\sqrt{E}$ (eV)) $+ 0.696$ b (1970SO1A).

A resonance occurs at $E_n = 245$ keV, with $\sigma_{max} = 3.0 \pm 0.1$ b (1974PO07), [$E_n \approx 240$ keV, $\sigma_{max} = 3.36 \pm 0.06$ b: see (1978RE1B)]. [From a study of the inverse reaction, (1977BR21) find $\sigma_{max} = 3.15$ b at $E_n = 241$ keV.] The resonance is formed by p-waves, $J^\pi = \frac{5}{2}^-$ and has a large neutron width and a small α-width: see Table 7.4 (1959GA08). Above the resonance the cross section decreases monotonically to $E_n = 18$ MeV, except for a slight bump near $E_n \approx 1.8$ MeV: see (1976GAYV, 1978SA19). An S-matrix analysis of the ^{6}Li(n, t) reaction to 3.9 MeV suggests that the first $\frac{3}{2}^-$ excited state of ^{7}Li is located at ≈ 8.87 MeV, $\Gamma = 1.42$ MeV (1978SA19): see, however, reaction 7. See also (1974LE30).

Angular distributions have been measured at many energies: see (1974AJ01) and (1974OV01: 0.1 to 1.8 MeV; also yield) and (1977RO01: 4.71 to 7.25 MeV; and excitation curve at $0°$ for $E_n = 4.4$ to 7.25 MeV). Cross-section measurements have been reported in abstracts or other preliminary forms by (1974CO1A: $E_n = 1$ to 500 keV), (1976LA1E: 3 to 600 keV), (1975FR1B, 1975FR1C: 3 to 1500 keV), (1976LA1D: 10 to 500 keV), (1974FO1B: 20 to 1700 keV), (1974PO1C: 30 to 600 keV), (1978RE1B: 80 to 470 keV), (1974ST1E, 1975ST1D, 1975ST1E: 964 keV), (1974BA1K, 1974BA1L, 1975BA1M: 2.2 to 9.7 MeV) and (1976BA1K: 10 to 14 MeV). See also (1975HO01).

(1976RA1D; preliminary results) have studied the (n, α)/(n, t) ratio at $0°$ and $180°$ for $E_n = 0.5$ eV to 25 keV. This ratio is not equal to 1 above 10 eV: it is suggested that the anisotropy arises from interference between the p-wave resonance at 0.25 MeV and the s-wave contributions which account for the large $1/v$ cross section for this reaction. See also (1975SC1G).

Polarization measurements are reported by (1977KA06) for $E_{\bar{n}} = 0.2$ to 2.4 MeV: the data suggest interference between s-waves and the p-wave resonance at 0.25 MeV. Interference between this $\frac{5}{2}^-$ state and a broad $\frac{3}{2}^-$ state 2 MeV higher also appears to contribute. At the higher energies A_y is close to $+0.9$ near $90°$ and varies slowly with E_n (1977KA06).

See also (1975SC1J), (1973LI1E, 1974ST1D, 1975HA1H, 1975TA1B, 1978BO1F, 1978PI1A; applied), (1974FO1C, 1974ST1F, 1974TS1A, 1976FO1C, 1976LI1H, 1976SL2A; reviews) and (1974HA1D, 1975HA1G, 1975HA1L, 1976HA1G, 1976HA1H, 1977GU04, 1977LO1C; theor.).

12. ^{6}Li(p, π^+)^{7}Li $\qquad Q_m = -133.099$

At $E_p = 600$ MeV, the reaction preferentially excites ^{7}Li*(4.63). ^{7}Li*(0, 0.48, 6.68, 7.46) are also populated. Angular distributions have been obtained for the pions to ^{7}Li*(0, 0.48, 4.63). The $T = \frac{3}{2}$ state at $E_x = 11.24$ MeV is not observed [dσ/dΩ $(10°) < 40$ nb/sr] (1977BA37). See also (1977HO1B).

13. (a) ^{6}Li(d, p)^{7}Li $\qquad Q_m = 5.026$

(b) ^{6}Li(d, np)^{6}Li $\qquad Q_m = -2.22463$

(c) ^{6}Li(d, pt)^{4}He $\qquad Q_m = 2.5592$

Angular distributions of proton groups have been measured for $E_d = 1$ to 15 MeV [see (1966LA04, 1974AJ01)] and at $E_d = 0.118$ to 0.975 MeV (1977EL09; p_0, p_1) and 0.49 to 3.44 MeV (1975MC02, 1974MCZS; p_0, p_1). In addition to ^{7}Li*(0, 0.48) states with $E_x = 4.630 \pm 0.009$ and 7.464 ± 0.010 MeV, $\Gamma_{c.m.} = 93 \pm 8$ and 91 ± 8 keV are reported (1960HA14, 1957BR97). Ratios of observed θ_n^2 [see Table 7.3 in (1966LA04)] are consistent with assignments ^{22}P to ^{7}Li*(0, 0.48) and ^{24}P to ^{7}Li*(7.46) (1960HA14, 1960MA32); $S = 0.90$ and 1.15 for ^{7}Li*(0, 0.48) (1967SC29: DWBA analysis). ^{7}Li*(0.48) has $J = \frac{1}{2}$ since the angular correlation between p_1 and the 0.48 MeV γ-rays is isotropic: see (1955AJ61).

A kinematically complete study of reaction (b) at $E_d = 10$ MeV shows pronounced FSI via ^{7}Li*(7.46) and possibly ^{7}Li*(9.6) [$\Gamma = 0.5 \pm 0.1$ MeV] (1971VO07). Reaction (c) strongly involves ^{7}Li*(4.63, 7.46) (1977MI13; $E_d = 7.5 \to 10.5$ MeV). See also (1974MI10). See also ^{8}Be, (1977GL05, 1977TE1A) and (1975KU27, 1976KU07; theor.).

14. ^{6}Li(t, d)^{7}Li $\qquad Q_m = 0.993$

See (1974AJ01).

15. ^{6}Li(α, ^{3}He)^{7}Li $\qquad Q_m = -13.327$

Not reported.

16. (a) ^{6}Li(^{6}Li, pα)^{7}Li $\qquad Q_m = 3.552$
(b) ^{6}Li(^{9}Be, ^{8}Be)^{7}Li $\qquad Q_m = 5.585$

See ^{12}C in (1975AJ02) for reaction (a) and ^{8}Be, reaction 34 for reaction (b).

17. ^{7}Li(γ, γ)^{7}Li

See Table 7.4 in (1966LA04) [summary of early measurements] for τ_m of ^{7}Li*(0.48) $= 0.107 \pm 0.005$ psec.

18. (a) ^{7}Li(γ, n)^{6}Li $\qquad Q_m = -7.251$
(b) ^{7}Li(γ, 2n)^{5}Li $\qquad Q_m = -12.91$
(c) ^{7}Li(γ, p)^{6}He $\qquad Q_m = -9.975$
(d) ^{7}Li(γ, pn)^{5}He $\qquad Q_m = -11.84$
(e) ^{7}Li(γ, d)^{5}He $\qquad Q_m = -9.62$
(f) ^{7}Li(γ, t)^{4}He $\qquad Q_m = -2.467$
(g) ^{7}Li(γ, pt)^{3}H $\qquad Q_m = -22.281$

The total photoneutron cross section rises sharply from 10 MeV to reach a broad plateau at about 15 mb from 14 to 20 MeV, decreases more slowly to about 0.5 mb at 25 MeV and then decreases further to about 0.3 mb at $E_\gamma = 30$ MeV (1976BE1H; monoenergetic photons): there are indications of weak structure throughout the entire region. See also (1975BE60, 1975BE1F). (1977FE05; bremsstrahlung) report differential cross sections for n_{0+1}, n_0 and n_1, for $E_\gamma = 7$ to 25 MeV. The integrated cross section to 23 MeV is 39 ± 4 MeV $\cdot$ mb for the n_0 transition and 17 ± 4 MeV $\cdot$ mb for the n_1 transition: together these account for 0.4 of the exchange augmented dipole sum of ^{7}Li (1977FE05).

The cross section for the (γ, p) reaction (reaction (c)) shows a maximum at ≈ 15.6 MeV with a width of ≈ 4 MeV: see (1974AJ01). The total cross sections at $E_\gamma = 60$ and 80 MeV for the p_{0+1} groups are, respectively, 43.8 ± 1.2 μb and 11.4 ± 0.4 μb. Angular distributions have also been measured (1976MA34). See also (1974DE52, 1974GO04, 1976MU1A) and ^{6}He. For polarization of the protons see (1969AN20, 1970TO09).

Reaction (e) has been studied in the giant resonance reaction with $E_{bs} \lesssim 30$ MeV. Deuteron groups to $^5He_{g.s.}$ and possibly to the first excited state are reported. States of ^{7}Li with $E_x = 25-30$ MeV may be involved when $E_{bs} = 37$ to 50 MeV is used (1975DE37).

A number of peaks have been reported in reaction (f): see Table 7.5 in (1966LA04): see, however, (1977LE02). See also (1977JU1A). For reaction (g) see (1973KO30). (1975AH06, 1974AH03) have measured the total nuclear photon absorption cross section for *natural* Li from 10 to 210 MeV: some broad structures are observed. For pion production see (1974GO04, 1975AH06). See also (1974BU1A, 1975BR1F, 1977DA1B) and (1978OC1B; theor.).

19. (a) ^{7}Li(e, e′)^{7}Li*

(b) ^{7}Li(e, ep)^{6}He	$Q_m = -9.975$
(c) ^{7}Li(e, et)^{4}He	$Q_m = -2.467$
(d) ^{7}Li(e, eπ^+)^{7}He	$Q_m = -150.77$

The electric form factor measurements for $E_e = 100$ to 600 MeV are well accounted for by a simple harmonic oscillator shell model with a quadrupole contribution described by an undeformed p-shell: $R_{rms} = 2.39 \pm 0.03$ fm, $|Q| = 42 \pm 2.5$ mb (1967SU1A). From results obtained for $E_e = 24.14$ to 97.19 MeV, $R_{rms} = 2.35 \pm 0.10$ fm (model independent), 2.29 ± 0.04 fm (shell model) (1972BU01). A study of the ratio of the electric charge scattering from ^{6}Li and from ^{7}Li as a function of (momentum transfer)^2 yields $\langle r^2 \rangle_6^{1/2} / \langle r^2 \rangle_7^{1/2} = 1.001 \pm 0.008$. The rms radius of the ground state magnetization density distribution, $\langle r^2 \rangle_M^{1/2} = 2.98 \pm 0.05$ fm. From the ratio of transverse inelastic and elastic cross sections at $180°$, B(M1, $\uparrow$; 0.48) $= 2.50 \pm 0.12$ μ_N^2. The cross section for the longitudinal excitation of ^{7}Li*(0.48) has been found from the scattering through angles of $90°$ to $150°$, B(C2, $\uparrow$; 0.48) $= 7 \pm 4$ fm^4. The harmonic oscillator length parameter of the 1p shell is found to be $a_{1p} = 1.90 \pm 0.03$ fm (1971VA20).

The magnetic form factor has been measured for $E_e = 70$ to 200 MeV. The ratio of the magnetic octupole moment to the dipole moment $\Omega/\mu = 2.30 \pm 0.50$ fm^2 (1966RA29).

Inelastic scattering studies show peaks corresponding to ^{7}Li*(0, 0.48, 4.63, 6.68, 7.46, 11.24): see (1974AJ01) and Table 7.5. At $E_e = 700$ MeV the proton separation spectra (reaction (b)) are similar to those observed in (p, 2p) (1978NA05). See also (1973AN31, 1973KU19). For reaction (c) see (1977LE02). For pion production (reaction (d)) see (1977SH1C).

See also (1973BI1A, 1974DE1E, 1975FA1A) and (1973GA19, 1973HO1A, 1974BE10, 1974GR24, 1974KU06, 1974NA23, 1975GR26, 1975JA1B, 1976DU05, 1977KU12; theor.).

Table 7.5: Levels of ^{7}Li(e, e′)^{7}Li* [a]

E_x (MeV)	$J^\pi; T$	$\Gamma_{\gamma 0}$ (eV)	Type	$\Gamma_{\gamma 0}/\Gamma_W$	Refs.
0.48	$\frac{1}{2}^-; \frac{1}{2}$	$(2.8 \pm 1.6) \times 10^{-7}$	E2	18	(1971VA20)
		$(6.30 \pm 0.31) \times 10^{-3}$	M1	2.8	(1971VA20)
4.63 ± 0.05	$\frac{7}{2}^-; \frac{1}{2}$		E2 [c]		(1963BE26, 1963BE53, 1969HU05)
6.6 ± 0.1 [b]	$\frac{5}{2}^-; \frac{1}{2}$		E2		(1969HU05)
7.5 ± 0.08	$\frac{5}{2}^-; \frac{1}{2}$	0.6 ± 0.3	E2		(1963BE26, 1963BA19)
		0.9 ± 0.4			(1964GR1A) [d]

[a] For a summary of B(E2↑) measurements, see Table 7.6 in (1966LA04) and ^{7}Li, the "GENERAL" section.

[b] $\Gamma_{\rm c.m.} = 875^{+200}_{-100}$ keV (1969HU05).

[c] Purely longitudinal (1969HU05).

[d] From ^{7}Li(γ, n).

20. (a) ^{7}Li(n, n′)^{7}Li*
    (b) ^{7}Li(n, nt)^{4}He $\qquad Q_m = -2.467$
    (c) ^{7}Li(n, nd)^{5}He $\qquad Q_m = -9.62$

Angular distributions of neutron groups have been measured at $E_n = 1.5$ to 14 MeV [see (1966LA04, 1974AJ01)] and at $E_n = 2.3$ and 2.8 MeV (1978KN1D; n_0, n_1), 4.0 to 7.5 MeV (1976KN1D, 1976LA1C; n_{0+1}), 7 to 13 MeV (1976BI1B, 1976GL1A; n_{0+1}, n_2), 14.1 MeV (1974HY01; n_{0+1}, n_2; 1977HO31; n_{0+1}) and 14.6 MeV (1976MI1C; n_{0+1}). Reaction (b) at $E_n = 14.4$ MeV proceeds primarily via ^{7}Li*(4.63) although some involvement of ^{7}Li*(6.68) may also occur (1974AN02). See also (1976RI1A). For reaction (c) see (1978RI02) and reaction 12 in ^{6}Li. See also ^{8}Li, (1974TU1A, 1977KN1B) and (1977HO1A; theor.).

21. (a) ^{7}Li(p, p′)^{7}Li*
    (b) ^{7}Li(p, 2p)^{6}He $\qquad Q_m = -9.975$
    (c) ^{7}Li(p, pn)^{6}Li $\qquad Q_m = -7.251$
    (d) ^{7}Li(p, pd)^{5}He $\qquad Q_m = -9.62$
    (e) ^{7}Li(p, pα)^{3}H $\qquad Q_m = -2.467$
    (f) ^{7}Li(p, p2d)^{3}H $\qquad Q_m = -26.295$
    (g) ^{7}Li(p, d^{3}He)^{3}H $\qquad Q_m = -20.820$

Angular distributions of protons (reaction (a)) have been measured for $E_p = 49.8$ to 155 MeV [see (1974AJ01) – the listing in that review includes a number of unpublished references]. Inelastic proton groups have been observed corresponding to ^{7}Li*(0.48, 4.63, 6.68, 7.46) [see (1952AJ38)] as well as to states at $E_x = 5.5 \pm 0.3$ ($\Gamma \approx 0.4$ MeV) and 9.6 ± 0.2 MeV (1965HA17). The width of ^{7}Li*(6.7) is ≈ 1 MeV (1965HA17). $\tau_m(0.48) = 106 \pm 14$ fsec (1966PA11): see also Table 7.4 in (1966LA04) and (1976DO10: 73 ± 6 fsec). Analysis of the 155 MeV data yields B(E2 $\uparrow$) $= 10.5 \pm 2$, 28 ± 6 and 4.5 ± 2.3 fm^4 for ^{7}Li*(0.48, 4.63, 6.68); Γ(E2 $\downarrow$) $= 0.43$, 0.025 and 0.029 μeV (1965JA1A).

A comparison of σ_t for ^{7}Li(p, p′)^{7}Li*(0.48) and ^{7}Li(p, n)^{7}Be*(0.43) has been carried out for $E_p = 23$ to 52 MeV: the spin-flip, isospin-flip part of the effective interaction is approximately independent of energy while the pure central part appears to decrease with increasing energy (1967LO07). See also (1974JA1F, 1975LE18, 1977ST04; theor.).

For reaction (b) see (1976BH02, 1977MC1F, 1977RO1E, 1978CH1K, 1978CH1H), (1975JA1B, 1975JA1C; theor.) and ^{6}He. For reaction (c) see (1977WA05) and (1974AV02; theor.). For reactions (d, e, f) see (1975CH1B, 1974CH1J). See also (1975SA01; theor.). Reaction (e) proceeds sequentially via ^{7}Li*(4.63, 6.68) (1970JA17). At $E_p = 100$ MeV, (1977RO02) find $S_\alpha = 0.94 \pm 0.05$, using a DWIA analysis. This value is very close to that predicted by simple LS coupling shell model predictions (1977RO02). See also (1975AN1D: $E_p = 600$ MeV) and (1975RO1B, 1978DE1J). Comparison of the data of reaction (g), at $E_p = 100$ MeV, with the (p, pα) work of (1977RO02) and DWIA indicates a dominance of the quasi-free reaction process p $+ \alpha \rightarrow$ d $+$ ^{3}He. The derived S_α, in this work, is 1.09 ± 0.11 (1977CO07).

22. ^{7}Li(d, d′)^{7}Li*

Angular distributions have been reported for $E_d = 11.8$ to 28 MeV [see (1974AJ01)] and at $E_d = 1.0$ to 2.6 MeV (1974LO10: d$_0$) and 3 to 10 MeV (1976AB11; d$_0$). See also (1974CH58; theor.) and ^{9}Be.

23. ^{7}Li(^{3}He, ^{3}He)^{7}Li

Angular distributions have been measured at $E(^3$He$) = 11$ MeV (1970SC23; elastic). [Other papers quoted in (1974AJ01) have not been published.] At $E(^3$He$) = 37.5$ MeV, the three-body final states which are most strongly populated are the ^{3}He $+ \alpha +$ t and ^{3}He $+$ d $+$ ^{5}He branches. Detection of ^{3}He–t coincidences lead to a most probable momentum for the spectator α-particle of 60 MeV/c; the d–^{3}He breakup results suggest the unlikelihood of deuteron clusters in ^{7}Li (1976WA12).

24. (a) ^{7}Li(α, α')^{7}Li*
(b) ^{7}Li(α, 2α)^{3}H $\qquad Q_m = -2.467$

Angular distributions (reaction (a)) have been reported for $E_\alpha = 3.6$ to 29.4 MeV: see (1974AJ01). Reaction (b) has been studied at $E_\alpha = 25$ to 64.3 MeV: see (1974AJ01) and (1974MA49). ^{7}Li*(4.63) is strongly involved in the sequential decay. The population of ^{7}Li*(7.46) is reported by (1970LA14). See also (1975GR41, 1975VO1B) and (1974BE1J, 1974KA32, 1974KU1A, 1975MI09, 1977BE51, 1977NI1A, 1977SA22; theor.).

25. ^{7}Li(^{7}Li, ^{7}Li)^{7}Li

The elastic angular distribution has been studied for $E(^7\text{Li}) = 4.0$ to 6.5 MeV (1966PI02). See also (1978NO08).

26. ^{7}Li(^{9}Be, ^{9}Be)^{7}Li

The elastic angular distribution has been measured at $E(^7\text{Li}) = 34$ MeV (1977KE09).

27. ^{7}Li(^{10}B, ^{10}B)^{7}Li

See ^{10}B.

28. (a) ^{7}Li(^{12}C, ^{12}C)^{7}Li
(b) ^{7}Li(^{13}C, ^{13}C)^{7}Li

The elastic scattering has been studied at $E(^7\bar{\text{Li}}) = 9$ MeV (1978DR07) and $E(^7\text{Li}) = 4.5$ to 13 MeV (1976PO02), 20 MeV (1969BE90) [on ^{13}C] and at 34 [^{13}C] and 36 [^{12}C] MeV (1973SC26). The inelastic scattering angular distributions involving $^7\text{Li}^*_{0.48} + {}^{12}\text{C}_{\text{g.s.}}$ and $^7\text{Li}^*_{0.48} + {}^{12}\text{C}^*_{4.43}$ have been measured at $E(^7\text{Li}) = 36$ MeV (1973SC26). See also ^{12}C in (1975AJ02) and ^{13}C in (1976AJ04).

29. ^{7}Li(^{16}O, ^{16}O)^{7}Li

See Table 16.25 in (1977AJ02) and (1976PO02: $E(^7\text{Li}) = 9.0$ and 13.0 MeV).

30. ^{7}Li(^{20}Ne, ^{20}Ne)^{7}Li

The elastic angular distribution has been measured at $E(^7\text{Li}) = 36$ MeV (1976CO23).

31. ^{7}Be(ϵ)^{7}Li $\qquad Q_\text{m} = 0.862$

The decay proceeds to the ground and 0.48 MeV states. The branching ratio to ^{7}Li*(0.48) is (10.32 ± 0.16)% (1962TA11), (10.42 ± 0.18)% (1973PO10), (10.35 ± 0.8)% (1974GO26). The weighted mean of the half-life is 53.29 ± 0.07 d, including a recent value of 53.17 ± 0.07 d (1975LA16). See also (1974CR05). Both transitions are superallowed. $\log ft = 3.32$ and 3.55 for the decays to ^{7}Li*(0, 0.48) respectively (M.J. Martin, Nuclear Data Project, private communication).

The energy of the γ-ray is 477.593 ± 0.012 keV (1971HE20) [$E_\text{x} = 477.611 \pm 0.012$ keV]. A measurement of the bremsstrahlung spectrum to ^{7}Li*(0.48) measured in coincidence with the 478 keV γ-ray leads to a transition of energy of 388 ± 8 keV (1972PE05).

See also (1974SA1J), (1974AJ01), (1974VA1C, 1975UL1A; astrophys.) and (1974CH46, 1974KU06, 1975KR14, 1976KU07, 1977AZ02, 1978CH12, 1978SA18; theor.).

32. ^{9}Be(γ, d)^{7}Li $\qquad Q_\text{m} = -16.696$

See ^{9}Be.

33. ^{9}Be(π^-, 2n)^{7}Li $\qquad Q_\text{m} = 119.864$

The capture of stopped pions has been studied in a kinematically complete experiment by (1977BA51): ^{7}Li*(0, 0.48) are weakly populated. Two large peaks are attributed to the excitation of ^{7}Li*(7.46, 10.25) [see, however, reaction 11]. The recoil momentum distributions corresponding to these peaks are rather similar and both indicate a strong $L = 0$ component (1977BA51).

34. ^{9}Be(n, t)^{7}Li $\qquad Q_\text{m} = -10.439$

Angular distributions of the t_0 and t_1 groups are reported at $E_\text{n} = 13.99$ MeV (1974PE06). See also (1976DI13, 1977RO01) and ^{10}Be.

35. (a) ^{9}Be(p, ^{3}He)^{7}Li $\qquad Q_\text{m} = -11.202$

(b) ^{9}Be(p, pd)^{7}Li $\qquad Q_\text{m} = -16.696$

At $E_p = 43.7$ MeV angular distributions have been obtained for the ^{3}He particles corresponding to ^{7}Li*(0, 0.48, 4.63, 7.46). The 7.46 MeV state is strongly excited while the mirror state in ^{7}Be is not appreciably populated in the mirror reaction (see reaction 17 in ^{7}Be). The angular distribution indicates that the transition to ^{7}Li*(7.46) involves both $L = 0$ and 2, with a somewhat dominant $L = 0$ character (1966CE05). The $J^\pi = \frac{3}{2}^-$, $T = \frac{3}{2}$ state is located at $E_x = 11.28 \pm 0.04$ MeV, $\Gamma = 260 \pm 50$ keV (1967MC14). See also (1975HA1K) in reaction 17, ^{7}Be. For reaction (b) see ^{9}Be.

36. (a) ^{9}Be(d, α)^{7}Li $\qquad Q_m = 7.151$
(b) ^{9}Be(d, t)^{4}He^{4}He $\qquad Q_m = 4.684$

Angular distributions have been measured for $E_d = 0.4$ to 27.5 MeV [see (1966LA04, 1974AJ01)] and at $E_d = 0.20$ to 0.50 MeV (1973SZ07; α_{0+1}), 0.22 to 2.50 MeV (1974CH1L; α_0, α_1), 0.6 to 2.2 MeV (1974FR02; α_0, α_1), 0.9 to 2.5 MeV (1976BO45; α_0, α_1), 2.25 to 3.1 MeV (1977SL02; α_0, α_1) and 12.35 and 14.06 MeV (1978TA04; α_0, α_1, α_2, α_4). A study at $E_d = 11$ MeV finds $\Gamma_{c.m.} = 93 \pm 25$ and 80 ± 20 keV, respectively, for ^{7}Li*(4.63, 7.46). No evidence was observed for ^{7}Li*(5.5, 8.6, 9.7, 12.5) or for the $T = \frac{3}{2}$ state ^{7}Li*(11.25) (1966HA09). In a kinematically complete study of reaction (b) at $E_d = 26.3$ MeV, ^{7}Li*(4.6, $6.5 + 7.5$, 9.4) are strongly excited. No sharp α-decaying states of ^{7}Li are observed with $10 < E_x < 25$ MeV. Parameters for ^{7}Li*(9.7) are $E_x = 9.36 \pm 0.05$ MeV, $\Gamma = 0.8 \pm 0.2$ MeV (1973SO08). See also ^{8}Be, ^{11}B in (1980AJ01) and (1974SO1C).

37. ^{9}Be(t, ^{5}He)^{7}Li $\qquad Q_m = 0.096$

See (1976VO1A).

38. ^{9}Be(^{3}He, αp)^{7}Li $\qquad Q_m = 1.657$

See (1974AJ01).

39. (a) ^{9}Be(^{6}Li, ^{8}Be)^{7}Li $\qquad Q_m = 5.585$
(b) ^{9}Be(^{6}Li, 2α)^{7}Li $\qquad Q_m = 5.677$

Angular distributions have been studied (reaction (a)) for $E(^6\text{Li}) = 5.5$ and 6.5 MeV to ^{7}Li*(0, 0.48) (1974VO06). See ^{11}B in (1975AJ02) for reaction (b).

40. ^{10}Be(p, α)^{7}Li $\qquad Q_{\rm m} = 2.563$

See (1976EP1A; astrophysics).

41. (a) ^{10}B(n, α)^{7}Li $\qquad Q_{\rm m} = 2.790$
(b) ^{10}B(n, t)^{4}He^{4}He $\qquad Q_{\rm m} = 0.3233$

Angular distributions have been studied at $E_{\rm n} = 0.2$ to 1.25 MeV (1976SE06; α_0, α_1), 13.9 MeV (1978MO09; α_{0+1}, α_2) and 14.4 MeV (1969AN25; α_{0+1}, α_2). $\tau_{\rm m}(0.48) = 92 \pm 11$ fsec (1967CA02). See also (1974ST1C, 1974TU1A, 1975LA08, 1978ST1H), ^{11}B in (1975AJ02) and (1974HA1D, 1975MU1A, 1978BI1E, 1978DU1E; applications).

42. ^{10}B(α, ^{7}Be)^{7}Li $\qquad Q_{\rm m} = -16.202$

See reaction 20 in ^{7}Be.

43. ^{11}B(γ, α)^{7}Li $\qquad Q_{\rm m} = -8.665$

See ^{11}B in (1975AJ02).

44. ^{11}B(p, pα)^{7}Li $\qquad Q_{\rm m} = -8.665$

See (1964BA1C).

45. (a) ^{11}B(α, 2α)^{7}Li $\qquad Q_{\rm m} = -8.665$
(b) ^{11}B(α, ^{8}Be)^{7}Li $\qquad Q_{\rm m} = -8.757$

For reaction (a) see (1974AJ01). Angular distributions have been measured at $E_\alpha = 28.4$ and 29.0 MeV (1968KA24: to ^{7}Li*(0, 0.48) and ^{8}Be*(0, 2.9)) and at 65 MeV (1976WO11: ^{7}Li*(0, 4.63)). The angular distributions are quite featureless (1976WO11). At $E_\alpha = 65$ and 72.5 MeV ^{7}Li*(0, 4.64 ± 0.03) are very strongly populated while ^{7}Li*(0.48, 6.68, 7.46) are weakly excited (1976WO11, 1974WO1C, 1973WO06). See also (1974WO1D) and (1973SC1B).

46. ^{11}B(d, ^{6}Li)^{7}Li $Q_{\rm m} = -7.192$

At $E_{\rm d} = 19.5$ MeV angular distributions have been measured for the transitions to ^{6}Li(0) and ^{7}Li*(0, 0.48) (1971GU07). See also (1974AJ01).

47. ^{11}B(^{16}O, ^{20}Ne)^{7}Li $Q_{\rm m} = -3.934$

See reaction 4 in ^{20}Ne (1978AJ03).

48. ^{12}C(d, ^{7}Be)^{7}Li $Q_{\rm m} = -17.542$

At $E_{\rm d} = 39.8$ MeV, angular distributions have been measured for the transitions to ^{7}Li(0) + ^{7}Be(0), ^{7}Li*(0.48) + ^{7}Be(0), ^{7}Li(0) + ^{7}Be*(0.43), and ^{7}Li*(0.48) + ^{7}Be*(0.43). Asymmetries exceeding 20% are observed in the ratio of the cross sections to ^{7}Li(0) and ^{7}Be(0) (1971YO06). See also (1974VA1A).

49. ^{12}C(^{3}He, ^{8}B)^{7}Li $Q_{\rm m} = -22.899$

See (1971DE37). See also (1975PA11; theor.).

50. ^{12}C(^{6}Li, ^{11}C)^{7}Li $Q_{\rm m} = -11.471$

At $E(^{6}{\rm Li}) = 36$ MeV, angular distributions have been obtained for the transitions involving $^{7}{\rm Li}_{\rm g.s.} + {}^{11}{\rm C}_{\rm g.s.}$ and $^{7}{\rm Li}^{*}_{0.48} + {}^{11}{\rm C}_{\rm g.s.}$ (1973SC26).

51. ^{13}C(p, ^{7}Be)^{7}Li $Q_{\rm m} = -20.264$

At $E_{\rm p} = 45.0$ MeV an angular distribution has been measured for the transition to ^{7}Be(0) + ^{7}Li(0) (1971BR07).

52. ^{13}C(d, ^{8}Be)^{7}Li $Q_{\rm m} = -3.589$

At $E_d = 14.6$ MeV, angular distributions are reported for the transitions to ^{8}Be(0) and ^{7}Li*(0, 0.48) (1967DE03).

53. ^{13}C(^{6}Li, ^{12}C)^{7}Li $\quad Q_m = 2.304$

At $E(^6\text{Li}) = 34$ MeV angular distributions have been measured for the transitions involving $^7\text{Li}_{\text{g.s.}} + {}^{12}\text{C}_{\text{g.s.}}$, $^7\text{Li}^*_{0.48} + {}^{12}\text{C}_{\text{g.s.}}$, $^7\text{Li}_{\text{g.s.}} + {}^{12}\text{C}^*_{4.4}$, and $^7\text{Li}^*_{0.48} + {}^{12}\text{C}^*_{4.4}$ (1973SC26).

54. ^{14}N(n, 2α)^{7}Li $\quad Q_m = -8.823$

At $E_n = 14.1$ MeV, ^{7}Li*(0, 0.48) are produced with about equal probability (1971SC16). At $E_n = 18.2$ MeV, ^{7}Li*(4.63) may be involved (1976TU04, 1977TU1D).

55. ^{14}N(^{6}Li, ^{13}N)^{7}Li $\quad Q_m = -3.303$

See reaction 38 in ^{13}N (1976AJ04).

56. ^{16}O(α, ^{13}N)^{7}Li $\quad Q_m = -22.566$

See reaction 45 in ^{13}N (1976AJ04).

57. ^{16}O(^{6}Li, ^{15}O)^{7}Li $\quad Q_m = -8.413$

See reaction 30 in ^{15}O (1976AJ04).

58. (a) ^{17}O(d, ^{12}C)^{7}Li $\quad Q_m = -2.582$
(b) ^{18}O(d, ^{13}C)^{7}Li $\quad Q_m = -5.680$
(c) ^{19}F(d, ^{14}N)^{7}Li $\quad Q_m = -6.123$

At $E_d = 14.6$ to 15.0 MeV, angular distributions have been measured for the transitions to ^{12}C(0) + ^{7}Li*(0, 0.48) [reaction (a)], ^{13}C(0) + ^{7}Li*(0, 0.48) [reaction (b)] and ^{14}N(0) + ^{7}Li*(0, 0.48) [reaction (c)] (1967DE03).

59. ^{23}Na(e, e$'$)^{7}Li + ^{16}O $\quad Q_m = -19.701$

See (1978SA1F).

^{7}Be

(Figs. 9 and 10)

GENERAL: (See also (1974AJ01).)

Nuclear models: (1974KA11).

Astrophysical question: (1973BA1H, 1973IB1A, 1973SM1A, 1973TR1C, 1973WE1D, 1974KO1C, 1974PA10, 1974RA09, 1974SH1D, 1975HO1C, 1975KI14, 1975SC1H, 1976BE1C, 1976BO1E, 1976CL1A, 1976CO1B, 1976FU1B, 1976GI1C, 1976HE15, 1976PE1A, 1976RA1C, 1976SI1C, 1976VI1A, 1977AU1B, 1977BA1V, 1977BI1E, 1977GA1C, 1977HA1L, 1977KO1J, 1977MO1E, 1977SC1D, 1977SI1D, 1978ME1D).

Electromagnetic transitions: (1974KU06, 1974MU1B, 1976KU07).

Special levels: (1974IR04, 1974KA11, 1976IR1B).

Applied work: (1976WI1B).

Special reactions: (1974BA70, 1974BO08, 1974DI16, 1974HA11, 1974KA22, 1974PA10, 1974PE1C, 1974RA09, 1974RA11, 1975FU01, 1975HO12, 1975HU10, 1975RA12, 1975RA14, 1975RA21, 1975RA25, 1975RE18, 1975RU09, 1975WI1D, 1975ZE01, 1975ZE03, 1976BE1K, 1976BO08, 1976BU16, 1976CU05, 1976DI01, 1976HE15, 1976HU1D, 1976IN04, 1976LE1F, 1976MA1D, 1976MI13, 1976OS04, 1976RA1C, 1976SI1D, 1976ST11, 1977AR06, 1977AS03, 1977BI1E, 1977GO07, 1977ST34, 1977ST1G, 1977YA1B, 1978BI08, 1978CU01, 1978DI04, 1978GE1C, 1978GR1F, 1978WE1D).

Reactions involving pions and kaons: (1975GI1B, 1976EN02, 1977AL21 †, 1977SP1B, 1977WA02, 1978WA02).

Other topics: (1974DA1B, 1974IR04, 1975PN1A, 1976IR1B).

Ground state properties of ^{7}Be: (1975BE31).

Spectroscopic factors (1975HU10)

	$p_{3/2}$	$p_{1/2}$
^{7}Be$_{\mathrm{g.s.}}$	0.37	0.35
^{7}Be*(0.43)	0.95	0.00

1. ^{7}Be(ϵ)^{7}Li $\qquad Q_{\mathrm{m}} = 0.862$

The decay is complex: see ^{7}Li.

† Cross section for ^{7}Li(π^{+}, π^{0})^{7}Be to ^{7}Be*(0, 0.43) for $E_{\pi} = 90$ to 210 MeV (1977AL21).

Table 7.6: Energy levels of ^{7}Be

E_x (MeV ± keV)	$J^\pi; T$	τ or $\Gamma_{c.m.}$	Decay	Reactions
g.s.	$\frac{3}{2}^-; \frac{1}{2}$	$\tau_{1/2} = 53.29 \pm 0.07$ d	ϵ	1, 2, 4, 5, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35
0.42920 ± 0.10	$\frac{1}{2}^-; \frac{1}{2}$	$\tau_m = 192 \pm 25$ fsec	γ	2, 5, 10, 11, 12, 14, 15, 16, 17, 18, 19, 21, 24, 25, 26, 27, 29, 32, 33, 34, 35
4.57 ± 50	$\frac{7}{2}^-; \frac{1}{2}$	$\Gamma = 175 \pm 7$ keV	^{3}He, α	3, 12, 14, 15, 16, 17, 18, 21
6.73 ± 100	$\frac{5}{2}^-; \frac{1}{2}$	1.2 MeV	p, ^{3}He, α	3, 9, 10, 14, 17
7.21 ± 60	$\frac{5}{2}^-; \frac{1}{2}$	$\lesssim$ 0.5 MeV	p, ^{3}He, α	3, 6, 9, 10, 14, 17
9.27 ± 100	$\frac{7}{2}^-; \frac{1}{2}$		p, ^{3}He, α	3, 14
9.9	$\frac{3}{2}^-; \frac{1}{2}$	≈ 1.8 MeV	p, ^{3}He, α	3, 6
11.01 ± 30	$\frac{3}{2}^-; \frac{3}{2}$	320 ± 30	p, ^{3}He, α	3, 6, 14, 17
17	$\frac{1}{2}^-; \frac{1}{2}$	≈ 6.5 MeV	^{3}He	3

2. ^{4}He(^{3}He, γ)^{7}Be $\qquad Q_m = 1.586$

In the range $E_\alpha = 0.38$ to 5.80 MeV the cross section rises from 8×10^{-3} to 4 μb (1963PA12, 1969NA24). The capture proceeds mainly by E1, with both s- and d-waves contributing above $E_\alpha = 1$ MeV (1963TO06). The branching ratio γ_1/γ_0 [^{7}Be*(0.43)/^{7}Be(0)] is approximately constant at 37% for $E_\alpha = 0.57$ to 3.2 MeV (1963PA12, 1969NA24). The zero-energy intercept of the cross-section factor $S = 0.61 \pm 0.07$ keV · b and $(\mathrm{d}S/\mathrm{d}E)_0 = -(5.8 \pm 0.3) \times 10^{-4}$ b using all the data. If the low-energy data ($E_{c.m.} \leq 0.7$ MeV) is fitted using a direct capture calculation (1963TO06) the zero-energy intercept of the cross-section factor is $S = 0.51 \pm 0.05$ keV · b and $(\mathrm{d}S/\mathrm{d}E)_0 = -(2.8 \pm 0.4) \times 10^{-4}$ b (1969NA24). A second-order (in energy) polynomial fit to the low-energy data ($E_{c.m.} \leq 0.8$ MeV) determines $S = 0.61 \pm 0.07$ keV · b and $(\mathrm{d}S/\mathrm{d}E)_0 = -(5.8 \pm 0.3) \times 10^{-4}$ b (1969NA24). Recent papers discussing the astrophysical implications of this reaction are (1971BA1A, 1974VA1C, 1976NO1C).

3. (a) ^{4}He(^{3}He, ^{3}He)^{4}He $\qquad E_b = 1.586$

(b) ^{4}He(^{3}He, p)^{6}Li

Table 7.7: ^{7}Be levels [a] from ^{3}He + ^{4}He

E_x (MeV ± keV)	J^π	l_α	LS term	R (fm)	θ^2_α [b]	θ^2_p	$\theta^2_{p'}$	Refs.
4.57 ± 50	$\frac{7}{2}$	3	$^2F_{7/2}$	4.0	0.70 ± 0.04			(1967SP10)
6.73 ± 100	$\frac{5}{2}^-$	3	$^2F_{5/2}$	4.0	1.36 ± 0.13	0.000 ± 0.002		(1967SP10)
7.21 ± 60	$\frac{5}{2}^-$	3	$^4P_{5/2}$	4.0	0.010 ± 0.001	0.26 ± 0.02		(1967SP10)
9.27 ± 100	$\frac{7}{2}^-$	3	$^4D_{7/2}$	4.0	0.70 ± 0.26	$0.29^{+0.09}_{-0.18}$	1.8 ± 0.5	(1967SP10)
10.0 [c]	$\frac{3}{2}^-$	1	$(^4P_{3/2})$					(1967HA07, 1967HA08)
≈ 10.0 [d]	$\frac{1}{2}^-$		$(^4P_{1/2})$					(1967HA07, 1967HA08)
11.00 ± 50 [e]	$\frac{3}{2}^-$	1	$(^2P_{3/2}, {}^2D_{3/2})$			0.13 ± 0.02 [f]		(1967HA07, 1967HA08)

[a] Compare Table 7.10 in (1966LA04).
[b] $\gamma^2/(\frac{3}{2}\hbar^2/\mu a^2)$.
[c] $\Gamma = 1.8$ MeV.
[d] Broad.
[e] $\Gamma = 0.4 \pm 0.05$ MeV; $T = \frac{3}{2}$.
[f] $\theta^{2''}_p$.

Elastic scattering studies have been reported for $E(^3He) = 1.72$ to 140 MeV [see (1974AJ01)] and at $E_\alpha = 22.8$ to 26.4 MeV (1976ZA11) and 65.3 to 102.7 MeV (1973FE1B). The total reaction cross section at $E(^3He) = 28$ MeV is 433 ± 10 mb (1977KO09). Polarization measurements have been carried out at $E(^3He) = 7.8$ to 13 MeV and $E_\alpha = 4.3$ to 18.5 MeV [see (1974AJ01)], $E(^3He) = 18 \rightarrow 32$ MeV (1978LU05), and at $E_\alpha = 24.5$ to 42 MeV (1976BA1L; on $^3\bar{He}$), $E(^3\bar{He}) = 38.2$ MeV (1976BI1C) and at $E_\alpha = 98$ MeV (1973FE1B). For an R-matrix analysis of the $^2F_{5/2}$ state at $E_x = 6.73$ MeV, see (1976DO1B).

For $l \leq 4$, only f-wave phase shifts show resonance structure for $E(^3He) < 18$ MeV, corresponding to ^{7}Be*(4.57, 6.73, 9.27): see Table 7.7 (1967SP10). No structure corresponding to ^{7}Be*(7.21) $(J^\pi = \frac{5}{2}^-)$ is seen in the elastic data. The s-wave phase shift is somewhat greater than hard-sphere; the p-wave splitting agrees with (1964BA09, 1967SP10). The decay of ^{7}Be*(9.27) $(J^\pi = \frac{7}{2}^-)$ to ^{6}Li(0) requires f-shell configuration admixture. An estimate of the yield of ground state protons relative to those corresponding to ^{6}Li*(2.19) yields $\gamma^2(p_0)/\gamma^2(p_1) = (16^{+5}_{-10})$% (1967SP10). A phase shift analysis (single-level R-matrix) has been carried out for $E(^3He) = 18$ to 32 MeV: the p-wave phase shifts indicate a $\frac{1}{2}^-$ state at $E_x \approx 16.7$ MeV ($E_r = 26.4$ MeV), with $\Gamma = 6.5$ MeV (1978LU05). At higher energies [$E(^3He) = 27.2$ to 42.8 MeV] (1969SC16) report that the s- and f-wave phase shifts fall appreciably below the predictions of resonating group calculations, while (1970BR42) see some indication of broad resonant structure at $E(^3He) \approx 34$ MeV, in rough qualitative agreement with such calculations. The bremsstrahlung cross section at $E(^3He) = 7.4$ MeV is 12.6 ± 3.4 μb/sr^2 (1973FR17).

The differential reaction cross section for reaction (b) has been determined for $E(^3He) = 8$ to 18 MeV (1967SP10) and at 28 MeV (1977KO09: d_0, d_1, d_2): resonances are observed corresponding to ^{7}Be*(7.21, 9.27) in the p_0 yield and to ^{7}Be*(9.27) in the p_1 yield: see Table 7.7

(1967SP10). A study of the γ-rays from ^{6}Li*(3.56) (p$_2$) carried out at $E(^3\mathrm{He}) = 13.8$ to 18.5 MeV shows the excitation of two $J^\pi = \frac{3}{2}^-$ states at $E_x \approx 10.0$ MeV ($T = \frac{1}{2}$) and 11.00 ± 0.05 MeV ($\Gamma = 400 \pm 50$ keV, $\theta^2_{\mathrm{p}_2} = 0.13 \pm 0.02$, $T = \frac{3}{2}$). The $T = \frac{3}{2}$ resonance is evidenced mainly through interference. There is also some evidence for an extremely broad $J^\pi = \frac{1}{2}^-$ structure at $E_x \gtrsim 10$ MeV (1967HA07, 1967HA08: see also ^{6}Li(p, p)^{6}Li). At $E(^3\mathrm{He}) = 28$ MeV sequential breakup via ^{6}Li*(2.19) significantly contributes to the reaction mechanism (1977KO09).

See also (1975TO1A, 1978BR1E) and (1974BA40, 1974KO03, 1974TE05, 1975BA05, 1975CL1C, 1975KU09, 1975TA1A, 1977BA1N, 1977BU01, 1977SA1C, 1978LE13; theor.).

4. ^{4}He(α, n)^{7}Be $\qquad Q_\mathrm{m} = -18.992$

The production cross section for ^{7}Be has been measured for $E_\alpha = 39.4$ to 47.4 MeV: it is essentially equal to that for the (α, p) reaction above 43 MeV but is smaller below because of threshold effects. See also (1977RA1B; prelim., $E_\alpha = 400$, 600 and 1000 MeV). For a discussion of the production of ^{7}Li in the galaxy, see (1977KI12, 1975KI14) and reaction 4 in ^{7}Li. See also (1974KO1C; astrophys.) and ^{8}Be.

5. ^{6}Li(p, γ)^{7}Be $\qquad Q_\mathrm{m} = 5.606$

Gamma transitions are observed to the ground (γ_0) and to the 0.43 MeV (γ_1) states. The yield shows no evidence of resonance for $E_\mathrm{p} = 0.2$ to 1.0 MeV and the branching ratio remains approximately constant at (62 ± 5)% to the ground state, 38% to ^{7}Be*(0.43), < 4% to ^{7}Be*(4.57): see (1974AJ01).

6. (a) ^{6}Li(p, p)^{6}Li $\qquad E_\mathrm{b} = 5.606$
(b) ^{6}Li(p, 2p)^{5}He $\qquad Q_\mathrm{m} = -4.59$
(c) ^{6}Li(p, pα)^{2}H $\qquad Q_\mathrm{m} = -1.4735$

Measurements of elastic angular distributions have been reported for $E_\mathrm{p} = 0.5$ to 600 MeV: see (1966LA04, 1974AJ01) and ^{6}Li. Two resonances are reported at $E_\mathrm{p} = 1.84$ and 5 MeV in the elastic yield [^{7}Be*(7.21, 9.9)]. The parameters of the lower resonance are shown in Table 7.4 (1963MC09). The 5 MeV resonance has $\Gamma \approx 1.8$ MeV and appears to also be formed by p-waves: γ^2_p is then 3 ± 2 MeV $\cdot$ fm. A weak rise near $E_\mathrm{p} = 8$ to 9 MeV may indicate a further level, ^{7}Be* ≈ 13 MeV (1963HA53). A broad resonance at $E_\mathrm{p} = 14$ MeV is suggested by (1977NE1A). Polarization measurements have been carried out for $E_\mathrm{p} = 1.2$ to 155 MeV [see (1974AJ01)], at $E_{\bar{\mathrm{p}}} = 32$ MeV (1976MO1B: p$_1$, p$_2$). A phase shift analysis for $E_\mathrm{p} = 0.5$ to 5.6 MeV shows that only ^{2}S, ^{4}S and ^{4}P are involved. The $^4\mathrm{P}_{5/2}$ phase resonates at $E_\mathrm{p} = 1.8$ MeV, and the broad resonance at 5 MeV can be reproduced equally well by either $^4P_{3/2}$ or $^4P_{1/2}$: tensor polarization measurements are necessary to distinguish between the two (1969PE22). An R-matrix analysis of the $^2F_{5/2}$ state at $E_x = 6.73$ MeV is reported by (1976DO1B).

The reaction cross section for formation of ^{6}Li*(2.19) has been measured for $E_p = 3.6$ to 9.40 MeV: a broad resonance indicates the presence of a state with $E_x \approx 10$ MeV, $\Gamma = 1.8$ MeV, $J^\pi = (\frac{3}{2}, \frac{5}{2})^-$, $T = \frac{1}{2}$ (1967HA07, 1967HA08). The cross-section and angular distributions of p_2 (^{6}Li*(3.56)) for $E_p = 4.26$ to 9.40 MeV is analyzed in terms of two $J^\pi = \frac{3}{2}^-$ states at $E_x \approx 10$ and 11 MeV: see reaction 3 (1967HA07, 1967HA08). The total cross section for formation of ^{6}Li*(3.56) decreases slowly with energy for $E_p = 24.3$ to 46.4 MeV (1968AU06). The reaction cross section has been measured for $E_p = 25.0$ to 48 MeV by (1976SO1B).

For reaction (b) see ^{5}He and (1977NA16). For reaction (c) see ^{6}Li and the polarization measurements of (1974DU10) and (1976DU1C) at $E_p = 40$ and 19.4 MeV, respectively. See also (1977FR1F, 1978FR1D), (1977MC1C; applied) and (1975BA05, 1977BI1E, 1978MA37; theor.).

7. ^{6}Li(p, n)^{6}Be $\quad Q_m = -5.070 \quad E_b = 5.606$

The yield of neutrons increases approximately monotonically from threshold to $E_p = 14.3$ MeV (1964BA16). For polarization measurements at $E_p = 30$ and 50 MeV, see (1969RO20). See also ^{6}Be.

8. ^{6}Li(p, d)^{5}Li $\quad Q_m = -3.44 \quad E_b = 5.606$

See ^{5}Li.

9. ^{6}Li(p, α)^{3}He $\quad Q_m = 4.0201 \quad E_b = 5.606$

Over the range $E_p = 25$ to 50 keV, the cross section rises from 0.8 to 72 μb: in the formula $\sigma \approx E^{-1}e^{-B/\sqrt{E}}$, $B = 90 \pm 6$ keV$^{1/2}$ (1967FI05). Cross-section measurements for $E_p = 62$ to 188 keV show deviation from an s-wave Gamow plot above ≈ 130 keV (1966GE11). Using cross-section measurements at $E_p = 151$ and 317 keV, as well as the (1966GE11) data (1971SP05) calculate $S(0) = 3.0$ MeV · b. See also (1978EL1A: $E_p = 0.1$ to 1.0 MeV).

At higher energies the cross section exhibits a broad, low maximum near $E_p = 1$ MeV and a pronounced resonance at $E_p = 1.85$ MeV (1956MA91, 1951BA79) and (1977LI01: $\Gamma < 0.5$ MeV; $E_p = 1.0$ to 2.6 MeV). No other structure is reported up to $E_p = 5.6$ MeV: see (1974AJ01). Measurements between $E_p = 0.4$ and 3.4 MeV show that the polarizations are generally large and positive. The $E_p = 1.9$ MeV resonance appears in A_1 and A_2 (1968BR18).

Angular distributions have been reported for $E_p = 0.15$ to 16 MeV [see (1974AJ01)] and at $E_p = 0.5$ to 1.82 MeV (1974JO08), 1.0 to 2.0 MeV (1977LI01), 25.5 to 45 MeV (1974SC24) and

45 MeV (1971BR12). Angular distributions at $E_p = 8$ to 18.5 MeV have been analyzed using a finite-range multi-interaction DWBA formalism. The analysis leads to reduced widths of 0.69 for $\alpha +$d in a relative s-state, 0.04 for $\alpha +$d in a relative d-state and 0.44 for ^{3}He$+$t in a relative s-state (1973WE07). A polarization measurement is reported at $E(^6\text{Li}) = 16.8$ MeV (1976FI1B).

See (1971BR12) for a discussion of the search for excited states of ^{3}He. See also (1974VA1B), (1978PR1B; applied) and (1973LI23, 1975CL1C, 1975WI1C; theor.).

10. ^{6}Li(d, n)^{7}Be $\qquad Q_m = 3.382$

Angular distributions of the n_0 and n_1 groups have been measured at $E_d = 0.24$ to 3.5 MeV [see (1974AJ01)] and at $E_d = 0.204$ to 0.873 MeV (1977EL09) and 15.25 MeV (1975AZ02).

The n-γ correlations are isotropic, indicating $J^\pi = \frac{1}{2}^-$ for ^{7}Be*(0.43) (1956NE13). Broad maxima are observed in the ratio of low-energy to high-energy neutrons at $E_d = 4.2$ and 5.1 MeV [^{7}Be*(6.5, 7.2), $\Gamma_{\text{c.m.}} = 1.2$ and 0.5 MeV, respectively] (1957SL01). See also (1974MCZS, 1975MC02, 1977GL05) in ^{8}Be.

11. ^{6}Li(^{3}He, d)^{7}Be $\qquad Q_m = 0.113$

Angular distributions of the d_0 and d_1 groups to ^{7}Be*(0, 0.43) have been measured at $E_d = 8$, 10, 14 and 18 MeV: all the distributions show an $l = 1$ maximum at small angles. The DWBA analysis leads to a ratio of spectroscopic factors S*/S [for ^{7}Be*(0.43)/^{7}Be(0)] $= 1.55$, in fair agreement with other measurements (1968LU02).

12. ^{6}Li(α, t)^{7}Be $\qquad Q_m = -14.208$

Angular distributions of t_0, t_1 and t_2 have been reported at $E_\alpha = 40$ to 46 MeV: see (1974AJ01). [Some of the reported work is unpublished.]

13. ^{6}Li(^{6}Li, αn)^{7}Be $\qquad Q_m = 1.908$

See (1977RU06) and ^{12}C in (1980AJ01).

14. ^{7}Li(p, n)^{7}Be $\qquad Q_m = -1.644$

$E_{\rm thresh.} = 1880.59 \pm 0.08$ keV [recommended by (1970RO07)]. The excitation energy of ^{7}Be*(0.43) is 429.20 ± 0.10 keV (1972BO02); $\tau_{\rm m} = 192 \pm 25$ fsec (1966PA11). [(1976DO10) report 136 ± 10 fsec.] Angular distributions are reported at $E_{\rm p} = 1.9$ to 50 MeV [see (1974AJ01)] and at 2.1 to 3.8 MeV (1974BU16: n_0), 3.1 to 4.9 MeV (1976BR1E: n_1), 14.9 and 17.8 MeV (1974AR05: n_0, n_1 (not resolved at the lower energy)), 15.1 to 26 MeV (1976PO06: n_0, n_1), and 24.8, 35.0 and 45.0 MeV (1977SC37: n_0, n_1). (1976PO06) also report the population of ^{7}Be*(4.55, 6.51, 7.19, 10.79). See also (1977RI07: $E_{\rm p} = 800$ MeV) and (1974AJ01).

See also (1976RO10, 1977LO10), (1973RY03, 1974JA1M, 1976NE1B, 1976WA1E, 1978GO1E; applied), (1977ME1C; theor.) and ^{8}Be.

15. ^{7}Li(^{3}He, t)^{7}Be $\qquad Q_{\rm m} = -0.880$

Angular distributions have been measured at $E(^{3}{\rm He}) = 3.0$ to 4.0 MeV (1969OR01: t_0, t_1). See also (1974AJ01). The width of ^{7}Be*(4.57), $\Gamma_{\rm c.m.} = 175 \pm 7$ keV (1971PI06). See also (1974LO1B).

16. ^{7}Li(^{6}Li, ^{6}He)^{7}Be $\qquad Q_{\rm m} = -4.369$

See (1974AJ01).

17. ^{9}Be(p, t)^{7}Be $\qquad Q_{\rm m} = -12.083$

Angular distributions of tritons have been measured at $E_{\rm p} = 43.7$ MeV (1966CE05, 1965DE08, 1968BR23: ^{7}Be*(0, 0.43, 4.57, 6.51, 11.01)) and 46 MeV (1967VE01: ^{7}Be*($0 + 0.43$, 4.57, 6.51, 10.69)). The 11 MeV state has $E_{\rm x} = 11.01 \pm 0.04$ MeV (1968BR23), $\Gamma = 298 \pm 25$ keV, $J^{\pi} = \frac{3}{2}^{-}$, $T = \frac{3}{2}$ [the J^{π}; T assignments are based on the similarity of the angular distribution to that in the (p, ^{3}He) reaction to ^{7}Li*(11.13)] (1965DE08). The ratio of the cross section for formation of ^{7}Be*(0.43) to that for formation of ^{7}Li*(0.48) [in the (p, ^{3}He) mirror reaction] has been measured for $E_{\rm p} = 14.8$ to 27 MeV (1975HA1K).

18. ^{10}B(p, α)^{7}Be $\qquad Q_{\rm m} = 1.146$

Angular distributions have been measured for $E_{\rm p} = 2.8$ to 7.0 MeV (1964JE01). See also (1966YO1A), (1974AJ01) and ^{11}C in (1975AJ02).

19. ^{10}B(^{3}He, ^{6}Li)^{7}Be $\qquad Q_{\rm m} = -2.874$

At $E(^3\text{He}) = 30.0$ MeV angular distributions have been obtained for the transitions to ^{7}Be*(0, 0.43) + ^{6}Li*(0, 2.19): see (1970DE12, 1972OH01).

20. ^{10}B(α, ^{7}Li)^{7}Be $\qquad Q_\text{m} = -16.202$

At $E_\alpha = 45.6$ MeV (1969FO06) have measured the angular distributions of the ^{7}Li and of the ^{7}Be ions, corresponding to the ground state transitions. At a given angle the intensities of the two ions are the same, implying that the wave functions of the ground states of ^{7}Li and ^{7}Be are very similar (1969FO06).

21. ^{10}B(^{7}Li, ^{10}Be)^{7}Be $\qquad Q_\text{m} = -1.418$

See (1977KO27).

22. ^{11}B(d, ^{6}He)^{7}Be $\qquad Q_\text{m} = 11.560$

See (1974AJ01).

23. ^{11}B(^{3}He, ^{7}Li)^{7}Be $\qquad Q_\text{m} = -7.079$

See (1971RO1A).

24. ^{12}C(p, ^{6}Li)^{7}Be $\qquad Q_\text{m} = -22.568$

Angular distributions have been measured at $E_\text{p} = 36.0$, 40.7, 45.0, 50.0 and 56.8 MeV (1971HO25, 1971BR07; ^{7}Be*$(0 + 0.43)$) and 51.9 MeV (1976KA14; ^{7}Be*(0, 0.43)). See also (1978KU02; theor.).

25. ^{12}C(d, ^{7}Li)^{7}Be $\qquad Q_\text{m} = -17.542$

At $E_\text{d} = 39.8$ MeV angular distributions have been measured for the transitions ^{7}Li(0)+^{7}Be(0), ^{7}Li*(0.48) + ^{7}Be(0), ^{7}Li(0) + ^{7}Be*(0.43) and ^{7}Li*(0.48) + ^{7}Be*(0.43). The ratios of the ^{7}Li(0) and ^{7}Be(0) cross sections show asymmetries exceeding 20% (1971YO06). See also (1974VA1A).

26. ^{12}C(^{3}He, ^{8}Be)^{7}Be $Q_{\rm m} = -5.781$

Angular distributions have been obtained at $E(^{3}{\rm He}) = 25.5$ to 29 MeV (1976PI10: ^{7}Be*(0, 0.43)) and 28 and 30 MeV (1970DE12: ^{7}Be*(0, 0.43) + ^{8}Be*(0, 2.9)). See also (1974AJ01), (1976PA07), (1973OG1A), (1974DO03; theor.) and ^{15}O in (1976AJ04).

27. ^{12}C(α, ^{9}Be)^{7}Be $Q_{\rm m} = -24.693$

At $E_{\alpha} = 42$ MeV, angular distributions have been measured to ^{7}Be*(0, 0.43)+^{9}Be(0) (1972RU03).

28. ^{13}C(p, ^{7}Li)^{7}Be $Q_{\rm m} = -20.264$

At $E_{\rm p} = 45.0$ MeV the angular distribution has been measured for the transition to ^{7}Li(0) + ^{7}Be(0) (1971BR07).

29. ^{14}N(^{3}He, ^{10}B)^{7}Be $Q_{\rm m} = -10.027$

See (1976RO04).

30. ^{14}N(^{6}Li, ^{13}C)^{7}Be $Q_{\rm m} = -1.944$

See ^{13}C in (1976AJ04).

31. ^{16}O(p, ^{10}B)^{7}Be $Q_{\rm m} = -25.270$

See (1974AJ01).

32. ^{16}O(^{3}He, ^{12}C)^{7}Be $Q_{\rm m} = -5.576$

Angular distributions are reported at $E(^{3}{\rm He}) = 30$ MeV (1970DE12: to ^{12}C*(0, 4.4, 7.7, 9.6) + ^{7}Be*(0, 0.43)). See also (1974AJ01).

33. ^{16}O(α, ^{13}C)^{7}Be $\qquad Q_m = -21.207$

At $E_\alpha = 42$ MeV, angular distributions have been obtained for the transitions to ^{7}Be*(0, 0.43)+ ^{13}C(0) (1972RU03).

34. ^{19}F(d, ^{14}C)^{7}Be $\qquad Q_m = -7.142$

The angular distributions to ^{7}Be*$(0 + 0.43)$ + ^{14}C(0) has been measured at $E_d = 14.9$ MeV (1967DE03).

35. (a) ^{19}F(^{3}He, ^{15}N)^{7}Be $\qquad Q_m = -2.428$
(b) ^{20}Ne(^{3}He, ^{16}O)^{7}Be $\qquad Q_m = -3.145$

(1970DE12) have studied at E(^{3}He) $= 30$ MeV the angular distributions to ^{15}N(0) + ^{7}Be*(0, 0.43) and to ^{16}O*(0, $6.06 + 6.13$) + ^{7}Be*(0, 0.43).

^{7}B

(Fig. 10)

GENERAL

See also (1974DA1B, 1974IR04, 1975BE31, 1975BE56, 1976IR1B, 1977SP1B).

1. ^{10}B(^{3}He, ^{6}He)^{7}B $\qquad Q_m = -18.55$

A ^{6}He group corresponding to the unbound ground state of ^{7}B has been identified at E(^{3}He) $=$ 50 MeV: $M - A$ (^{7}B) $= 27.94 \pm 0.10$, $\Gamma = 1.4 \pm 0.2$ MeV. The isobaric quartet mass law would predict $M - A = 27.76 \pm 0.17$ MeV. ^{7}B is unbound with respect to ^{6}Be + p ($Q = 2.27$), ^{5}Li + 2p ($Q = 1.68$), ^{4}He + 3p ($Q = 3.65$). The expected single-particle width is $\Gamma = 0.64$ MeV: it is suggested that the two-proton and three-proton decays make an appreciable contribution to the width (1967MC14). See also (1974AJ01) and (1969ST02).

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