

Energy Levels of Light Nuclei $A = 10$

F. Ajzenberg-Selove

University of Pennsylvania, Philadelphia, Pennsylvania 19104-6396

Abstract: An evaluation of $A = 5-10$ was published in *Nuclear Physics A320* (1979), p. 1. This version of $A = 10$ differs from the published version in that we have corrected some errors discovered after the article went to press. Figures and introductory tables have been omitted from this manuscript. [Reference](#) key numbers have been changed to the NNDC/TUNL format.

(References closed 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).

Table of Contents for $A = 10$

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

A. Nuclides: [\$^{10}\text{n}\$](#) , [\$^{10}\text{He}\$](#) , [\$^{10}\text{Li}\$](#) , [\$^{10}\text{Be}\$](#) , [\$^{10}\text{B}\$](#) , [\$^{10}\text{C}\$](#) , [\$^{10}\text{N}\$](#) , [\$^{10}\text{O}\$](#) , [\$^{10}\text{F}\$](#) , [\$^{10}\text{Ne}\$](#)

B. Tables of Recommended Level Energies:

[Table 10.1](#): Energy levels of ^{10}Be

[Table 10.5](#): Energy levels of ^{10}B

[Table 10.22](#): Energy levels of ^{10}C

C. [References](#)

D. Figures: [\$^{10}\text{Be}\$](#) , [\$^{10}\text{B}\$](#) , [\$^{10}\text{C}\$](#) , [Isobar diagram](#)

E. Erratum to the Publication: [PS](#) or [PDF](#)

¹⁰n
(Not illustrated)

¹⁰n has not been observed in the interaction of 0.7 and 400 GeV protons with uranium: the cross section is $< 0.7 \pm 10^{-5} \mu\text{b}$ (1977TU02) at 0.7 GeV and $< 0.5 \mu\text{b}$ (1977TU1B) at 400 GeV. See also (1977DE08).

¹⁰He
(Not illustrated)

¹⁰He has not been observed: see (1974AJ01). The calculated mass excess of ¹⁰He is 53.34 MeV based on the modified form of the mass equation: ¹⁰He is then unstable with respect to breakup into ⁹He + n and ⁸He + 2n by 0.78 and 4.60 MeV (1975JE02). See also (1973VO1D, 1974TH01) and (1974IR04, 1975BE31, 1976IR1B, 1976VA29, 1978KO1H, 1978NA07; theor.).

¹⁰Li
(Fig. 22)

At $E(^9\text{Be}) = 121 \text{ MeV}$, the ground state of ¹⁰Li has been observed in the ⁹Be(⁹Be, ⁸B)¹⁰Li reaction with a differential cross section (c.m.) of $\approx 30 \text{ nb/sr}$ at $\theta = 14^\circ$ (lab): $Q_0 = -34.06 \pm 0.25 \text{ MeV}$, and the atomic mass excess of ¹⁰Li is $33.83 \pm 0.25 \text{ MeV}$. The width of the ground state is $\approx 1.2 \pm 0.3 \text{ MeV}$. ¹⁰Li_{g.s.} is unbound with respect to breakup into ⁹Li + n by $0.80 \pm 0.25 \text{ MeV}$ (1975WI26). See also (1974BA15, 1974CE1A, 1974TH01, 1975JE02), (1974IR04, 1974SE1B, 1975BE31, 1976IR1B, 1977BA11) and (1974AJ01).

¹⁰Be
(Figs. 19 and 22)

GENERAL (See also (1974AJ01).):

Shell model: (1977JA14).

Cluster and α -particle models: (1977SE1D).

Special levels: (1974IR04, 1976IR1B, 1977JA14).

Electromagnetic transitions: (1976VO1C, 1977BO1V, 1977FL05).

Astrophysical questions: (1973WE1D, 1974RA09, 1974SC1D, 1975GA1D, 1976DA1F, 1976FU1B, 1976GI1C, 1976LI1K, 1976PE1A, 1976RA1C, 1976SC1F, 1976SI1C, 1976VI1A, 1977AU1B, 1977DW1A, 1977GA1C, 1977HA1L, 1977MA1H, 1977WE1D, 1977WE1F, 1978BU1G, 1978ME1D, 1978YO1C).

Special reactions: (1974FO22, 1974LA18, 1974RA09, 1975AB1D, 1975CO1E, 1975GR13, 1975KU01, 1975RA12, 1975RA14, 1975RA21, 1975ZE01, 1976BU16, 1976LE1F, 1976MI13, 1976OS04, 1976RA1C, 1976VA29, 1977AR06, 1977FE1B, 1977GO07, 1977MO1C, 1977ST1G, 1977YA1B, 1978GE1C, 1978GR1F, 1978WE1D).

Muon capture and reactions: (1973MU1B, 1975KN1C, 1978DE15).

Pion capture and reactions: (1974MI06, 1975BA52, 1975RE01, 1976NO1D, 1977AS1D, 1977BA1Q, 1977DO06, 1978BH01, 1978PE1D).

Applied topics: (1976LI1K, 1977MU1B, 1978GU1F, 1978MU1C, 1978RA1E).

Other topics: (1974CA1H, 1974IR04, 1976IR1B).

Ground state properties: (1975BE31, 1976BE1G, 1977BA2E, 1977FL05).

1. $^{10}\text{Be}(\beta^-)^{10}\text{B}$ $Q_m = 0.5559$

The half-life of ^{10}Be is $(1.6 \pm 0.2) \times 10^6$ y; $\log ft = 13.42$: see (1974AJ01). The spectrum is of the D_2 type (1950WU1A). See also (1973TA30, 1976BE1E) and (1975SZ03; theor.).

2. (a) $^7\text{Li}(t, \gamma)^{10}\text{Be}$ $Q_m = 17.251$
 (b) $^7\text{Li}(t, n)^9\text{Be}$ $Q_m = 10.4387$ $E_b = 17.251$
 (c) $^7\text{Li}(t, p)^9\text{Li}$ $Q_m = -2.386$
 (d) $^7\text{Li}(t, d)^8\text{Li}$ $Q_m = -4.225$
 (e) $^7\text{Li}(t, \alpha)^6\text{He}$ $Q_m = 9.838$

The yield of γ_0 and γ_1 has been studied for $E_t = 0.5$ to 3.0 MeV (1973BL1B; unpublished): see (1974AJ01) and for $E_t = 0.4$ to 1.1 MeV (1978SU02) [$^{10}\text{Be}^*(17.79)$ is said to be involved]. The neutron yield exhibits a weak structure at $E_t = 0.24$ MeV and broad resonances at $E_t \approx 0.77$ MeV [$\Gamma = 160 \pm 50$ keV] and 1.74 MeV (1960SE12, 1961VA43, 1962SE1A). Studies of reaction (c) have suggested the formation of the $T = 2$ state in ^{10}Be but they have not been published: see (1974AJ01). For reaction (d) see (1974AJ01). For reaction (e) see (1975CI1B; σ for α_0 ; $E_t = 75$ to 400 keV) and (1966LA04). See also (1977SU1B). For total breakup into neutrons and α -particles see (1975JE04). See also (1975FO19; astrophys.). See also ^6He and ^9Li .

3. $^7\text{Li}(\alpha, p)^{10}\text{Be}$ $Q_m = -2.5635$

Table 10.1: Energy levels of ^{10}Be

E_x (MeV \pm keV)	$J^\pi; T$	τ or $\Gamma_{\text{c.m.}}$	Decay	Reactions
g.s.	$0^+; 1$	$\tau_{1/2} = (1.6 \pm 0.2) \times 10^6 \text{ y}$	β^-	1, 3, 4, 5, 12, 13, 15, 16, 17, 18, 19, 20, 22, 23, 24, 25, 26, 27, 29, 30
3.3680 ± 0.2	$2^+; 1$	$\tau_m = 180 \pm 17 \text{ fsec}$	γ	3, 4, 5, 12, 13, 15, 17, 18, 20, 22, 23, 25, 26, 27, 30, 31
5.9583 ± 0.3	$2^+; 1$	$\tau_m < 80 \text{ fsec}$	γ	3, 4, 5, 13, 18, 22, 26, 27, 30
5.9599 ± 0.6	$1^-; 1$		γ	3, 4, 13, 22, 27
6.1793 ± 0.7	$0^+; 1$	$\tau_m = 1.1^{+0.4}_{-0.3} \text{ psec}$	π, γ	13, 27
6.2633 ± 5	$2^-; 1$		γ	13, 27
7.371 ± 1	$3^-; 1$	$\Gamma = 15.7 \pm 0.5 \text{ keV}$	n	4, 6, 12, 13
7.542 ± 1	$2^+; 1$	6.3 ± 0.8	n	3, 6, 12, 13, 30
9.27	$(4^-); 1$	150 ± 20	n	6, 12, 13
9.4	$(2^+); 1$	291 ± 20	n	4, 6, 12, 13, 26, 30
10.57 ± 30	$\geq 1; 1$		n	3, 4, 6, 13, 24
11.76 ± 20		121 ± 10		3, 4, 12, 13, 30
17.79		110 ± 35	$\gamma, \text{ n, t}$	2, 3, 4, 20
18.55		≈ 350	n, t	2, 3, 4
(24)				24

Angular distributions have been measured at $E_\alpha = 30 \text{ MeV}$ (1960KL03, 1972ME07; p_0, p_1) and 50 MeV (1975BU27; p to $^{10}\text{Be}^*(3.4, 6.0, 7.5, 10.7, 12.0, 17.8, 18.8)$).

4. $^7\text{Li}(^7\text{Li}, \alpha)^{10}\text{Be}$ $Q_m = 14.784$

Angular distributions are reported for $E(^7\text{Li}) = 2.1$ to 5.75 MeV (1969CA1A; $\alpha_1, \alpha_{2+3+4+5}$), 3.5 to 5.75 MeV (1969CA1A; α_0) and 30.3 MeV (1971GL07; α -groups to $^{10}\text{Be}^*(0, 3.4, 6.0, 7.4, 9.4, 10.7, 11.9, 17.9)$). (1971GL07) also report an α -group corresponding to $^{10}\text{Be}^*(18.8)$. See also (1973OG1A, 1978KA1H) and ^{14}C in (1976AJ04).

5. $^9\text{Be}(\text{n}, \gamma)^{10}\text{Be}$ $Q_m = 6.8118$

Table 10.2: Neutron capture γ -rays in ^{10}Be

E_γ ^b (keV)	Transition	Intensities ^a		E_x ^b (keV)
		A	B	
6809.4 ± 0.4	capt. \rightarrow g.s.	70	65	5958.3 ± 0.3
5955.9 ± 0.5	5.96 ^d \rightarrow g.s.	2	$\lesssim 2$	
3443.3 ± 0.3	capt. \rightarrow 3.37	15	11	
3367.4 ± 0.2 ^c	3.37 \rightarrow g.s.	28	28	3368.0 ± 0.2
2589.9 ± 0.25	5.96 ^d \rightarrow 3.37	17	21	
853.5 ± 0.3	capt. \rightarrow 5.96 ^d	16	24	

A: (1961JA19).

B: (1963DR02).

^a Gamma rays per 100 captures.

^b (1966GR18).

^c Not Doppler broadened (1969WE10).

^d This is the 2^+ member of the doublet at $E_x = 5.96$ MeV: see reaction 13.

The thermal capture section is 9.2 ± 1.0 mb (1973MU14). Reported γ -ray transitions are displayed in Table 10.2. See also (1978DU1E; applications).

6. $^9\text{Be}(n, n)^9\text{Be}$

$$E_b = 6.8118$$

The cross-section data are summarized in (1976GAYV). Recent measurements of the total cross section have been carried out at $E_n = 0.002$ to 0.3 eV (1975KA1F; as a function of the temperature of the Be sample), 0.5 to 20.0 MeV (1974SC1C), 1.5 to 14 MeV (1976AU1D), 5.9 , 10.1 and 14.2 MeV (1977DR09; also σ_{el}), 20.7 to 43.9 MeV (1974BU05; several energies), 900 to 2600 MeV/ c (1973SC01) and 34 to 273 GeV/ c (1974JO13, 1975MU1B). Differential elastic cross sections have been measured for $E_n = 7$ to 15 MeV by (1976BI1B, 1976HO1B). See also ^9Be and (1974AJ01). The coherent scattering length (thermal, unbound) is 7.74 ± 0.10 fm (1973MU14).

Five resonances are reported in the total cross section at $E_n = 0.63$, 0.82 , 2.73 , (2.85) and 4.3 MeV; see Table 10.3. Polarization and differential cross sections are reported for $E_n = 0.2$ to 2 MeV by (1961LA1A, 1962EL01, 1964LA04). Analysis of these data leads to the 3^- , 2^+ assignments for $^{10}\text{Be}^*(7.37, 7.55)$ (1964LA04). Below $E_n = 0.5$ MeV the scattering cross section reflects the effect of bound 1^- and 2^- states, presumably $^{10}\text{Be}^*(5.960, 6.26)$. There is also indication of interference with s-wave background and with a broad $l = 1$, $J^\pi = 3^+$ state (1964LA04). The structure at $E_n = 2.73$ MeV is ascribed to two levels: a broad state at about 2.85 MeV with $J^\pi = 2^+$, and a narrow one, $\Gamma \approx 100$ keV, at $E_n = 2.73$ MeV with a probable assignment of

Table 10.3: Resonances in ${}^9\text{Be}(n, n){}^9\text{Be}$

E_{res} (MeV \pm keV)	${}^{10}\text{Be}^*$ (MeV)	$\Gamma_{\text{c.m.}}$ (keV)	J^π	l	R (fm)	θ^2 (%)	Refs.
0.6220 ± 0.8	7.371	15.7 ± 0.5	3^-	2	5.6	7.5	(1964LA04, 1951BO45, 1974SC1C)
0.8118 ± 0.7	7.542	6.3 ± 0.8	2^+	1	5.6	0.28	(1964LA04, 1951BO45, 1955WI25, 1974SC1C)
2.73	9.27	≈ 100	(4^-)	(2)			(1951BO45, 1966SC16, 1974SC1C)
(2.85)	9.4	≈ 400	(2^+)	(1)			(1951BO45)
4.3	10.7		≥ 1				(1961FO07, 1974SC1C)

$J^\pi = 4^-$ (1951BO45, 1966SC16). The 4^- assignment results from a study of the polarization of the n_0 group at $E_n = 2.60$ to 2.77 MeV. A rapid variation of the polarization over this interval is observed, and the data are consistent with 4^- ($l = 2$) for ${}^{10}\text{Be}^*(9.27)$ (1966SC16). A weak dip at $E_n \approx 4.3$ MeV is ascribed to a level with $J \geq 1$ (1961FO07). The analyzing power has been measured for $E_n = 1.6$ to 4.8 MeV (1975HO01). See also (1974HE1E), (1975HO1F, 1975RO1G) and (1978BY1B; theor.).

7. (a) ${}^9\text{Be}(n, n'){}^9\text{Be}^*$

$$E_b = 6.8118$$

(b) ${}^9\text{Be}(n, 2n){}^8\text{Be}$

$$Q_m = -1.6652$$

(c) ${}^9\text{Be}(n, 3n){}^7\text{Be}$

$$Q_m = -20.565$$

Data on inelastic and non-elastic cross sections are summarized by (1976GAYV); the non-elastic and the $(n, 2n)$ cross sections rise rapidly to ≈ 0.6 b (≈ 0.5 b for $(n, 2n)$) at $E_n \approx 3.5$ MeV and then stay approximately constant to $E_n = 15$ MeV. Cross sections for reaction (a) [to ${}^9\text{Be}^*(2.4)$] and (b) are also reported by (1977DR09; $E_n = 5.9, 10.1$ and 14.2 MeV) and for reactions (b) and (c) by (1976VE1A; $E_n = 14.7$ to 24.0 MeV). Inelastic and non-elastic cross sections are also reported by (1974WE11; 2.46 to 3.92 MeV), (1976BI1B, 1976HO1B; $E_n = 7$ to 15 MeV) and (1974HY01; 14.1 MeV). See also (1974AJ01, 1974CA1J, 1974KO35).

8. ${}^9\text{Be}(n, p){}^9\text{Li}$

$$Q_m = -12.825$$

$$E_b = 6.8118$$

Cross sections have been measured at $E_n = 14.1, 14.5$ and 14.9 MeV (1973AU1A, 1974AU01). See also (1974BO1E, 1976GAYV).

9. ${}^9\text{Be}(n, d){}^8\text{Li}$

$$Q_m = -14.663$$

$$E_b = 6.8118$$

The cross section for the (n, d) reaction has been measured for $E_n = 16.3$ to 18.7 MeV (1969SC05).

$$10. \text{}^9\text{Be}(n, t)^7\text{Li} \qquad Q_m = -10.439 \qquad E_b = 6.8118$$

The (n, t_1) cross section has been measured for $E_n = 13.3$ to 15.0 MeV: at the lower energy it is 7.3 ± 0.7 mb (1976DI13). At $E_n \approx 22.5$ MeV the cross section for triton production is 44 ± 12 mb (1978QA01). See also (1973BI1B, 1975BI07, 1977DR09).

$$11. \text{}^9\text{Be}(n, \alpha)^6\text{He} \qquad Q_m = -0.600 \qquad E_b = 6.8118]$$

The cross section for production of ${}^6\text{He}$ shows a smooth rise to a broad maximum of 104 ± 7 mb at 3.0 MeV, followed by a gradual decrease to 70 mb at 4.4 MeV (1957ST95). From $E_n = 3.9$ to 8.6 MeV, the cross section decreases smoothly from 100 mb to 32 mb (1961BA53). At $E_n = 14.4$ MeV, the total cross section for the α_0 transition is 11.7 ± 1.8 mb (1967PA03). Excitation functions have been measured for α_0 and α_1 for $E_n = 12.2$ to 18.0 MeV (1976SM02). See also (1974BO1E, 1974CA1J, 1976GAYV).

$$12. \text{}^9\text{Be}(p, \pi^+)^{10}\text{Be} \qquad Q_m = -133.537$$

At $E_p = 185$ MeV the π^+ spectrum shows groups corresponding to ${}^{10}\text{Be}^*(0, 3.37 \pm 0.12, 6.07 \pm 0.13, 7.39 \pm 0.13, 9.31 \pm 0.24, 11.75 \pm 0.11)$. Angular distributions have been obtained for the π^+ corresponding to these six states (1973DA09). Angular distributions are also reported at $E_p = 200$ MeV to ${}^{10}\text{Be}^*(0, 3.37)$ (1978AU07). See also reaction 3 in ${}^{10}\text{C}$.

$$13. \text{}^9\text{Be}(d, p)^{10}\text{Be} \qquad Q_m = 4.5872$$

Angular distributions of proton groups have been studied at many energies. Except at the lowest energies the stripping process appears to dominate. In addition to the earlier work [$E_d = 0.3$ to 15 MeV: see (1966LA04, 1974AJ01)] angular distributions have been measured at $E_d = 0.15$ to 2.50 MeV (1974CH1L; p_0, p_1), 0.6 to 2.7 MeV (1974FR02; p_0, p_1), 0.9 to 2.5 MeV (1974BO42, 1974BO45, 1974BO48; p_0, p_1), 0.9 to 3.1 MeV (1975ZW01; p_0, p_1 : average $S = 2.26$ and 0.18), 17.3 MeV (1974AN27; p to ${}^{10}\text{Be}^*(0, 3.37, 5.96, 6.26, 7.37, 7.54, 11.76)$; $S = 0.94, 0.17, 0.54, 0.36, 0.20$ for ${}^{10}\text{Be}^*(0, 3.37, 5.96 [2^+], 7.37, 7.54)$) and at $E_d = 15$ MeV (1976DA15). In the latter experiment $S = 2.1, 0.23$ ($j_n = \frac{3}{2}$) and 0.12 ($j_n = \frac{1}{2}$), $\leq 1.0, 0.065$ ($j_n = \frac{5}{2}$) and 0.132 ($j_n = \frac{1}{2}$), for ${}^{10}\text{Be}^*(0, 3.37, 5.96, 6.26)$ (1976DA15). The angular distributions show $l_n = 1$ transfer for ${}^{10}\text{Be}^*(0, 3.37, 5.958, 7.54)$, $l_n = 0$ transfer for ${}^{10}\text{Be}^*(5.960, 6.26)$, $l = 2$ transfer for ${}^{10}\text{Be}^*(7.37)$. ${}^{10}\text{Be}^*(6.18, 9.27, 9.4)$ are also populated, as are two states at $E_x = 10.57 \pm 0.03$ and 11.76 ± 0.02 MeV (1974AN27). ${}^{10}\text{Be}^*(9.27, 9.4, 11.76)$ have $\Gamma_{c.m.} = 150 \pm 20, 291 \pm 20$ and 121 ± 10 keV (1974AN27).

Table 10.4: Radiative transitions in ${}^9\text{Be}(d, p){}^{10}\text{Be}$ ^a

E_x (keV)	Transition	ΔJ^π	Mult.	Branch (%)	τ_m (psec)	Γ_γ (meV)
3368.0 ± 0.2 ^b	$3.37 \rightarrow \text{g.s.}$	$2^+ \rightarrow 0^+$	E2	100	0.189 ± 0.020 ^g	3.48 ± 0.37
					0.160 ± 0.030 ^h	4.11 ± 0.78
5958.3 ± 0.3 ^{b,c}	$5.96 \rightarrow 3.37$	$2^+ \rightarrow 2^+$	M1	> 90	< 0.08 ^h	
	$5.96 \rightarrow \text{g.s.}$	$2^+ \rightarrow 0^+$	E2	< 10		
5959.9 ± 0.6 ^{c,e}	$5.96 \rightarrow \text{g.s.}$	$1^- \rightarrow 0^+$	E1	83_{-6}^{+10}	$1.1_{-0.3}^{+0.4}$ ^d	0.028 ± 0.012
	$5.96 \rightarrow 3.37$	$1^- \rightarrow 2^+$	E1	17_{-10}^{+6}		
6179.3 ± 0.7 ^d	$6.18 \rightarrow 5.96$	$0^+ \rightarrow 1^-$	E1	0.24 ± 0.02 ⁱ	$1.1_{-0.3}^{+0.4}$ ^d	0.57 ± 0.17
	$6.18 \rightarrow 3.37$	$0^+ \rightarrow 2^+$	E2	0.76 ± 0.02 ⁱ		
	$6.18 \rightarrow \text{g.s.}$	$0^+ \rightarrow 0^+$	E0	0.24 ± 0.08 ^d		$(1.4 \pm 0.6) \times 10^{-3}$
6263.3 ± 5 ^d	$6.26 \rightarrow 5.96$	$2^- \rightarrow 1^-$	M1	≤ 1 ^f		
		$2^- \rightarrow 2^+$	E1			
	$6.26 \rightarrow 3.37$	$2^- \rightarrow 2^+$	E1	99_{-2}^{+1} ^f		
	$6.26 \rightarrow \text{g.s.}$	$2^- \rightarrow 0^+$	M2	1 ± 1 ^f		

^a See also Tables 10.2 and 10.5 in (1966LA04).

^b From (1966GR18): ${}^9\text{Be}(n, \gamma){}^{10}\text{Be}$.

^c From (1966GR18, 1969RO12): see (1969AL17).

^d See (1969AL17).

^e (1966WA1C) and F.C. Young, private communication.

^f (1969RO12).

^g (1968FI09).

^h (1966WA10).

ⁱ (1975WA06). See also (1969AL17).

Attempts to understand the γ -decay of $^{10}\text{Be}^*(5.96)$ and its population in $^9\text{Be}(n, \gamma)^{10}\text{Be}$ led to the discovery that it consisted of two states separated by 1.6 ± 0.5 keV. The lower of the two has $J^\pi = 2^+$ and decays primarily by a cascade transition via $^{10}\text{Be}^*(3.37)$ [it is the state fed in the $^9\text{Be}(n, \gamma)$ decay]; the higher state has $J^\pi = 1^-$ and goes mainly by a crossover to $^{10}\text{Be}_{\text{g.s.}}$. Angular correlations measured with the γ -ray detector located normal to the reaction plane (\equiv angular distributions) lead to l_n values consistent with the assignments of 2^+ and 1^- for $^{10}\text{Be}^*(5.9658, 5.9660)$ obtained from the character of the γ -decay (1969RO12). $^{10}\text{Be}^*(6.18)$ decays primarily to $^{10}\text{Be}^*(3.37)$. $E_\gamma = 219.4 \pm 0.3$ keV for the $6.18 \rightarrow 5.96$ transition (1969AL17). See Table 10.4 for a listing of the information on radiative transitions obtained in this reaction (1969AL17, 1969RO12), and lifetime measurements (1966WA10, 1968FI09, 1969AL17). For (p, γ) correlations through $^{10}\text{Be}^*(3.37)$ see (1974AJ01) and (1975HU18, 1978AL25). For polarization measurements see ^{11}B in (1975AJ02, 1980AJ01). See also (1977TE1A), (1978MC1F; applied) and (1977RI08; theor.).

$$14. \ ^9\text{Be}(t, d)^{10}\text{Be} \quad Q_m = 0.5545$$

See (1974AJ01).

$$15. \ ^9\text{Be}(^7\text{Li}, ^6\text{Li})^{10}\text{Be} \quad Q_m = -0.439$$

Angular distributions have been measured at $E(^7\text{Li}) = 34$ MeV to $^{10}\text{Be}^*(0, 3.4)$: $S = 2.07$ and 0.42 ($p_{1/2}$), 0.38 ($p_{3/2}$) (1977KE09).

$$16. \ ^9\text{Be}(^{18}\text{O}, ^{17}\text{O})^{10}\text{Be} \quad Q_m = -1.233$$

Angular distributions have been measured at $E(^{18}\text{O}) = 16$ and 20 MeV (1971KN05).

$$17. \ (a) \ ^{10}\text{Be}(p, p)^{10}\text{Be}$$

$$(b) \ ^{10}\text{Be}(d, d)^{10}\text{Be}$$

Angular distributions of the p_0 and p_1 groups have been measured at $E_p = 12.0$ to 16.0 MeV. The elastically scattered deuterons have been studied at $E_d = 12.0$ and 15.0 MeV. $B(E2)$ for the $^{10}\text{Be}^*(3.4) \xrightarrow{\gamma} ^{10}\text{Be}(0)$ transition is $23.8 e^2 \cdot \text{fm}^4$ (from a comparison of the angular distributions with DWBA predictions) (1970AU02).

$$18. {}^{10}\text{B}(\pi^-, \gamma){}^{10}\text{Be} \quad Q_m = 139.011$$

The total radiative capture branching ratio for stopped pions is $(2.27 \pm 0.22)\%$. The γ -spectrum is dominated by the transition to ${}^{10}\text{Be}^*(6.0) [J^\pi = 2^+]$ (1975BA52).

$$19. {}^{10}\text{B}(n, p){}^{10}\text{Be} \quad Q_m = 0.2265$$

See (1974AJ01).

$$20. {}^{10}\text{B}(p, p\pi^+){}^{10}\text{Be} \quad Q_m = -140.123$$

At $E_p = 895$ MeV, ${}^{10}\text{Be}^*(0, 3.4, 17.7)$ are populated (1977AS1D, 1977AS1E).

$$21. {}^{10}\text{B}(t, {}^3\text{He}){}^{10}\text{Be} \quad Q_m = -0.5373$$

Not reported.

$$22. {}^{10}\text{B}({}^7\text{Li}, {}^7\text{Be}){}^{10}\text{Be} \quad Q_m = -1.418$$

See (1977KO27).

$$23. {}^{11}\text{B}(\gamma, p){}^{10}\text{Be} \quad Q_m = -11.2287$$

Transitions to ${}^{10}\text{Be}^*(3.4)$ from upper region of the giant resonance in ${}^{11}\text{B}$ are reported to be about twice as intense as those from the lower region (1971PA10): see ${}^{11}\text{B}$ in (1975AJ02). Angular distributions of the p_0 and p_1 groups have been measured with $E_{\text{bs}} = 18.5$ MeV (1970SO03). The yield of the 3.37 MeV γ -ray has been measured for $E_{\text{bs}} = 100$ to 800 MeV (1975AD04). See also (1977BR1J).

$$24. {}^{11}\text{B}(n, d){}^{10}\text{Be} \quad Q_m = -9.0041$$

The angular distribution of the d_0 group has been measured at $E_n = 14.4$ MeV (1968MI10, 1971MI12).

25. $^{11}\text{B}(\text{p}, 2\text{p})^{10}\text{Be}$ $Q_{\text{m}} = -11.2287$

Structure is observed in the summed proton spectrum corresponding to $Q = -10.9 \pm 0.35$, -14.7 ± 0.4 , -21.1 ± 0.4 , -35 ± 1 MeV: see (1966LA04, 1966TY01) and ^{11}B in (1975AJ02).

26. $^{11}\text{B}(\text{d}, ^3\text{He})^{10}\text{Be}$ $Q_{\text{m}} = -5.7352$

Angular distributions have been measured at $E_{\text{d}} = 11.8$ and 22 MeV to $^{10}\text{Be}_{\text{g.s.}}$ [see (1974AJ01)] and at 52 MeV to $^{10}\text{Be}^*(0, 3.37, 5.96, 9.60)$: $S = 0.65, 2.03, 0.13, 1.19$ (normalized to the theoretical value for the ground state); $\pi = +$ for $^{10}\text{Be}^*(9.6)$ (1975SC41).

27. $^{11}\text{B}(\text{t}, \alpha)^{10}\text{Be}$ $Q_{\text{m}} = 8.585$

Angular distributions of α_0 and α_1 have been measured for $E_{\text{t}} = 1.0$ to 2.1 MeV (1969SI12). The γ -decay of $^{10}\text{Be}^*(6.18)$ has been studied: see Table 10.4 (1975WA06). See also (1977CI1A) and ^{14}C in (1981AJ01).

28. $^{11}\text{B}(^{12}\text{C}, ^{13}\text{N})^{10}\text{Be}$ $Q_{\text{m}} = -9.285$

See (1974AN36).

29. $^{11}\text{B}(^{14}\text{N}, ^{15}\text{O})^{10}\text{Be}$ $Q_{\text{m}} = -3.932$

Angular distributions of the ground state transitions have been measured at $E(^{14}\text{N}) = 41, 77$ and 113 MeV (1971LI11).

30. $^{12}\text{C}(^6\text{Li}, ^8\text{B})^{10}\text{Be}$ $Q_{\text{m}} = -21.442$

At $E(^6\text{Li}) = 80$ MeV, $^{10}\text{Be}^*(0, 3.37, 5.96, 7.54, (9.4), 11.8)$ are populated and the angular distribution to $^{10}\text{Be}_{\text{g.s.}}$ has been measured (1976WE09, 1977WE03, 1977WE1B). See also (1974CE1A).

31. $^{12}\text{C}(^{12}\text{C}, ^{14}\text{O})^{10}\text{Be}$ $Q_{\text{m}} = -20.616$

See (1972SC21, 1974AN36) and ^{14}O in (1976AJ04).

$$32. \text{}^{12}\text{C}(\text{}^{18}\text{O}, \text{}^{20}\text{Ne})\text{}^{10}\text{Be} \quad Q_{\text{m}} = -6.348$$

See (1974BA15, 1975CO15) and ^{20}Ne in (1978AJ03).

$$33. \text{}^{13}\text{C}(\text{n}, \alpha)\text{}^{10}\text{Be} \quad Q_{\text{m}} = -3.836$$

See (1974GO1J) and ^{14}C in (1970AJ04).

$$34. \text{}^{13}\text{C}(\text{}^{11}\text{B}, \text{}^{14}\text{N})\text{}^{10}\text{Be} \quad Q_{\text{m}} = -3.678$$

See (1974AN36).

¹⁰B
(Figs. 20 and 22)

GENERAL (See also (1974AJ01).):

Shell and deformed models: (1973BO1C, 1974BO29, 1974BO54, 1974BO1P, 1975DI04, 1977JA14).

Cluster and α -particle models: (1976GA34, 1977NA20, 1977OK1C).

Special levels: (1974BO29, 1974BO1P, 1974IR04, 1974NI1A, 1975DI04, 1976GA34, 1976IR1B, 1977BI1D, 1977JA14, 1977NA20).

Electromagnetic transitions: (1974BO29, 1974BO54, 1974BO1P, 1974HA1C, 1974MU13, 1977BO1V, 1977DO06, 1977KO1N, 1977OK1C, 1978KI08).

Astrophysical questions: (1973CO1B, 1973TI1A, 1973TR1B, 1973WE1D, 1974AU1A, 1974JA11, 1974RE1A, 1975ME1E, 1975TR1A, 1976AU1B, 1976AU1C, 1976BO1E, 1976CO1B, 1976EP1A, 1976HA1F, 1976RO12, 1976SI1C, 1976SI1D, 1976VI1A, 1977AU1B, 1977DW1A, 1977HA1L, 1977KO1L, 1977MA1H, 1977PR1D, 1977SC1D, 1977SI1D, 1977ST1J, 1977WE1D, 1978AU1C, 1978DW1A).

Special reactions: (1974BA70, 1974FO22, 1974JA11, 1974LA18, 1975KU01, 1975RA21, 1976BU16, 1976CH28, 1976HI05, 1976LE1F, 1976MI13, 1976NA11, 1976OS04, 1976RA1C, 1976RO12, 1977AR06, 1977FO04, 1977KU1D, 1977SH1D, 1977ST1J, 1977YA1B, 1978BI08, 1978FA1D, 1978GE1C, 1978WE1E, 1978ZE02).

Muon capture and reactions: (1973MU1B, 1974EN10, 1977BA1P, 1977CA1E, 1977DO06, 1977MU1A, 1978DE15).

Pion capture and reactions: (1973GO41, 1974CA1G, 1974DA27, 1974DI20, 1974HU14, 1974LE12, 1974LI15, 1974TA18, 1975BA52, 1975GI1B, 1975HU1D, 1975RO1G, 1975VE05, 1976AS1B, 1976BA1R, 1974BO1U, 1976ED1A, 1976EN02, 1976GI01, 1976LI26, 1976RO14, 1976SH01, 1977AM1B, 1977BA2H, 1977BA51, 1977BA1Q, 1977BA2G, 1977BE1W, 1977DO06, 1977HO1B, 1977MA35, 1977PI1C, 1977SM06, 1977TE1A, 1977WA02, 1978BH01, 1978KI08, 1978PE1D).

Kaon capture and reactions: (1973GO41, 1975TA1C, 1976DE1D, 1978AT01, 1978HE02).

Applied topics: (1975MU1A, 1976HU05, 1976JO1A).

Other topics: (1974IR04, 1974MU13, 1975KU01, 1976IR1B, 1976MA04, 1976MI1B).

Ground state properties: (1974AD1C, 1974BO29, 1974DE1E, 1974EN10, 1974MU13, 1974SHYR, 1975BE31, 1975EP02, 1976FU06, 1977AN21, 1977MA35, 1977NA20, 1977PA25, 1978AN07, 1978ZA1D).

Table 10.5: Energy Levels of ^{10}B ^a

E_x (MeV \pm keV)	$J^\pi; T$	τ_m or $\Gamma_{\text{c.m.}}$ (keV)	Decay	Reactions
g.s.	$3^+; 0$	stable		1, 4, 5, 7, 12, 14, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 42, 43, 44, 49, 50, 51, 53, 54, 58, 59
0.71832 ± 0.09	$1^+; 0$	$\tau_m = 1.013 \pm 0.015$ nsec $g = +0.63 \pm 0.12$	γ	1, 4, 5, 7, 12, 14, 19, 20, 21, 22, 27, 28, 30, 32, 33, 40, 42, 43, 44, 49, 50, 51, 53, 58
1.74016 ± 0.17	$0^+; 1$	< 30 fsec	γ	1, 12, 14, 19, 20, 21, 22, 27, 28, 32, 40, 42, 43, 44, 49, 50, 54
2.1543 ± 0.5	$1^+; 0$	2.30 ± 0.26 psec	γ	1, 4, 12, 14, 19, 20, 22, 27, 28, 30, 32, 33, 42, 43, 44, 49, 50, 51, 53, 58, 59
3.5871 ± 0.5	$2^+; 0$	153 ± 13 fsec	γ	1, 4, 7, 14, 19, 20, 21, 22, 27, 28, 30, 32, 33, 41, 42, 44, 49, 50, 51, 53, 58, 59
4.7740 ± 0.5	$3^+; 0$	$\Gamma = 0.014$ keV	γ, α	4, 7, 12, 19, 20, 27, 28, 30, 32, 33, 42, 44, 49, 50, 59
5.1103 ± 0.6	$2^-; 0$	1.2	γ, α	14, 19, 20, 26, 28, 44, 50
5.1639 ± 0.6	$2^+; 1$	0.002	γ, α	1, 14, 19, 20, 28, 30, 41, 44, 49
5.180 ± 10	$1^+; 0$	110 ± 10	γ, α	1, 3, 14, 19, 30, 50
5.9195 ± 0.6	$2^+; 0$	6 ± 1	γ, α	1, 3, 14, 19, 20, 28, 30, 33, 44, 49, 50
6.0250 ± 0.6	4^+	0.05 ± 0.03	γ, α	1, 3, 19, 20, 26, 27, 28, 30, 32, 33, 44, 54, 59
6.1272 ± 0.7	3^-	2.36 ± 0.03	α	3, 19, 20, 28, 30, 44, 50, 58
6.561 ± 1.9	$(4)^-$	25.1 ± 1.1	α	3, 19, 20, 27, 28, 30, 32, 33, 42, 44, 49, 50

Table 10.5: Energy Levels of ^{10}B ^a (continued)

E_x (MeV \pm keV)	$J^\pi; T$	τ_m or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
6.873 \pm 5	$1^-; 0 + 1$	120 \pm 5	γ, p, d, α	1, 14, 16, 18, 19
7.002 \pm 6	$(1, 2)^+; (0)$	100 \pm 10	p, d, α	3, 18, 19, 28, 30, 44, 50
7.430 \pm 10	$2^{(-)}; 0 + 1$	100 \pm 10	γ, p, d, α	1, 14, 18
7.467 \pm 10	1^+	65 \pm 10	p	16, 19, 44
7.477 \pm 2	$2^-; 1$	74 \pm 4	γ, p	14, 16, 19, 26, 44
7.5595 \pm 0.9	$0^+; 1$	2.65 \pm 0.18	γ, p	14, 16, 19, 44
(7.67 \pm 30)	$(1^+; 0)$	250 \pm 20	γ, p, d	14, 16, 18
7.817 \pm 20	1^-	260 \pm 30	p	16, 44
8.07	$(2^-; 0)$	800 \pm 200	p, d	18
(8.7)	$(1^+, 2^+)$	(\approx 200)	p	18
8.889 \pm 6	$3^-; 1$	84 \pm 7	γ, n, p, α	15, 18, 26
8.893 \pm 1	$2^+; 1$	40 \pm 1	γ, p, α	14, 18, 24, 26
(9.7)	$(T = 1)$	(\approx 700)	n, p	15
10.84 \pm 10	$(2^+, 3^+, 4^+)$	300 \pm 100	γ, n, p	14, 15, 26
11.52 \pm 35		500 \pm 100	(γ)	26
12.56 \pm 30	$(0^+, 1^+, 2^+)$	100 \pm 30	γ, p	14
13.49 \pm 5	$(0^+, 1^+, 2^+)$	300 \pm 50	γ, p	14, 44
14.4 \pm 100		800 \pm 200	γ, p	3, 44
(18.2 \pm 200)		(1500 \pm 300)		44
18.43	$2^-; 1$	340	$\gamma, ^3\text{He}$	7
18.8	$2^+, 1^+$	< 600	$\gamma, ^3\text{He}, \alpha$	7, 11
19.3	$2^-; 1$	190 \pm 20	$\gamma, n, ^3\text{He}, \alpha$	7, 8, 11
20.2	$1^-; 1$	350 \pm 70	$\gamma, n, t, ^3\text{He}, \alpha$	7, 8, 10, 11, 24
(21.1)			$\gamma, ^3\text{He}$	7
23.1		broad	γ, n	24

^a See also Tables 10.6 and 10.9.

$$\mu = +1.80065 \pm 0.00001 \text{ nm (1978SH1E);}$$

$$Q = +84.72 \pm 0.56 \text{ mb (1978SH1E).}$$

1. $^6\text{Li}(\alpha, \gamma)^{10}\text{B}$

$$Q_m = 4.4605$$

Table 10.6: Electromagnetic transitions in ^{10}B ^a

Initial state	$J^\pi; T$	Γ_γ (total) (eV)	Branching ratios (%) to final states at:						Γ_γ/Γ	Refs.
			g.s. 3 ⁺ ; 0	0.72 1 ⁺ ; 0	1.74 0 ⁺ ; 1	2.15 1 ⁺ ; 0	3.59 2 ⁺ ; 0	4.77 3 ⁺ ; 0		
0.72	1 ⁺ ; 0	6.5×10^{-7}	100							Table 10.9
1.74	0 ⁺ ; 1	> 0.02	< 0.2	100						Table 10.9, (1966SE03, 1969YO01)
2.15	1 ⁺ ; 0	$(2.9 \pm 0.3) \times 10^{-4}$	21.1 ± 1.6	27.3 ± 0.9	51.6 ± 1.6					Table 10.9, (1969YO01)
3.59	2 ⁺ ; 0	4.5×10^{-3}	19 ± 3	67 ± 3	< 0.3	14 ± 2				Table 10.9, (1966SE03, 1968WA15, 1969GA06, 1969YO01)
4.77	3 ⁺ ; 0	0.033 ± 0.006	0.5 ± 0.1	> 99					$(2.3 \pm 0.3) \times 10^{-3}$ ^b	Table 10.7, (1966AL06)
5.11	2 ⁻ ; 0		64 ± 7	31 ± 7	5 ± 5					Table 10.7, (1966FO05)
5.16	2 ⁺ ; 1	1.5 ± 0.4 ^f	5 ± 1	27 ± 2	< 0.5	61 ± 2	7 ± 3		0.77 ± 0.25 ^c	Table 10.7, (1966AL06, 1966FO05, 1967PA01, 1979SP01)
5.18	1 ⁺ ; 0	0.06 ± 0.03			≈ 100					Table 10.7
5.92	2 ⁺ ; 0	≤ 54	82 ± 5	18 ± 5	^d				≤ 0.009	Table 10.7, (1966FO05, 1969YO01)
6.03	4 ⁺	≤ 0.5	≈ 100						≤ 0.009	Table 10.7, (1969YO01)
6.13	3 ⁻	≤ 21							≤ 0.009	(1969YO01)
_e										

^a See also Table 10.7 in (1966LA04).

^b $\Gamma_\alpha = 14 \pm 3$ eV.

^c $\Gamma_\alpha = 0.44 \pm 0.09$ eV.

^d Other branches < 3%.

^e For γ -decay of higher ^{10}B states [see Table 10.5], refer to Tables 10.7, 10.10, 10.11 and 10.12.

^f See Table 10.7 here.

Table 10.7: Levels of ^{10}B from $^6\text{Li}(\alpha, \gamma)^{10}\text{B}$ ^a

E_{res} (keV)	E_x (MeV \pm keV)	$J^\pi; T$	Γ_{lab} (keV)	Decay to E_f	Branch (%)	$\omega\gamma$ (eV)	Γ_γ (eV)	$ M ^2$ ^g	
500 \pm 25	4.761	3 ⁺ ; 0		0	0.5 \pm 0.1		0.033 \pm 0.006 ^c		
				0.72	> 99				
1085	5.112	2 ⁻ ; 0	2 ^b	0	64 \pm 7	0.059 \pm 0.012 ^d		(1.5) ^e	
				0.72	31 \pm 7	0.028 \pm 0.008		9 \times 10 ⁻⁴ ^k	
				1.74	5 \pm 5	0.005 \pm 0.005		(1.5) ^e	
1175 ⁱ	5.166	2 ⁺ ; 1	< 0.5 ^b	0	5 \pm 1	0.020 \pm 0.004 ^g	0.076 \pm 0.02 ^g	6 \times 10 ⁻⁴ ^k	
				0.72	27 \pm 2	0.11 \pm 0.02 ^g			100 \pm 100 ^e
				1.74	< 0.5				
				2.15	61 \pm 2	0.24 \pm 0.03 ^g			
				3.58	7 \pm 3	0.03 \pm 0.03 ^g			
1210 \pm 35	5.187	1 ⁺ ; 0	340 \pm 50	1.74	\approx 100		0.06 \pm 0.03		
				2435	5.922	2 ⁺			10 \pm 1
2605	6.025	4 ⁺	< 1.5 ^b	0.72	18 \pm 5	0.07 \pm 0.02		0.1 \rightarrow 9 ^{f,j}	
				1.74		< 0.02			
				0	\approx 100	0.57 \pm 0.08		20 ^f	
4019	6873 \pm 5 ^l	1 ⁻ ; 0 + 1	200 \pm 10	0.72		< 0.02	1.2 ^m	4 \times 10 ⁻³ ^h	
				0	6 \pm 2				
				0.72	21 \pm 4				
				1.74	59 \pm 3				

Table 10.7: Levels of ^{10}B from $^6\text{Li}(\alpha, \gamma)^{10}\text{B}$ ^a (continued)

E_{res} (keV)	E_x (MeV \pm keV)	$J^\pi; T$	Γ_{lab} (keV)	Decay to E_f	Branch (%)	$\omega\gamma$ (eV)	Γ_γ (eV)	$ M ^2$ ^g
4963	7.440 ± 20 ⁿ	$2^{(-)}; 0 + 1$	150 ± 15	2.15 ⁿ	14 ± 4			

^a (1957ME27, 1961SP02, 1966AL06, 1966FO05, 1966SE02, 1975AU02, 1979SP01).

^b See (1958ME81) and $^9\text{Be}(\text{d}, \text{n})^{10}\text{B}$.

^c $\Gamma_\gamma/\Gamma = (2.3 \pm 0.3) \times 10^{-3}$, $\Gamma_\alpha = 14 \pm 3$ eV (1966AL06).

^d Absolute errors only.

^e M2.

^f E2.

^g (1979SP01).

^h M1.

ⁱ $\Gamma_\gamma = 2.9 \pm 1.1$ eV, $\Gamma_\alpha = 0.44 \pm 0.09$ eV, $\omega\gamma = 0.63 \pm 0.13$ eV; α -branch is $(13 \pm 4)\%$ (1966AL06).

^j E2/M1 = 0.01 or 10 (1957ME27).

^k E1.

^l (1975AU02); branching ratios calculated from 0° relative intensities; $\Gamma_\alpha/\Gamma_p = 1.25 \pm 0.12$.

^m Implies $\Gamma_\alpha \approx 50$ keV which is not compatible with $^6\text{Li}(\alpha, \alpha)$ results: see (1975AU02).

ⁿ (1975AU02). At 0° the branches to $^{10}\text{B}^*(0, 0.72)$ are equally strong $(50 \pm 12)\%$.

Table 10.8: ^{10}B levels from $^6\text{Li}(\alpha, \alpha)^6\text{Li}$

E_α (keV)	E_x (MeV)	Γ_{lab} (keV)	$J^\pi; T$	Refs.
1210 ± 30	5.19	175	$1^+; 0$	(1962DE10)
2440	5.93	≈ 30	$2^+; 0$	(1962DE10)
2606.0 ± 1.5	6.025	0.09 ± 0.04	4^+	(1967ME08)
2785.5 ± 1.5	6.133	3.93 ± 0.05	3^-	(1967ME08)
3498.5 ± 1.6 ^a	6.561	41.8 ± 1.9	$4^-, 2^-$	(1967ME08, 1971BA41)
4250 ± 15 ^a	7.012	183 ± 25	$(2)^+; (0)$ ^b	(1971BA41)
16000	14.1	broad		(1971BI12)

^a There is evidence of broad structure near these states (1971BA41).

^b See, however, (1973SI27) in reaction 18.

Observed resonances are displayed in Table 10.7. See also (1974AJ01), (1977BI1D) and (1976BI10; theor.).

2. (a) $^6\text{Li}(\alpha, n)^9\text{B}$ $Q_m = -3.975$ $E_b = 4.4605$
 (b) $^6\text{Li}(\alpha, p)^9\text{Be}$ $Q_m = -2.1248$
 (c) $^6\text{Li}(\alpha, d)^8\text{Be}$ $Q_m = -1.5654$

The excitation functions for neutrons [from threshold to $E_\alpha = 15.5$ MeV (1963ME08)] and for deuterons [$E_\alpha = 9.5$ to 11.4 MeV (1963BL20; d_0); 12 to 25 MeV (1974KO24, 1974LE14, 1976LE1K; d_0, d_1)] do not show resonance structure. See also ^9B , ^9Be and ^8Be .

3. $^6\text{Li}(\alpha, \alpha)^6\text{Li}$ $E_b = 4.4605$

Excitation functions of α_0 and α_1 have been reported for $E_\alpha \leq 18.0$ MeV and 9.5 to 12.5 MeV, respectively: see (1974AJ01). Reported anomalies are displayed in Table 10.8. Polarization measurements are reported at $E(^6\text{Li}) = 21.3$ and 22.8 MeV (1976EG1A, 1976KA1E). See also ^6Li , (1974AJ01, 1974LO1B) and (1975CL01, 1975CL1C, 1975RE1C, 1977BA1N; theor.).

4. $^6\text{Li}(^6\text{Li}, d)^{10}\text{B}$ $Q_m = 2.987$

Table 10.9: Lifetimes of ^{10}B states ^a

^{10}B state	τ_m	Reactions	Refs.
0.72	1.013 ± 0.015 nsec	mean of values quoted in Table 10.20	(1966LA04)
1.74	< 40 fsec	$^{11}\text{B}(^3\text{He}, \alpha)$	(1968DO01)
	< 30 fsec ^A	$^9\text{Be}(^3\text{He}, \text{d})$	(1966FI01, 1968FI09)
2.15 ^b	$2.1^{+0.8}_{-0.5}$ psec	$^{11}\text{B}(^3\text{He}, \alpha)$	(1968DO01)
	$2.7^{+0.5}_{-0.4}$ psec	$^9\text{Be}(\text{d}, \text{n}), ^9\text{Be}(^3\text{He}, \text{d}), ^{10}\text{B}(\text{p}, \text{p}')$	(1968FI09)
	2.0 ± 0.6 psec	$^9\text{Be}(\text{d}, \text{n})$	(1969AL17)
	2.15 ± 0.45 psec	$^7\text{Li}(\alpha, \text{n})$	(1970GA01)
	2.30 ± 0.26 psec	mean	
3.59	115 ± 40 fsec ^d	$^9\text{Be}(\text{d}, \text{n})$	(1966WA10)
	150 ± 15 fsec	$^9\text{Be}(\text{d}, \text{n}), ^{10}\text{B}(\text{p}, \text{p}')$	(1968FI09)
	192^{+35}_{-29} fsec	$^9\text{Be}(\text{p}, \gamma)$	(1977KI1H)
	170 ± 70 fsec	$^{11}\text{B}(^3\text{He}, \alpha)$	(1968DO01)
	153 ± 13 fsec	mean	
5.16 ^c	< 80 fsec	$^9\text{Be}(\text{d}, \text{n})$	(1966WA10)

A = adopted.

^a See also (1966LA04).

^b See also (1966FI01).

^c See also (1967PA01).

^d Based on τ_m of $^{10}\text{Be}^*(3.37) = 180$ fsec.

Angular distributions of deuteron groups have been determined at $E(^6\text{Li}) = 2.4$ to 9.0 MeV ($\text{d}_0, \text{d}_1, \text{d}_3$) and 7.35 and 9.0 MeV (d_4, d_5) (1966KI09). The d_2 group is also observed but its intensity is weak. See also (1974AJ01) and ^{12}C in (1975AJ02, 1980AJ01).

5. $^6\text{Li}(^7\text{Li}, \text{t})^{10}\text{B}$ $Q_m = 1.994$

Angular distributions of the t_0 and t_1 groups have been measured at $E(^6\text{Li}) = 3.3$ MeV (1967GA06) and $E(^7\text{Li}) = 3.78$ to 5.95 MeV (1967KI03). See also (1974AJ01) and ^{13}C in (1976AJ04).

Table 10.10: Resonances in ${}^7\text{Li} + {}^3\text{He}$ ^a

E_{res} (MeV)	$\Gamma_{\text{c.m.}}$ (keV)	E_x (MeV)	$J^\pi; T$	Γ_γ (eV) for transition to				Γ_α (keV)	Γ_n	Γ_p	Γ_t
				g.s.	0.72	3.59	4.77				
0.92	340	18.43	$2^-; 1$	≥ 3			≥ 17				
1.4	< 600	18.8	$2^+, 1^+$		≥ 20	≥ 20 ^c		res < 80			
2.1	280 ^b	19.3	$2^-; 1$	≥ 12			≥ 49	res < 20	res n_0	(p) ^d	
3.4	910 ^b	20.2	$1^-; 1$			≥ 350		res α_2	res n_0	(p)	res t_0
(4.7)		(21.1)			res						

^a See references listed in Table 10.10 (1974AJ01).

^b (1966DI04) report $\Gamma_{\text{c.m.}} = 190 \pm 20$ and 350 ± 70 keV, respectively, from the n_0 yield.

^c Assumes isotropy of angular distribution (1971LI20).

^d (1975BO55).

6. ${}^6\text{Li}({}^9\text{Be}, {}^5\text{He}){}^{10}\text{B}$ $Q_m = 1.99$

See (1974AJ01).

7. ${}^7\text{Li}({}^3\text{He}, \gamma){}^{10}\text{B}$ $Q_m = 17.788$

Capture γ -rays have been observed for $E({}^3\text{He}) = 0.8$ to 6.0 MeV. The γ_0 and γ_5 yields [to ${}^{10}\text{B}^*(0, 4.77)$] show resonances at $E({}^3\text{He}) = 1.1$ and 2.2 MeV [$E_{\text{res}} = 0.92$ and 2.1 MeV: see (1971LI20)], the γ_1 and γ_4 yields [to ${}^{10}\text{B}^*(0.72, 3.59)$] at 1.4 MeV and the γ_4 yield at 3.4 MeV: see Table 10.10. Both the 1.1 and 2.2 MeV resonances [${}^{10}\text{B}^*(18.4, 19.3)$] appear to result from s-wave capture; the subsequent decay is to two 3^+ states [${}^{10}\text{B}^*(0, 4.77)$]. Therefore the most likely assignment is 2^- , $T = 1$ for both [there appears to be no decay of these states via α_0 to ${}^6\text{Li}^*(3.56)$ which has $J^\pi = 0^+$, $T = 1$: see reaction 11] (1965PA02, 1971LI20). The assignment for ${}^{10}\text{B}^*(18.8)$ [1.4 MeV resonance] is 1^+ or 2^+ but there appears to be α_2 decay and therefore $J^\pi = 2^+$. ${}^{10}\text{B}^*(20.2)$ [3.4 MeV resonance] has an isotropic angular distribution of γ_4 and therefore $J^\pi = 0^+, 1^-, 2^-$. The γ_2 group resonates at this energy which eliminates 2^- , and 0^+ is eliminated on the basis of the strength of the transition which is too large for E2 (1971LI20).

8. ${}^7\text{Li}({}^3\text{He}, n){}^9\text{B}$ $Q_m = 9.352$ $E_b = 17.788$

The excitation curve is smooth up to $E({}^3\text{He}) = 1.8$ MeV [see (1974AJ01)] and the n_0 yield shows resonance behavior at $E({}^3\text{He}) = 2.2$ and 3.25 MeV, $\Gamma_{\text{lab}} = 270 \pm 30$ and 500 ± 100 keV. No other resonances are observed up to $E({}^3\text{He}) = 5.5$ MeV (1966DI04). See also Table 10.10.

9. ${}^7\text{Li}({}^3\text{He}, \text{p}){}^9\text{Be}$

$$Q_m = 11.2025$$

$$E_b = 17.788$$

The yield of protons has been measured for $E({}^3\text{He}) = 0.60$ to 4.8 MeV [see (1974AJ01)] and for 1.0 to 2.5 MeV (1975BO55; p_0, p_2): there is some indication of weak maxima at $1.1, 2.3$ and 3.3 MeV. Polarization measurements are reported at $E({}^3\text{He}) = 14$ MeV by (1976IR02; p_0). The evidence for a $T = 2$ state at $E_x \approx 23$ MeV has not been published: see (1974AJ01). See also (1975FO19; astrophys.).

10. (a) ${}^7\text{Li}({}^3\text{He}, \text{d}){}^8\text{Be}$

$$Q_m = 11.762$$

$$E_b = 17.788$$

(b) ${}^7\text{Li}({}^3\text{He}, \text{t}){}^7\text{Be}$

$$Q_m = -0.880$$

(c) ${}^7\text{Li}({}^3\text{He}, {}^3\text{He}){}^7\text{Li}$

Yields of deuterons have been measured for $E({}^3\text{He}) = 1.0$ to 2.5 MeV (1975BO56, 1977BO29; d_0) and yields of tritons are reported for 2.0 to 4.2 MeV (1969OR01; t_0): a broad peak is reported at $E({}^3\text{He}) \approx 3.5$ MeV (1969OR01). See also (1974AJ01, 1974LO1B), ${}^8\text{Be}$ and ${}^7\text{Be}$. For reaction (c) see ${}^7\text{Li}$.

11. ${}^7\text{Li}({}^3\text{He}, \alpha){}^6\text{Li}$

$$Q_m = 13.327$$

$$E_b = 17.788$$

Excitation functions have been measured for $E({}^3\text{He}) = 1.3$ to 18.0 MeV: see (1974AJ01). The α_0 group (at 8°) shows a broad maximum at ≈ 2 MeV, a minimum at 3 MeV, followed by a step rise which flattens off between $E({}^3\text{He}) = 4.5$ and 5.5 MeV. Integrated α_0 and α_1 yields rise monotonically to 4 MeV and then tend to decrease (1965FO07). Angular distributions give evidence of the resonances at $E({}^3\text{He}) = 1.4$ and 2.1 MeV seen in ${}^7\text{Li}({}^3\text{He}, \gamma){}^{10}\text{B}$: $J^\pi = 2^+$ or 1^- , $T = (1)$ for both [see, however, reaction 7]: Γ_α is small (1965PA03). The α_2 yield [to ${}^6\text{Li}^*(3.56)$, $J^\pi = 0^+$, $T = 1$] shows some structure at $E({}^3\text{He}) = 1.4$ MeV and a broad maximum at ≈ 3.3 MeV (1965FO07, 1969OR01): see Table 10.10. See also (1974LO1B) and ${}^6\text{Li}$.

12. ${}^7\text{Li}(\alpha, \text{n}){}^{10}\text{B}$

$$Q_m = -2.790$$

Angular distributions have been measured for the n_0 group at $E_\alpha = 4.78$ to 7.85 MeV (1972VA02) and 13.5 and 13.9 MeV (1962KJ05), and for the n_1 group [to ${}^{10}\text{B}^*(0.7)$] at $E_\alpha = 6.71$ to 7.85 MeV (1972VA02). Slow-neutron threshold measurements have been reported corresponding of the formation of ${}^{10}\text{B}^*(0, 0.72, (4.77), (6.42))$: see (1974AJ01). The γ -decay of ${}^{10}\text{B}^*(2.15)$ involves $E_\gamma = 415.1 \pm 0.5$ keV ($2.15 \rightarrow 1.74$), 1435.6 ± 1.0 keV ($2.15 \rightarrow 0.72$) and 719.1 ± 0.6 keV ($0.72 \rightarrow 0$). The excitation energies for the first three excited states are then 719.1 ± 0.6 , 1739.7 ± 1.5 and 2154.8 ± 1.2 keV (1970GA01). For τ_m measurements see Table 10.9. See also (1978LO1C).

Table 10.11: Resonances in ${}^9\text{Be}(p, \gamma){}^{10}\text{B}$ ^a

E_p (MeV \pm keV)	E_x (MeV \pm keV)	$\Gamma_{\text{c.m.}}$ (keV)	$J^\pi; T$	Γ_p/Γ	Γ_γ (eV)	Refs.
0.320	6.873 ± 5	120 ± 5	$1^-; 0 + 1$ ^b	0.30	4.8 ^d	(1956CL69, 1975AU02)
0.938 ± 10 (0.98)	7.429 (7.47)	140 ± 30	$2^{(-)}; 0 + 1$ ^b (2^+)	0.7	2.4	(1962EL06, 1964HO02, 1975AU02) (1962EL06)
0.992 ± 2	7.477	72 ± 4	$2^-; 1$	≈ 65	25.8	(1964HO02)
1.0832 ± 0.4	7.5595	2.65 ± 0.18	$0^+; 1$	1.0	8.5	(1964BO13, 1964HO02, 1972HA63)
1.29	7.75	210 ± 60	$2^-; (1)$ ^c	≈ 0.65	8.5	(1964HO02)
2.567 ± 2	8.894	36 ± 2	$2^+; 1$			(1953MA1A ^e , 1956MA55)
4.72	10.83	≈ 500	$2^+, 3^+, 4^+$			(1952HA10, 1970FI1B) ^e
6.7	12.6	< 200	$0^+, 1^+, 2^+$			(1970FI1B) ^e
(7.0)	(12.9)	(≈ 100)	($\pi = +$)			(1970FI1B) ^e
7.5	13.3	≈ 300	$0^+, 1^+, 2^+$			(1970FI1B) ^e
8.4	14.1	≈ 250	$0^+, 1^+, 2^+$			(1970FI1B) ^e
8.9	14.6	≈ 150	$2^+, 3^+, 4^+$			(1970FI1B) ^e
10.0	15.6	≈ 400	$2^+, 3^+, 4^+$			(1970FI1B) ^e
14.6	19.7	≈ 500	$2^-, 3^-, 4^-$			(1970FI1B) ^e

^a See Table 10.12 for decay schemes.

^b See also (1969RO12).

^c See, however, (1973RO24) in reaction 16.

^d See, however, footnote ^m in Table 10.7.

^e Unpublished Ph.D. thesis.

$$13. {}^7\text{Be}(t, np){}^4\text{He}{}^4\text{He} \quad Q_m = 10.510$$

See (1975FO19; astrophysics).

$$14. {}^9\text{Be}(p, \gamma){}^{10}\text{B} \quad Q_m = 6.5853$$

Parameters of observed resonances are listed in Tables 10.11 and 10.12. Table 10.6 summarizes the γ -transitions from this and other reactions.

The $E_p = 0.32$ MeV resonance (${}^{10}\text{B}^* = 6.87$ MeV) is ascribed to s-wave protons because of its comparatively large proton width [see ${}^9\text{Be}(p, p)$] and because of the isotropy of the γ -radiation. The strong transition to ${}^{10}\text{B}^*(1.74)$ requires E1 and hence $J^\pi = 1^-$, $T = 0$. $T = 0$ is also indicated by the large deuteron width. On the other hand, the strength of E1 transitions to ${}^{10}\text{B}^*(0.7, 2.1)$ indicates $T = 1$. The amplitudes for the $T = 0$ and $T = 1$ parts of the wave function for ${}^{10}\text{B}^*(6.87)$ are 0.92 and 0.39, respectively (1972RE07). See also (1975AU02).

Table 10.12: Radiative transitions in ${}^9\text{Be}(p, \gamma){}^{10}\text{B}$

Initial state (MeV)	$\Gamma_\gamma(\text{tot})$ (eV)	Relative intensities to final states									Refs.
		ground 3 ⁺ ; 0	0.72 1 ⁺ ; 0	1.74 0 ⁺ ; 1	2.15 1 ⁺ ; 0	3.59 2 ⁺ ; 0	5.11 2 ⁻ ; 0	5.16 2 ⁺ ; 1	5.18 1 ⁺ ; 0	5.92 2 ⁺ ; 1	
6.87 $E_p = 0.32$ 1 ⁻ ; 0 + 1	4.8 ^b	< 0.05 < 0.7	0.35 ± 0.04 0.20 ± 0.02 1.0 6.4	0.48 ± 0.04 0.53 ± 0.02 2.6 15	0.11 ± 0.04 0.13 ± 0.01 0.5 4.5	< 0.01 ≈ 1	0.04 ± 0.01	0.03 ± 0.01	< 0.01 0.65 < 2.9	0.035 ± 0.01	(1972RE07) (1975AU02) (1956CL69) (1959ME1A) (1972RE07)
7.43 $E_p = 0.94$ 2 ⁽⁻⁾ ; 0 + 1	[2.4]	< 2	1.3 0.013	[< 0.14]	0.62 0.013	0.5 0.03			[< 1]		(1964HO02) (1964HO02)
7.48 $E_p = 0.99$ 2 ⁻ ; 1	[25.8]	400 25 0.19	< 10 0.3 0.003	19 [< 0.14]	22 0.49 0.10	< 7 0			< 13 [< 1]		(1959ME1A) (1964HO02) (1964HO02)
7.56 $E_p = 1.08$ 0 ⁺ ; 1	6.6 [8.5]	< 3 < 0.2	100 100 6.7 1.0	< 8 < 2 < 0.3	< 8 10 0.8 0.24	< 4 < 0.2			23 40 1.0 3.5		(1959ME1A) (1962ME1A) (1964HO02) (1964HO02)
7.75 ^a $E_p = 1.29$ 2 ⁻ ; 1	14.6 [8.5]	83 6.6 0.044	0.9 0.008	< 0.08	0.3 0.006	0.3 0.013			0.4 0.08		(1963FU11) (1964HO02) (1964HO02)

^a See, however, Table 10.14.^b See, however, Table 10.7, footnote ^m.

The proton capture data near $E_p = 1$ MeV appears to require at least five resonant states, at $E_p = 938, 980, 992, 1083$ and 1290 keV. The narrow $E_p = 1083$ keV level ($^{10}\text{B}^* = 7.56$ MeV) is formed by p-wave protons, $J^\pi = 0^+$ [see $^9\text{Be}(p, p), ^9\text{Be}(p, \alpha)$]. The isotropy of the γ -rays supports this assignment (1961TA02). The strong M1 transitions to $J^\pi = 1^+, T = 0$ levels at $0.72, 2.15$ and 5.18 MeV (Table 10.12) indicate $T = 1$ (1959WA16). The width of $^{10}\text{B}^*(5.18)$ observed in the decay is 100 ± 10 keV (1975AU02).

The excitation function for ground-state radiation shows resonance at $E_p = 992$ ($\Gamma = 80$ keV) and 1290 keV ($\Gamma = 230$ keV) (1962EL06, 1964HO02). Elastic scattering studies indicate s-wave formation and $J^\pi = 2^-$ for both (1956MO90). For the lower level ($E_x = 7.48$ MeV) the intensity of the g.s. capture radiation, $\Gamma_\gamma = 25$ eV (1964HO02) indicates E1 and $T = 1$. The angular distribution of γ -rays, $1 + 0.1 \sin^2 \theta$, is consistent with s-wave formation with some d-wave admixture (1953PA22) or with some contribution from a nearby p-wave resonance (1956MO90); possibly a $J^\pi = 2^+$ level at $E_p = 980$ keV (1956MO90, 1962EL06: see, however, (1964HO02)).

The angular distribution of ground-state radiation at $E_p = 1330$ keV is isotropic and $\Gamma_\gamma = 8.5$ eV (1964HO02), supporting E1, $T = 1$ for this level ($E_x = 7.75$ MeV). See, however, (1973RO24): reaction 15.

Transitions to $^{10}\text{B}^*(0.7)$ [γ_1] show resonance at $E_p = 992, 1290$ and 938 keV, $\Gamma = 155$ keV (1962EL06, 1964HO02). The latter is presumably also a resonance for (p, d) and (p, α). An assignment of $J^\pi = 2^-, T = 0$ is consistent with the data, although the E1 radiation then seems somewhat too strong for a $\Delta T = 0$ transition (1964HO02). See also (1973RO24) in reaction 15 and (1975AU02).

A resonance for capture radiation at $E_p = 2.567 \pm 0.003$ ($E_x = 8.894$ MeV) has a width of 40 ± 2 keV and decays mainly via $^{10}\text{B}^*(0.7)$ (1953MA1A): unpublished Ph.D. Thesis). It appears from the width that this resonance corresponds to that observed in $^9\text{Be}(p, \alpha)$, $J^\pi = 2^+, T = 1$ and not to the $^9\text{Be}(p, n)$ resonance at the same energy (1956MA55). A further resonance is reported at $E_p = 4.72 \pm 0.01$ MeV, $\Gamma \approx 0.5$ MeV (1952HA10).

In the range $E_p = 4$ to 18 MeV, the γ_0 yield at 90° shows the resonance at $E_p = 4.7$ MeV ($E_x = 10.7$ MeV) and shows fluctuations suggesting states at $E_x \approx 14.6, 15.6$ and 19.7 MeV. It is suggested that $^{10}\text{B}^*(19.7)$ decays via E1 and therefore $J^\pi = 2^-, 3^-, 4^-$. The other three states presumably decay by M1 and therefore $J^\pi = 2^+, 3^+, 4^+$. These fluctuations appear on a nearly constant γ_0 yield with a 90° differential cross section $\approx 1.5 \mu\text{b}/\text{sr}$. The average of γ_1 is $\approx \frac{2}{3}$ of the γ_0 yield. The broad giant resonance peak is centered at $E_x \approx 14.5$ MeV. Fluctuations in the γ_1 yield are reported at $E_x \approx 12.6, 13.3$ and 14.1 MeV. These states presumably decay by M1 to $^{10}\text{B}^*(0.7)$ [$J_f^\pi = 1^+$] and therefore $J_i^\pi = 0^+, 1^+, 2^+$. The weak γ_2 yield (to $^{10}\text{B}^*(1.74)$ [$J^\pi = 0^+; T = 1$]) seems to exhibit a broad peak centered near $E_x = 15$ MeV (maximum 90° differential cross section $\approx 0.5 \mu\text{b}/\text{sr}$) and possibly some structure near $E_x = 20$ MeV. The γ_3 yield (to $^{10}\text{B}^*(2.15)$ [$J^\pi = 1^+$]) increases to $\approx 0.4 \mu\text{b}/\text{sr}$ at $E_x \approx 16$ MeV and seems to remain constant beyond that energy, with some suggestion of a fluctuation corresponding to $E_x \approx 12.9$ MeV. $^{10}\text{B}^*(12.9)$ appears to have positive parity. Angular distributions of $\gamma_0, \gamma_1, \gamma_2$ and γ_3 are also reported (1970FI1B); unpublished Ph.D. thesis).

The magnetic moment of $^{10}\text{B}^*(0.72)$ has been studied via $\gamma - \gamma$ correlations from $^{10}\text{B}^*(7.56)$: $g = +0.63 \pm 0.12$ (1972AV01). For measurements of the mean life of $^{10}\text{B}^*(0.72)$, see Table 10.9.

See also (1966YO1A, 1973SZ07, 1974SO1D).

$$\begin{array}{lll}
 15. \text{ (a) } {}^9\text{Be}(p, n){}^9\text{B} & Q_m = -1.850 & E_b = 6.5853 \\
 \text{ (b) } {}^9\text{Be}(p, 2n){}^8\text{B} & Q_m = -20.428 &
 \end{array}$$

Resonances in the neutron yield occur at $E_p = 2562 \pm 6, 4720 \pm 10$ and, possibly, at 3500 keV with $\Gamma_{\text{c.m.}} = 84 \pm 7, \approx 500$ and ≈ 700 keV. These three resonances correspond to ${}^{10}\text{B}^*(8.889, 10.84, 9.7)$: see Table 10.13 in (1974AJ01).

The $E_p = 2.56$ MeV resonance is considerably broader than that observed at the same energy in ${}^9\text{Be}(p, \alpha)$ and ${}^9\text{Be}(p, \gamma)$ and the two resonances are believed to be distinct (1956MA55). The shape of the resonance and the magnitude of the cross section can be accounted for with $J^\pi = 3^-$ or 3^+ ; the former assignment is in better accord with ${}^{10}\text{Be}^*(7.37)$. For $J^\pi = 3^-$, $\theta_n^2 = 0.135$, $\theta_p^2 = 0.115$ ($R = 4.47$ fm). The $J^\pi = 2^+$ level should contribute about 10% to the cross section at $E_p = 2.56$ MeV (1962AL1A).

Polarization measurements have been carried out for $E_p = 2.4$ to 2.9 MeV by (1976RO05) who find that it is unlikely that both states at $E_x = 8.89$ MeV have even parity. (1976BY1A, 1976LI1J, 1977BY1A; abstracts) have compared the polarization and the analyzing power for $E_p = 3$ to 10 MeV. (1976CR1B; abstract) report measuring an excitation function for $E_p = 3.6$ to 5.6 MeV as well as the angular distribution of the analyzing power at the 4.72 MeV resonance. The polarization transfer coefficient has been studied for $E_p = 3.9$ to 15.1 MeV by (1976LI08): negative values of $K_y'(0)$ are reported near $E_p = 7$ MeV in a region where several states are known to exist in ${}^{10}\text{B}$; a spin-flip mechanism may also be involved.

Differential cross sections have been measured at 0° at $E_p = 14.7$ and 19.7 MeV (1975MC18) and 29.4, 39.2 and 50.6 MeV (1976RO10). See also (1973AT01, 1975SE1G, 1977LO10), (1976AR1F, 1976NO1E, 1976WA1B, 1976WA1C) and ${}^9\text{B}$. The ${}^8\text{B}$ yield (reaction (b)) has been measured for $E_p = 22.0$ to 47.5 MeV (1974DA18). See also (1978BY1B, 1978DE37; theor.).

$$\begin{array}{lll}
 16. \text{ (a) } {}^9\text{Be}(p, p){}^9\text{Be} & & E_b = 6.5853 \\
 \text{ (b) } {}^9\text{Be}(p, pn){}^8\text{Be} & Q_m = -1.6652 &
 \end{array}$$

The elastic scattering has been studied for $E_p = 0.2$ to 2.7 MeV [see (1974AJ01)] and at 1.95 to 2.8 MeV (1973MA59), 2.3 to 2.7 MeV (1977KI04), 4.0 to 6.0 MeV (1974YA05, 1974YA1C; also p_1, p_2) and 6.3 to 9.5 MeV (1974WI21; also p_2). Below $E_p = 0.7$ MeV only s-waves are present exhibiting resonance at $E_p = 330$ keV [${}^{10}\text{B}^*(6.88)$], $J^\pi = 1^-$. Between $E_p = 0.8$ to 1.6 MeV polarization and cross-section measurements are well fitted by a phase-shift analysis, using only the ${}^3S_1, {}^5S_2, {}^5P_1$ and 5P_2 phases. Four levels satisfy the data, 1^+ and 2^- states at $E_x = 7.48$ MeV, a sharp 0^+ state at $E_x = 7.56$ MeV, and a 1^- state at 7.82 MeV: see Table 10.13 (1956MO90, 1973RO24).

Table 10.13: Resonances in ${}^9\text{Be}(p, p){}^9\text{Be}$

E_{res} (keV)	E_x (MeV)	$\Gamma_{\text{c.m.}}$ (keV)	J^π	Γ_p/Γ	Refs.
330	6.88	145	1^-	0.30	(1956MO90, 1969MO29)
980 ± 10	7.467	65 ± 10	1^+ ^a	1.0	(1956MO90, 1969MO29, 1973RO24)
980 ± 10 ^a	7.467	80 ± 8	2^-	0.90 ± 0.05	(1956DE33, 1956MO90, 1969MO29, 1973RO24)
1084 ± 2	7.560	2.7	0^+	1.0	(1956MO90, 1969MO29)
(1200 ± 30)	(7.66)	250 ± 20	(1^+)	0.30 ± 0.10	(1969MO29)
1370 ± 20	7.817	265 ± 30	1^- ^a	0.90 ± 0.05	(1956MO90, 1969MO29, 1973RO24)
(2070 ± 10)	(8.4)	70 ± 10	$(1^-, 2^-)$	0.43	(1976MA64)
(2300)	(8.65)	≈ 300	$(1^+, 2^+)$		(1973MA59, 1973RO24) ^c
(2480)	(8.82)		$(3^-, 1)$		(1970AN1B, 1973MA59)
2560	8.89		$\geq 2; (1)$ ^e	large	(1956DE33, 1970AN1B, 1973MA59, 1977KI04)
(4600) ^b	(10.7)				(1972YA06, 1974YA05, 1974YA1C)
(5100)	(11.2)				(1972YA06, 1974YA05, 1974YA1C)
6700 ^d	12.6	broad			(1972VO17, 1973VO02, 1974WI21)

^a See, however, (1969MO29). (1969MO29) also suggest states $E_x = 7.44$ and 8.1 MeV with $J^\pi = 1^-$ and 2^+ and $\Gamma_{\text{c.m.}} = 130 \pm 10$ and ≈ 80 keV: see discussion in (1973RO24).

^b (1974YA05, 1974YA1C) suggest resonances at $E_p = 4.5$ MeV ($\Gamma = 1$ MeV; p_0), 4.5 MeV ($\Gamma = 0.2$ MeV; $T = 0$; p_0), 4.7 MeV ($\Gamma = 0.3$ MeV; 2^+ ; $T = 1$; p_0, p_2) and 5.1 MeV ($\Gamma = 0.3$ MeV; p_1). See also Table 10.14.

^c (1973MA59) suggest anomalies in the p_0 excitation function at $E_p = 2.350, 2.430, 2.545, 2.560, 2.610$ and 2.720 MeV.

^d Weak resonance near $E_p = 6.5$ MeV in p_0 (1974WI21).

^e Resonance shape shows $l_p = 2$ formation with a large Γ_p/Γ : the contribution from the 2^+ state appears small (1977KI04).

Pronounced minima at $E_p = 2.48$ and 2.55 are observed in the polarization (p_0): these are ascribed to $T = 1$ analogs of the 3^- and 2^+ states ${}^{10}\text{Be}^*(7.37, 7.52)$ (1970AN1B). A strong anomaly is observed at $E_p = 6.7$ MeV: see Table 10.13. (1973VO02) find that the p_0 differential cross sections and polarization analyzing power are adequately described by a spherical optical model potential for $E_p = 13$ to 30 MeV: only the volume real potential depth V_R and the surface imaginary potential depth W_S need vary with energy. When coupled-channels analyses were made (1973VO02) found that a quadrupole-deformed optical model potential with a deformation $\beta = 1.1$ gives an improved description of the (p, p_0) data and good fits to data obtained for (p, p_2).

Polarization measurements have been reported at $E_p = 0.9$ to 49.8 MeV, at 138.2 and 145 MeV, and at 990 MeV: see (1974AJ01). Recent measurements have been carried out at $E_p = 2.0$ to 2.8 MeV (1973MA59, 1976MA64) and 5.8 MeV (1974VA03) and at $E_{\bar{p}} = 32$ MeV (1976MO1B). The angular distributions of the depolarization parameter, D , have been studied at $E_{\bar{p}} = 17$ and 25 MeV (1974BI14, 1976BA1Q, 1976BL1B). See also (1970BE1B). Total reaction cross sections are reported at $E_p = 20.1$ to 46.2 MeV (1974MC19, 1975SL02). For earlier measurements

Table 10.14: Resonances in ${}^9\text{Be}(p, d){}^8\text{Be}$ and ${}^9\text{Be}(p, \alpha){}^6\text{Li}$

E_p (MeV)	E_x (MeV)	$\Gamma_{\text{c.m.}}$ (keV)	$J^\pi; T$	Γ_p/Γ	θ_p^2	θ_d^2	θ_α^2	Refs.
0.34	6.89		$1^-; 0$	0.30	0.34	0.15	0.055	(1956MO90, 1973SI27)
0.46	7.00		$1^+(2^+, 3^+)^b$		0.3	0.3	0.1	(1949TH05, 1951NE03, 1973SI27)
(0.68)	(7.20)							(1949TH05, 1951NE03)
0.94	7.43	140	$(2^-; 0)$	0.7	0.04	0.02		(1956WE37, 1964HO02)
1.15	7.62	225 ± 50	$(1^+; 0)$	≈ 0.4	≈ 0.1			(1956WE37, 1964HO02)
1.65	8.07	800 ± 200	$(2^-; 0)$	≈ 0.07	0.18	0.21		(1956WE37, 1964HO02)
(2.3)	(8.7)	(≈ 220)						(1956WE37, 1965MO1K)
2.56 ^c	8.89	36 ± 2	$2^+; 1$				a	(1956WE37, 1973MA59, 1977KI04)
3.5	9.7		; 1				a	(1959MA20)
4.49 ^d	10.62		; 1				a	(1959MA20)

^a Resonance for α_2 to ${}^6\text{Li}^*(3.56)$, $J^\pi = 0^+$, $T = 1$.

^b See, however, (1971BA41) in reaction 3.

^c (1977KI04) have analyzed the $(\alpha_2\gamma)$ and p_0 yields with an R -matrix formalism and find the following parameters:

$$\begin{array}{cc}
 2.566 \pm 0.001 & 2^+ \\
 2.561_{-2}^{+10} & 3^-
 \end{array}
 \Gamma_{\text{c.m.}} = \begin{cases} 40 \pm 1 \text{ keV}, \\ 100 \pm 20 \text{ keV}. \end{cases}$$

^d (1974YA1C) suggest a $T = 0$ resonance in the α_0 yield at $E_p = 4.5$ MeV ($\Gamma = 0.2$ MeV), a $(2^+; T = 1)$ state at 10.8 MeV ($E_p = 4.7$ MeV) seen in the α_2 and possibly in the α_1 channels ($\Gamma = 0.3$ MeV), and a state of mixed isospin at 11.5 MeV ($E_p = 5.5$ MeV, $\Gamma = 0.5$ MeV) seen in the α_1 and α_2 channels.

see (1974AJ01). For reaction (b) see ${}^8\text{Be}$. For spallation studies see (1976KO03, 1977AV01). See also (1973GO41, 1974GU23, 1975CA1L, 1975SE1G, 1978FR1D), (1974LO1B, 1976SH1J), (1974GU24, 1974GU13, 1975BA05, 1975BL10, 1975MA1H, 1976MA58, 1976RA1F, 1977KO1M, 1978BY1B, 1978FA04; theor.) and ${}^9\text{Be}$.

$$\begin{array}{lll}
 17. (a) {}^9\text{Be}(p, t){}^7\text{Be} & Q_m = -12.083 & E_b = 6.5853 \\
 (b) {}^9\text{Be}(p, {}^3\text{He}){}^7\text{Li} & Q_m = -11.202 &
 \end{array}$$

See (1976KO03, 1977AV01). See also ${}^7\text{Li}$ and ${}^7\text{Be}$.

18. (a) ${}^9\text{Be}(p, d){}^8\text{Be}$	$Q_m = 0.5594$	$E_b = 6.5853$
(b) ${}^9\text{Be}(p, \alpha){}^6\text{Li}$	$Q_m = 2.125$	

Knowledge of the cross sections of these two reactions at low energies is of importance for power generation and astrophysical considerations: see (1973SI27). Absolute cross sections for the d_0 and α_0 groups have been measured for $E_p = 28$ to 697 keV with $\pm 5 - 6\%$ uncertainty. The value of $S_{\text{c.m.}}(E = 0)$ for the combined cross sections is estimated to be 35_{-15}^{+45} MeV \cdot b. At the 0.33 MeV resonance ($J^\pi = 1^-$), $\sigma_{\alpha_0} = 360 \pm 20$ mb and $\sigma_{d_0} = 470 \pm 30$ mb. The data (including angular distributions), analyzed by an R -matrix compound nucleus model, were fitted by assuming three states at $E_p(\text{c.m.}) = -20$ keV ($J^\pi = 2^+$; 3^+ possible) [$E_x = 6.57$ MeV] [see, however, Table 10.8], 310 keV (1^-) and 410 keV (1^+ ; 2^+ or 3^+ possible) (1973SI27).

Measurements of excitation functions for deuterons and α -particles have been reported at a number of energies to $E_p = 15$ MeV: see (1974AJ01). Recent measurements include those of (1973MA59: 2.2 to 2.8 MeV; α_0), (1977KI04: 2.50 to 2.64 MeV; $\alpha_2\gamma$), (1974YA1C: 4.0 to 6.0 MeV; $d_0, \alpha_0, \alpha_1, \alpha_2$) and (1974WI21: 6.3 to 9.5 MeV; d_0, α_0). Observed resonances are displayed in Table 10.14.

Polarization measurements have been made in the range $E_p = 0.30$ to 15 MeV and at 185 MeV: see (1974AJ01). A recent study is reported at $E_p = 15$ MeV by (1976DA15; d_0, d_1). See also ${}^6\text{Li}$, ${}^8\text{Be}$, (1976KO03, 1977AV01) and (1974LO1B).

19. ${}^9\text{Be}(d, n){}^{10}\text{B}$	$Q_m = 4.3607$
--	----------------

Neutron groups are observed corresponding to the ${}^{10}\text{B}$ states listed in Table 10.15. Thresholds for slow-neutron production corresponding to ${}^{10}\text{B}$ states with $4.7 < E_x < 6.6$ MeV are displayed in Table 10.17 of (1974AJ01). Angular distributions have been measured from $E_d = 0.5$ to 16 MeV [see (1959AJ76, 1966LA04, 1974AJ01)] and at 15.25 MeV (1975AZ02; n to ${}^{10}\text{B}^*(0, 0.7, 1.7 + 2.2, 3.6, 5.11 + 5.16, 5.92 + 6.03, 6.35 + 6.50)$). Observed γ -transitions are listed in Tables 10.6 and 10.16. Reported values of τ_m are displayed in Table 10.9.

From all the various experiments the following picture emerges: the first five states of ${}^{10}\text{B}$ have even parity [from l_p]. The ground state is known to have $J = 3$, by direct measurement, and ${}^{10}\text{B}^*(1.74)$ has $J^\pi = 0^+$ and is the $T = 1$ analog of the ${}^{10}\text{C}_{\text{g.s.}}$ [from the β^+ decay of ${}^{10}\text{C}$]. Then looking at the branching ratios and lifetimes of the other states, the sequence for ${}^{10}\text{B}^*(0, 0.72, 1.74, 2.15, 3.59)$ is $J^\pi = 3^+, 1^+, 0^+, 1^+, 2^+$ [see discussion in (1966LA04, 1966WA10)].

At $E_d = 83.7$ MeV the relative neutron yield down to $E_n = 4$ MeV is bell-shaped with a peak at about 34 MeV and a FWHM of ≈ 22 MeV (1976MA43). See also ${}^{11}\text{B}$ in (1980AJ01), (1973SR1A, 1974KA34, 1975SR01, 1977BA2K, 1977LO10, 1977RI08, 1978LO1C) and (1975AU1C, 1976EA1A; applications).

20. ${}^9\text{Be}({}^3\text{He}, d){}^{10}\text{B}$	$Q_m = 1.0918$
--	----------------

Table 10.15: Levels of ^{10}B from $^9\text{Be}(d, n)^{10}\text{B}$ ^a

(1965BU10)			(1973PA14)		(1967FI01)	
$^{10}\text{B}^*$ (MeV \pm keV)	l_p ^d	S_{rel} ^e	S_{rel} ^k	$^{10}\text{B}^*$ (MeV \pm keV)	l_p ^g	S_{rel} ^h
0	1	1.0	1.0	0	1	1.0
0.72 ^b	1	2.3	1.97	0.72 \pm 10	1	2.8
1.74 ^b	1	1.0 ^f	1.42	1.74 \pm 10	1	1.4 ^f
2.15 ^b	1	0.41	0.41	2.15 \pm 10	1	0.5
3.59 ^b	1	0.45	0.10	3.58 \pm 10	(1)	0.3
4.77 ^b	(≥ 2)	0.43		4.77 \pm 10	undetermined	0.07 if $l = 1$ 0.4 if $l = 2$
5.11 \pm 20	0	1.3	0.14	5.11 \pm 12	0	1.7 ⁱ
5.16 \pm 20	1		0.43	5.17 \pm 14	1	0.6
5.90 \pm 80	(1)	1.3	0.49	5.93 \pm 10	1	0.7
6.10 \pm 80	(2)			{ 6.03 \pm 12 6.14 \pm 10	(2)	0.3 ^{i,j}
6.35 \pm 50	(0)	(0.86), 0.51				
6.50 \pm 50	1			6.57 \pm 10	(3)	
6.95 \pm 30 ^c	0	1.8		{ 6.89 \pm 15 7.00 \pm 12	(1) (1)	
7.50 \pm 50				7.48 \pm 15		
7.60 \pm 50				7.56 \pm 25		
(7.85 \pm 50)						
(8.07 \pm 50)						
(8.12 \pm 50)						

^a See also Table 10.17 in (1966LA04).

^b E_x not determined for the first five excited states.

^c $\Gamma \approx 200$ keV.

^d $E_d = 2.6 - 3.2$ MeV and 7 MeV.

^e $E_d = 7$ MeV. (1974KE06) recalculate S_{rel} for $^{10}\text{B}^*(0, 1.74)$ to be 1.0 and 1.06.

^f See, however, (1967TA1A).

^g $E_d = 3.0, 3.5, 5.5$ MeV.

^h Average of values shown by (1967FI01). See also (1975AZ02; $E_d = 15.25$ MeV).

ⁱ PWBA.

^j If $J = 3$.

^k Average of values shown by (1973PA14) at $E_d = 12.0, 15.0$ and 16.0 MeV. (1974KE06) have reanalyzed the results for $^{10}\text{B}^*(0, 1.74)$ and find $S_{\text{rel}}(\text{ave.}) = 1.0$ and 1.36 .

Table 10.16: The γ -rays observed in ${}^9\text{Be}(d, n){}^{10}\text{B}$

Transition	E_γ (keV)	Branching ratio ^d (%)
0.7 \rightarrow g.s.	716.6 ± 1 ^a	100
1.7 \rightarrow g.s.		< 2
1.7 \rightarrow 0.7	1022 ± 2 ^a	100
2.15 \rightarrow g.s.	2152 ± 15 ^a	22
2.15 \rightarrow 0.7	1433 ± 5 ^a	27
2.15 \rightarrow 1.7	413.5 ± 1 ^a	51
3.59 \rightarrow g.s.	3583 ± 13 ^{b,c}	19 ± 4 ^e
3.59 \rightarrow 0.7	2872 ± 15 ^{b,c}	70 ± 7 ^e
3.59 \rightarrow 1.74		< 1 ^e
3.59 \rightarrow 2.16		11 ± 2 ^e
5.16 \rightarrow g.s.	5.159 ± 16 ^b	5.5 ± 0.7 ^b
5.16 \rightarrow 0.7	4461 ± 13 ^{b,c}	29.5 ± 2 ^b
5.16 \rightarrow 2.16	3028 ± 15 ^b	65 ± 2 ^b

^a (1949RA02).

^b (1963WA17): Doppler corrected.

^c M1 + E2 (1964WA05).

^d See Table 10.6.

^e (1969GA06).

Deuteron groups have been seen corresponding to a number of states of ${}^{10}\text{B}$: see Table 10.17. Angular distributions have been measured at $E_d = 10$ to 25 MeV [see (1974AJ01)] and at $E({}^3\text{He}) = 33.3$ MeV (1976KA23) and lead to the l_p and spectroscopic factors shown in Table 10.17. For τ_m see Table 10.9. See also (1973CL1D, 1977RI08) and ${}^{12}\text{C}$ in (1980AJ01).

$$21. {}^9\text{Be}(\alpha, t){}^{10}\text{B} \quad Q_m = -13.229$$

Angular distributions have been studied at $E_\alpha = 27$ MeV (1974KE06; t_0, t_1, t_3), 28.3 MeV (1965KA14; t_0, t_1) and $E_\alpha = 43$ MeV (1967SI1A; t_0, t_2). The transition to ${}^{10}\text{B}^*(1.74) [0^+; T = 1]$ is suppressed by at least a factor of five compared to the transitions to the $T = 0$ states (1974KE06). See also ${}^{13}\text{C}$ in (1976AJ04).

$$22. {}^9\text{Be}({}^7\text{Li}, {}^6\text{He}){}^{10}\text{B} \quad Q_m = -3.390$$

Table 10.17: Levels of ^{10}B from $^9\text{Be}(^3\text{He}, \text{d})^{10}\text{B}$

E_x (MeV \pm keV)	$J\pi$	l_p ^e	S_{rel} ^f	S_{rel} ⁱ	S_{abs} ^j
0	3^+	1	1.0	1.0	0.68
0.717 ± 10 ^a	1^+	1	1.8	1.8	1.15
1.744 ± 10 ^a	0^+	1	2.6 ^g	2.6 ^g	
2.156 ± 10 ^a	1^+	1	0.71	0.55	
3.59 ^b	2^+	1	0.30		
4.77 ^c			0.15		
5.11 ^d			} 0.66 ^h		
5.16 ^{c,d}					
5.92 ^{c,d}	2^+	1	1.2		
6.03 ^d					
6.13 ^{c,d}			0.90 ^h		
6.56 ^{c,d}			0.86 ^h		

^a (1960HI08).

^b The E_x of this state and of the states below have not been determined.

^c (1967CR04).

^d (1966FO08).

^e See text.

^f $E_d = 10$ MeV (1967CR04).

^g The $\mathbf{t} \cdot \mathbf{T}$ term significantly changes S_{rel} (1968TA1A).

^h $(2J + 1)S_{\text{rel}}$.

ⁱ $E_d = 17$ MeV (1966SI02); see also (1973PA14). (1974KE06) have recalculated S_{rel} for $^{10}\text{B}^*(0, 1.74)$ and find 1.0 and 1.58.

^j (1976KA23): $E(^3\text{He}) = 33.3$ MeV; the transferred j are $\frac{3}{2}$ and $\frac{1}{2}$ for $^{10}\text{B}^*(0, 0.7)$.

At $E(^7\text{Li}) = 34$ MeV angular distributions have been obtained for the ^6He ions to the first four states of ^{10}B . Absolute values of the spectroscopic factors are $S = 0.88, 1.38$ ($p_{1/2}$ or $p_{3/2}$), 1.40 and 0.46 ($p_{1/2}$), 0.54 ($p_{3/2}$) for $^{10}\text{B}^*(0, 0.74, 1.74, 2.15)$ (FRDWBA analysis) (1977KE09). See also (1974KE06).

23. $^{10}\text{Be}(\beta^-)^{10}\text{B}$

$$Q_m = 0.5559$$

See ^{10}Be .

24. (a) $^{10}\text{B}(\gamma, n)^9\text{B}$ $Q_m = -8.436$
 (b) $^{10}\text{B}(\gamma, p)^9\text{Be}$ $Q_m = -6.5853$
 (c) $^{10}\text{B}(\gamma, d)^8\text{Be}$ $Q_m = -6.0259$
 (d) $^{10}\text{B}(\gamma, \alpha)^6\text{Li}$ $Q_m = -4.4605$

Absolute measurements have been made of the $^{10}\text{B}(\gamma, \text{Tn})$ cross section from threshold to 35 MeV with quasimonoenergetic photons; the integrated cross section is 0.54 in units of the classical dipole sum ($60NZ/A$ MeV · mb). The $(\gamma, 2n) + (\gamma, 2np)$ cross section is zero, within statistics, for $E_\gamma = 16$ to 35 MeV (1976KN04). The giant resonance is broad with the major structure contained in two peaks at $E_x = 20.1 \pm 0.1$ and 23.1 ± 0.1 MeV ($\sigma_{\text{max}} \approx 5.5$ mb for each of the two maxima) (1973HU09, 1976KN04). Using 12.5 MeV bremsstrahlung (1968SH21) report peaks in the (γ, p) cross section corresponding to ^{10}B states at 8.8 ± 0.1 [$J^\pi = 2^+$], 9.2 ± 0.1 [3^+] and (≈ 10.5) [$\pi = +$] MeV, with $T = 1$. See (1959AJ76, 1966LA04) for reactions (c) and (d). See also (1974BU1A, 1976BE1H).

25. $^{10}\text{B}(\gamma, \gamma)^{10}\text{B}$

See (1967LO1B).

26. (a) $^{10}\text{B}(e, e)^{10}\text{B}$
 (b) $^{10}\text{B}(e, ep)^9\text{Be}$ $Q_m = -6.5853$

The quadrupole contribution to the elastic form factor is best accounted for by the undeformed shell model, $Q = 7.45 (\pm 20\%) \text{ fm}^2$, $\langle r^2 \rangle^{1/2} = 2.45 \text{ fm}$ (1966ST12). The magnetic form factors for $E_e = 70$ to 200 MeV have been determined for the elastic group (+ a small contribution due to $^{10}\text{B}^*(0.7)$): there is no evidence of an M3 contribution – the magnetic octupole moment $\lesssim 1.6 \text{ fm}^2$, $a_0 = 1.4 \pm 0.2 \text{ fm}$ (1966RA29).

Inelastic groups are displayed in Table 10.18. There is evidence for M1 transition strength to at least one level at $E_x \approx 11 \text{ MeV}$ (1976FA13). See also (1977YE1A). No sharp states are observed for $15 < E_x < 20 \text{ MeV}$ (1977YE1A). See also (1974AJ01, 1974DE1E, 1975FA1A) and (1973GA19, 1974TA20, 1976DU05, 1978BO09; theor.). At $E_e = 700 \text{ MeV}$ the proton separation spectra (reaction (b)) are similar to those observed in $(p, 2p)$ except for an upward shift in the excitation (1978NA05).

27. $^{10}\text{B}(n, n')^{10}\text{B}$

Table 10.18: Radiative widths from $^{10}\text{B}(e, e)$

E_x in ^{10}B (MeV)	$J^\pi; T^a$	Mult.	R (fm)	Γ_{γ_0} (eV)	Refs.
5.11	$2^-; 0$	M2		$(6.9 \pm 1.4) \times 10^{-4}{}^c$	(1976FA13) ^g
			4.8 ± 1.1	$(10.2 \pm 2.2) \times 10^{-4}{}^d$	(1976FA13) ^g
6.014 ± 0.020	4^+	E2	(4.6 ± 1.0)	$0.3 \pm 0.07{}^{d,e}$	(1976FA13)
				$0.122 \pm 0.020{}^f$	(1966SP02)
7.477 ± 0.020	$2^+; 1^b$	M1		$11.3 \pm 2.0{}^c$	(1976FA13)
			2.4 ± 0.4	$10.1 \pm 1.9{}^d$	(1976FA13)
				11.0 ± 2.2	(1966SP02, 1969CH1A)
8.90	$2^+; 1$	E2		$0.5 \pm 0.2{}^d$	(1976FA13) ^g
	$3^-; 1$	M2		$(6 \pm 2) \times 10^{-3}{}^d$	(1976FA13) ^g
10.79		M1 or E2			(1976FA13)
11.56		(M1)		$11.4 \pm 2.3{}^c$	(1976FA13)

^a From Table 10.5.

^b From (1966SP02, 1976FA13); $\Gamma \approx 40$ keV (1966SP02); see, however, Table 10.11.

^c From comparison with DWBA oscillator model; oscillator parameter, 1.88 (1976FA13).

^d From DWBA corrected PWBA generalized Helm model expressions (1976FA13).

^e There is some question, due to other states in this region, as to whether all of the strength is due to a transverse E2 transition to the 4^+ state.

^f See also (1977YE1A).

^g Γ_{γ_0} is too large for an M2 transition. Unresolved contributions from other ^{10}B states may be present [I am grateful to P.M. Endt and L. Fagg for discussions of this matter].

Angular distributions have been studied for $E_n = 1.5$ to 14.1 MeV [see (1974AJ01)] and at $E_n = 4.08$ to 8.03 MeV (1978KN01; elastic) and 14.1 MeV (1974HY01; to $^{10}\text{B}^*(0+0.7, 1.7+2.2, 3.59, 6.03)$ and groups of unresolved states at higher E_x). The breakup of $^{10}\text{B} + n$ into $2\alpha + d + n$ has been studied at $E_n = 14.4$ MeV (1975AN1C). See also ^{11}B in (1975AJ02).

28. $^{10}\text{B}(p, p')^{10}\text{B}$

Angular distributions have been measured for $E_p = 3.0$ to 49.5 MeV [see (1974AJ01)] and at 30.3 MeV (1976DE15: to ^{10}B states with $E_x < 6.6$ MeV). Table 10.19 displays the observed results. The 4^+ state at 6.03 MeV is the most strongly excited of the ^{10}B states [see (1974AJ01)]; $B(\text{E}2\uparrow) = 26 \pm 5 \text{ fm}^4$ and $\Gamma(\text{E}2\downarrow) = 0.14 \text{ eV}$ (1965JA1A).

Gamma rays have been observed with $E_\gamma = 718.5 \pm 0.2$ keV and 1021.5 ± 0.5 keV (1966FR09: from decay of $E_x = 718.5 \pm 0.2$ and 1740.0 ± 0.6 keV) and $E_\gamma = 720.1 \pm 2.0, 1022.0 \pm 2.0, 1435.1,$

2155.6 \pm 2.0 and 2868.5 \pm 2.0 keV (1969PA09: from decay of $E_x = 720.4 \pm 1.9, 1742.3 \pm 2.3, 2155.4 \pm 1.9$ and 3589.7 ± 2.2 keV). See also reaction 40. (1968MA18) report $\delta(E2/M1) = -(0.23_{-0.05}^{+0.06})$ or $-(4.1_{-0.7}^{+1.0})$ for the 2.15 \rightarrow 0.72 transition. The 1.74 \rightarrow g.s. and 3.59 \rightarrow 1.74 transitions have not been observed: $< 0.2\%$ and $< 0.3\%$, respectively (1966SE03). The branching ratio for 5.16 \rightarrow 1.74 is $< 0.5\%$ and 5.16 \rightarrow 3.59 is $(4.5 \pm 1)\%$ [see Table 10.6] (1967PA01). See Table 10.9 for τ_m measurements. See also ^{11}C in (1980AJ01), (1977CO1G) and (1974GU13, 1977PH02; theor.).

29. (a) $^{10}\text{B}(p, 2p)^9\text{Be}$ $Q_m = -6.5863$
 (b) $^{10}\text{B}(p, pn)^9\text{B}$ $Q_m = -8.436$
 (c) $^{10}\text{B}(p, p\alpha)^6\text{Li}$ $Q_m = -4.4605$

The summed proton spectrum (reaction (a)), observed at $E_p = 460$ MeV, shows peaks corresponding to the removal of an $l \neq 0$ proton at $Q = -6.7 \pm 0.5, -11.9 \pm 0.5$ and -17.1 ± 0.6 MeV; for removal of an $l = 0$ proton, $Q = -30.5 \pm 0.6$ MeV (1966TY01). See also (1974AJ01). For reaction (b) see (1977WA05) and for reaction (c) see (1974AJ01).

30. $^{10}\text{B}(d, d')^{10}\text{B}$

Deuteron groups have been observed corresponding to twelve states of ^{10}B : see Table 10.19. The very low intensity of the group to $^{10}\text{B}^*(1.74)$ (1974ST01) and the absence of the group to $^{10}\text{B}^*(5.16)$ (1962AR02) is good evidence of their $T = 1$ character. Angular distributions have been reported at $E_d = 4$ to 28 MeV [see (1974AJ01)] and at 6.5 to 12.0 MeV (1974ST01; d_2, d_3), 13.6 MeV (1975ZA08; d_0) and at $E_d = 15$ MeV (1974BU06; d_0). See also ^{12}C in (1980AJ01) and (1977IZ01; theor.).

31. $^{10}\text{B}(t, t)^{10}\text{B}$

Angular distributions of elastically scattered tritons have been measured at $E_t = 1.5$ to 3.3 MeV: see (1974AJ01).

32. $^{10}\text{B}(^3\text{He}, ^3\text{He}')^{10}\text{B}$

Angular distributions of elastically scattered ^3He have been measured at $E(^3\text{He}) = 4$ to 32.5 MeV: see (1974AJ01). Angular distributions have also been measured at $E(^3\text{He}) = 32.5$ MeV to $^{10}\text{B}^*(0.72, 1.74, 2.15, 3.59, 4.77, 5.11 + 5.16 + 5.18, 6.03, 6.56)$. $L = 2$ gives a good fit to the distributions of ^3He ions to $^{10}\text{B}^*(0.72, 2.15, 3.59, 6.03)$: derived β_L are shown in Table 10.19 (1968SQ01).

Table 10.19: ^{10}B levels from $^{10}\text{B}(\text{p}, \text{p}')$, $^{10}\text{B}(\text{d}, \text{d}')$ and $^{10}\text{B}({}^3\text{He}, {}^3\text{He}')$

E_x (MeV \pm keV)			$\Gamma_{\text{c.m.}}$ (keV)	L	β_L	β_L
(1953BO70) ^a	(1974KA15) ^b	(1962AR02, 1964AR04) ^a	(1964AR04)	(1968SQ01) ^h (1976DE15) ⁱ	(1968SQ01) ^h	(1976DE15) ⁱ
0	0					
0.717 ± 5 ^b	0.7183 ± 0.4			2	0.37 ± 0.04	0.67 ± 0.05
1.739 ± 5 ^c	$\equiv 1740.2$			(3)	(0.69 ± 0.09)	
2.152 ± 5	2.1541 ± 0.5			2	0.36 ± 0.04	0.49 ± 0.04
3.583 ± 5	3.5870 ± 0.5			2	0.36 ± 0.04	0.45 ± 0.04
4.771 ± 5	4.7740 ± 0.5					
	5.1103 ± 0.6			3		0.45 ± 0.04
	5.1639 ± 0.6	5.16 ± 10 ^d				
		5.18 ± 10 ^e	110 ± 10 ^g			
	5.9195 ± 0.6	5.92 ± 10	< 5			0.28 ± 0.03
	6.0250 ± 0.6	6.03 ± 10	< 5	2		0.95 ± 0.04
	6.1272 ± 0.7	6.13 ± 10	< 5	$2^{\text{h}}, 3^{\text{i}}$	0.62 ± 0.03	0.58 ± 0.03
		6.55 ± 10	25 ± 5	3^{i}		0.59 ± 0.03 ^j
		7.00 ± 10	95 ± 10			
		7.48 ± 10 ^f	90 ± 15			

^a (p, p') and (d, d').

^b (p, p').

^c This state not observed at $E_d = 7.6$ MeV (1953BO70) nor at $E_d = 10.0$ MeV (1962AR02). Intensity of this d_2 group $\lesssim 1\%$ of d_3 group for $E_d = 6$ to 12 MeV (1974ST01).

^d Not observed in (d, d') at $E_d = 10$ MeV (1962AR02).

^e Not reported in (p, p') at $E_p = 10$ MeV (1962AR02).

^f Relative intensity in (d, d') at $E_d = 11.4$ MeV $< 2\%$.

^g (1962AR01).

^h (${}^3\text{He}, {}^3\text{He}'$): $E({}^3\text{He}) = 32.5$ MeV.

ⁱ (p, p'): $E_p = 30.3$ MeV.

^j If $J^\pi = 2^-$; $\beta_L = 0.46 \pm 0.04$ if $J^\pi = 4^-$.

33. (a) $^{10}\text{B}(\alpha, \alpha')^{10}\text{B}$
 (b) $^{10}\text{B}(\alpha, 2\alpha)^6\text{Li}$

$$Q_m = -4.4605$$

Angular distributions have been measured at $E_\alpha = 5$ to 30 MeV and at 56 MeV [see (1974AJ01)] as well as at 24 MeV (1976DE34; to $^{10}\text{B}^*(0, 0.72, 2.15, 3.59, 4.77, 5.11 + 5.18, 5.92 + 6.03)$), 30, 32, 34 and 40 MeV (1976BE1M; α_0) and at 50.6 MeV (1976BE1M; $\alpha_0, \alpha_1, \alpha_3, \alpha_4, \alpha_5$). $^{10}\text{B}^*(1.74)$ is not observed. S_α for $^{10}\text{B}_{\text{g.s.}} = 0.29$ (1976WO11).

At $E_\alpha = 24$ MeV a kinematically complete study of reaction (b) is said to require 17 new states of ^{10}B with $8.66 < E_x < 16$ MeV (1974ST13). See also ^{14}N in (1976AJ04) and (1974DO1G).

34. (a) $^{10}\text{B}(^6\text{Li}, ^6\text{Li})^{10}\text{B}$
 (b) $^{10}\text{B}(^7\text{Li}, ^7\text{Li})^{10}\text{B}$

Elastic scattering angular distributions (reaction (a)) have been studied at $E(^6\text{Li}) = 5.8$ (1976PO02) and 30 MeV (1977KE09). The elastic scattering in reaction (b) has been studied at $E(^7\text{Li}) = 24$ MeV (1972WE08). See also (1974KO1G).

35. (a) $^{10}\text{B}(^{10}\text{B}, ^{10}\text{B})^{10}\text{B}$
 (b) $^{10}\text{B}(^{11}\text{B}, ^{11}\text{B})^{10}\text{B}$

Elastic scattering angular distributions (reaction (a)) have been studied at $E(^{10}\text{B}) = 8, 13$ and 21 MeV (1975DI08). For yields see (1975DI08, 1976HI05, 1978MA07). For reaction (b) see (1976HI05).

36. $^{10}\text{B}(^{12}\text{C}, ^{12}\text{C})^{10}\text{B}$

Elastic scattering angular distributions have been measured at $E(^{10}\text{B}) = 18$ MeV (1968VO1A, 1969VO10) and 100 MeV (1975NA15, 1977TO02). For fusion cross section measurements see (1976ST12, 1977HI01). See also (1973BR1C) and (1978AV1A; theor.).

37. $^{10}\text{B}(^{14}\text{N}, ^{14}\text{N})^{10}\text{B}$

The elastic scattering angular distribution has been studied at $E(^{10}\text{B}) = 100$ MeV (1975NA15). For fusion cross-section measurements see (1977HI01, 1977WU1B, 1978KO1J, 1978WU1B, 1978WU1C). See also (1978RO1D; astrophys.) and (1977MO1J; theor.).

38. (a) $^{10}\text{B}(^{16}\text{O}, ^{16}\text{O})^{10}\text{B}$
 (b) $^{10}\text{B}(^{18}\text{O}, ^{18}\text{O})^{10}\text{B}$

Elastic scattering angular distributions (reaction (a)) have been studied with $E(^{16}\text{O}) = 15.0$ to 32.5 MeV [see (1968OK06, 1968OK1B, 1969KR03)] and at $E(^{10}\text{B}) = 100$ MeV (1975NA15, 1977TO02). For fusion cross section measurements see (1977GO1C). The elastic scattering in reaction (b) has been studied for $E(^{18}\text{O}) = 20, 24$ and 30.5 MeV (1971KN05).

39. $^{10}\text{B}(^{19}\text{F}, ^{19}\text{F})^{10}\text{B}$

The elastic scattering has been investigated for $E(^{19}\text{F}) = 20$ and 24 MeV (1971KN05).

40. $^{10}\text{C}(\beta^+)^{10}\text{B}$ $Q_m = 3.651$

The weighted mean of earlier values of the half-life is 19.42 ± 0.06 sec: see (1974AJ01). Recent values are $\tau_{1/2} = 19.28 \pm 0.02$ sec (1974AZ01). And 19.151 ± 0.026 sec (1974RO21): we adopt the average, $\tau_{1/2} = 19.255 \pm 0.053$ sec (1975HA45). The decay is to $^{10}\text{B}^*(0.7, 1.7)$: see Table 10.20 for branching ratios and $\log ft$. The “corrected” ft value for the transition to $^{10}\text{B}^*(1.7)$ is then 3108 ± 31 sec, based on $E_{\beta^+}(\text{max}) = 1910.22 \pm 0.59$ keV to $^{10}\text{B}^*(0.7)$ [see $^{10}\text{B}(\text{p}, \text{n})^{10}\text{C}$] (1975HA45). The excitation energies of $^{10}\text{B}^*(0.7, 1.7)$ are $E_x = 718.32 \pm 0.09$ and 1740.16 ± 0.17 keV [$E_\gamma = 718.29 \pm 0.09$ and 1021.78 ± 0.14 keV] (1969FR02). Based on the decay $^{10}\text{C}_{\text{g.s.}} \rightarrow ^{10}\text{B}^*(1.7)$ and on other $0^+ \rightarrow 0^+$ decays, (1975HA45, 1977TO11) find an effective coupling constant $G'_V = (1.4128 \pm 0.0005) \times 10^{-49}$ erg · cm³, in agreement with the CVC hypothesis. The Fierz interference constant $b_F \leq 0.006$ (1975HA45). See also (1975RA37), (1974AS07, 1974WI02, 1975KR14, 1977AZ02, 1977RI08, 1977SZ03, 1978SZ03; theor.) and this footnote †.

41. $^{11}\text{B}(\gamma, \text{n})^{10}\text{B}$ $Q_m = -11.4552$

The intensities of the transitions to $^{10}\text{B}^*(3.59, 5.16)$ [$T = 0$ and 1, respectively] depend on the region of the giant dipole resonance in ^{11}B from which the decay takes place: it is suggested that the lower energy region consists mainly of $T = \frac{1}{2}$ states and the higher energy region of $T = \frac{3}{2}$ states (1971PA10). See also ^{11}B in (1980AJ01).

† Note added in proof: $Q_0 = -23360.74 \pm 0.5$ keV (J.A. Nolen, private communication): this leads to an atomic mass excess of 15699.9 ± 0.5 keV for ^{10}C .

Table 10.20: The β -decay of ^{10}C ^a

Decay to $^{10}\text{B}^*$ (MeV)	Branching ratio (%)	$\log ft$	Refs.
0.72	98.53 ± 0.02	3.047	(1972RO03)
1.74	1.465 ± 0.014	3.492 ± 0.005	(1972RO03, 1975HA45) ^c
	1.52 ± 0.08		(1969BR13)
2.15	$\leq 8 \times 10^{-4}$ ^b	≥ 5.67	(1972GO1A)

^a See also Table 10.21 in (1974AJ01).

^b See also (1969BR13).

^c See also (1974RO21).

42. $^{11}\text{B}(\text{p}, \text{d})^{10}\text{B}$ $Q_m = -9.2306$

Angular distributions of deuteron groups have been measured at $E_p = 17.7$ MeV (1977GU14; d_0, d_1), 19 MeV (1963LE03; $d_0 \rightarrow d_4$), 33.6 MeV (1968KU04; $d_0 \rightarrow d_5$ and deuterons to states at 5.18 (unres.), 6.04 (unres.), and 154.8 MeV (1969BA05, 1969TO1A; $d_0 \rightarrow d_4$ and d to 5.1 ± 0.1 , 11.4 ± 0.2 and 14.1 ± 0.2 MeV). The weak excitation of states at 6.56 and 7.5 MeV is also reported (1968KU04), and $\Gamma_{\text{c.m.}}$ of $^{10}\text{B}^*(11.4) = 1.1 \pm 0.2$ MeV (1969BA05). Spectroscopic factors have been extracted by [(1963LE03): PWBA; (1968KU04): DWBA; (1969BA05); and (1969TO1A): DWBA].

43. $^{11}\text{B}(\text{d}, \text{t})^{10}\text{B}$ $Q_m = -5.1979$

Angular distributions have been measured at $E_d = 11.8$ MeV (1969FI1A; $t_0 \rightarrow t_3$; $l = 1$; $S = 1.88, 0.94, 1.35, 1.35$, respectively). The transition to $^{10}\text{B}^*(2.15)$ proceeds predominantly via a $p_{3/2}$ transfer whereas a dominant $p_{1/2}$ transfer occurs for the transition to $^{10}\text{B}^*(0.72)$ (1974VA1E; $E_{\bar{d}} = 27.8$ MeV). See also (1974AJ01) and ^{13}C in (1981AJ01).

44. (a) $^{11}\text{B}(^3\text{He}, \alpha)^{10}\text{B}$ $Q_m = 9.1226$
 (b) $^{11}\text{B}(^3\text{He}, 2\alpha)^6\text{Li}$ $Q_m = 4.662$

Reported levels are displayed in Table 10.21. Angular distributions have been measured at a number of energies between $E(^3\text{He}) = 1.0$ and 33 MeV: see (1974AJ01). For the decay of the observed states see Table 10.6; for lifetime measurements see Table 10.9.

Table 10.21: ^{10}B levels from $^{11}\text{B}(^3\text{He}, \alpha)^{10}\text{B}$

E_x^a (MeV \pm keV)	E_x (MeV \pm keV)	$\Gamma_{\text{c.m.}}^{b,c}$ (keV)	l^d	S_{rel}^d
0			1	1.0
0.718 \pm 7			1	0.22
1.744 \pm 7			1	0.73
2.157 \pm 6			1	0.44
3.587 \pm 6			1	0.09
4.777 \pm 5			1	0.09
5.114 \pm 5				
5.166 \pm 5			1	1.81
5.923 \pm 5				
6.028 \pm 5				
6.131 \pm 5				
6.573 \pm 8	6.566 \pm 10 ^b	30 \pm 10		
	7.002 \pm 10 ^b	95 \pm 10		
7.475 \pm 10				
7.567 \pm 10				
	7.87 \pm 40 ^b	240 \pm 50		
	10.85 \pm 100 ^c	300 \pm 100		
	11.52 \pm 35 ^{b,c}	500 \pm 100 ^c		
	12.56 \pm 30 ^{b,c}	100 \pm 30		
	13.49 \pm 50 ^c	300 \pm 50		
	14.4 \pm 100 ^c	800 \pm 200		
	(18.2 \pm 200) ^c	(1500 \pm 300)		

^a (1965GO05).

^b (1967PU04).

^c (1976AJ01).

^d (1969DE10): 33 MeV; JULIE code.

The $\alpha\alpha$ angular correlations (reaction (b)) have been measured for the transitions via $^{10}\text{B}^*(5.92, 6.03, 6.13, 6.56, 7.00)$. The results are consistent with $J^\pi = 2^+$ and 4^+ for $^{10}\text{B}^*(5.92, 6.03)$ and require $J^\pi = 3^-$ for $^{10}\text{B}^*(6.13)$. There is substantial interference between levels of opposite parity for the α -particles due to $^{10}\text{B}^*(6.56, 7.00)$: the data are fitted by $J^\pi = 3^+$ for $^{10}\text{B}^*(7.00)$ and $(3, 4)^-$ for $^{10}\text{B}^*(6.56)$ [the $^6\text{Li}(\alpha, \alpha)$ results then require $J^\pi = 4^-$] ([1971YO05](#)). See, however, ([1973SI27](#)) in reaction 18.

45. $^{11}\text{B}(^{16}\text{O}, ^{17}\text{O})^{10}\text{B}$ $Q_m = -7.311$

See ([1968OK06](#)).

46. $^{12}\text{C}(\gamma, d)^{10}\text{B}$ $Q_m = -25.1875$

See ([1973SK1A](#)).

47. $^{12}\text{C}(\text{n}, \text{t})^{10}\text{B}$ $Q_m = -18.9302$

Not reported.

48. $^{12}\text{C}(\pi^-, 2\text{n})^{10}\text{B}$ $Q_m = 111.372$

See ([1977BA51](#)).

49. (a) $^{12}\text{C}(\text{p}, ^3\text{He})^{10}\text{B}$ $Q_m = -19.6940$

(b) $^{12}\text{C}(\text{p}, \text{pd})^{10}\text{B}$ $Q_m = -25.1875$

Angular distributions of ^3He ions have been measured at $E_p = 39.8$ MeV ([1973HO10](#); to $^{10}\text{B}^*(0, 0.72, 1.74, 2.15, 3.59)$), 51.9 MeV ([1977YA10](#); to $^{10}\text{B}^*(0, 0.72, 1.74, 2.15, 3.59, 4.77, 5.16, 5.92, 6.56, 7.50, 8.90)$) and 185 MeV ([1972DA26](#); to $^{10}\text{B}^*(0, 1.0, 1.7, 2.5, 3.5, 4.8, 6.0, 7.3)$). See also ([1974KA15](#)). In reaction (b) ([1978DE1N](#)) report the excitation of the first four states of ^{10}B . See also ([1977GR04](#): $E_p = 75$ MeV; spectroscopic factors). See also ([1976HU1B](#)) and ([1974ZH01](#), [1975BA1H](#); theor.).

50. $^{12}\text{C}(\text{d}, \alpha)^{10}\text{B}$ $Q_{\text{m}} = -1.3408$

Alpha groups have been observed to the known states of ^{10}B below $E_{\text{x}} = 7.1$ MeV: see Table 10.23 in (1974AJ01). Angular distributions have been measured for $E_{\text{d}} = 5.0$ to 29.1 MeV [see (1974AJ01)] and at 13.8 to 16.0 MeV (1974JO01; α_2), 14 and 15 MeV (1974JO01; $\alpha_0, \alpha_1, \alpha_3$), at $E_{\text{d}} = 20.7$ and 29 MeV (1977CO17; $\alpha_0, \alpha_1, \alpha_3, \alpha_4, \alpha_5$), and at $E_{\text{d}} = 40$ MeV (1976VA07; $\alpha_0, \alpha_1, \alpha_3, \alpha_4, \alpha_5$). Single particle S -values are 1.5, 0.5, 0.1, 0.1 and 0.3 for $^{10}\text{B}^*(0, 0.72, 2.15, 3.59, 4.77)$ (1976VA07; ZRDWBA). A study of the $m_{\text{s}} = 0$ yield at $E_{\text{d}} = 14.5$ MeV ($\theta = 0^\circ$) leads to assignments of $3^+, 2^-$ and $(3^+, 4^-)$ for $^{10}\text{B}^*(4.77, 5.11, 6.56)$ (1975KU15).

The population of the isospin forbidden group to $^{10}\text{B}^*(1.74)$ [α_2] has been studied with E_{d} up to 30 MeV: see ^{14}N in (1976AJ04). See also (1977TO1E, 1978IZ02; theor.).

51. $^{12}\text{C}(\alpha, ^6\text{Li})^{10}\text{B}$ $Q_{\text{m}} = -23.714$

Angular distributions have been reported at $E_{\alpha} = 42$ MeV (1972RU03; to $^{10}\text{B}^*(0, 0.72, 2.15)$) and at 46 MeV (1976MA50; to $^{10}\text{B}^*(0, 0.72, 2.15, 3.59)$).

52. $^{12}\text{C}(^{10}\text{B}, 3\alpha)^{10}\text{B}$ $Q_{\text{m}} = -7.2748$

See (1965SH1A).

53. (a) $^{12}\text{C}(^{11}\text{B}, ^{13}\text{C})^{10}\text{B}$ $Q_{\text{m}} = -6.5088$
 (b) $^{12}\text{C}(^{12}\text{C}, ^{14}\text{N})^{10}\text{B}$ $Q_{\text{m}} = -14.9151$
 (c) $^{12}\text{C}(^{14}\text{N}, ^{16}\text{O})^{10}\text{B}$ $Q_{\text{m}} = -4.4512$

For reaction (a) see (1974AJ01). For reaction (b) see (1974AN36). Angular distributions (reaction (c)) have been measured at $E(^{14}\text{N}) = 53$ MeV (1976ZE04; to $^{10}\text{B}^*(0, 0.72, 2.15, 3.59)$) and 78.8 MeV (1977MO1H; to $^{10}\text{B}^*(0, 0.72, 2.15)$). See also ^{16}O in (1982AJ01).

54. $^{13}\text{C}(\text{p}, \alpha)^{10}\text{B}$ $Q_{\text{m}} = -4.0626$

Angular distributions have been measured for $E_{\text{p}} = 5.8$ to 18.0 MeV (1975OB01; α_0 and α_2 from $E_{\text{p}} = 7.95$ MeV) and at 43.7 and 50.5 MeV (1972MA21; α_2 ($L = 1$) and α to $^{10}\text{B}^*(6.03)$ ($L = 3$)). See also ^{14}N in (1976AJ04).

$$55. {}^{13}\text{C}({}^{11}\text{B}, {}^{14}\text{C}){}^{10}\text{B} \quad Q = -3.2787$$

See (1974AN36).

$$56. \text{(a) } {}^{14}\text{N}(\gamma, \alpha){}^{10}\text{B} \quad Q_{\text{m}} = -11.6132$$

$$\text{(b) } {}^{14}\text{N}(\text{p}, \text{p}\alpha){}^{10}\text{B} \quad Q_{\text{m}} = -11.6132$$

For reaction (a) see (1959AJ76); for reaction (b) see (1961CL09).

$$57. {}^{14}\text{N}(\text{d}, {}^6\text{Li}){}^{10}\text{B} \quad Q_{\text{m}} = -10.140$$

See (1978OE1B).

$$58. {}^{14}\text{N}({}^3\text{He}, {}^7\text{Be}){}^{10}\text{B} \quad Q_{\text{m}} = -10.027$$

At $E({}^3\text{He}) = 41$ MeV groups to ${}^{10}\text{B}^*(0, 0.72, 2.15, 3.59, 6.1)$ have been observed. The transition to ${}^{10}\text{B}^*(1.74)$ is very weak (1971DE37). See also (1976RO04).

$$59. {}^{14}\text{N}(\alpha, {}^8\text{Be}){}^{10}\text{B} \quad Q_{\text{m}} = -11.7051$$

See (1974WO1C, 1976WO11).

$$60. {}^{14}\text{N}({}^{11}\text{B}, {}^{10}\text{B}){}^{15}\text{N} \quad Q_{\text{m}} = -0.6219$$

See (1970GO1B).

$$61. {}^{15}\text{N}({}^{11}\text{B}, {}^{16}\text{N}){}^{10}\text{B} \quad Q_{\text{m}} = -8.964$$

See (1974AJ01).

$$62. {}^{16}\text{O}(\text{p}, {}^7\text{Be}){}^{10}\text{B} \quad Q_{\text{m}} = -25.270$$

See (1974AJ01).

^{10}C
(Figs. 21 and 22)

GENERAL (See also (1974AJ01).):

Model calculations: (1974IR04, 1976IR1B).

Special reactions (See also reaction 2 in (1974AJ01).): (1973BA81, 1974RI1A, 1975BA1Q, 1976BE1K, 1976BU16, 1977AR06).

Pion reactions (See also reactions 3 and 9 here.): (1975GI1B, 1975RE01, 1977HO1B, 1977WA02, 1978AM01).

Astrophysical questions: (1972PA1C, 1976VI1A, 1977SI1D).

Other topics: (1974IR04, 1976IR1B, 1976VO1C).

Ground state properties: (1975BE31) ‡ .

1. $^{10}\text{C}(\beta^+)^{10}\text{B}$ $Q_m = 3.651$

^{10}C decays with a half-life of 19.255 ± 0.053 sec to $^{10}\text{B}^*(0.7, 1.7)$: the branching ratios are $(98.53 \pm 0.02)\%$ and $(1.465 \pm 0.014)\%$ respectively (1972RO03): see reaction 40 in ^{10}B in Table 10.20.

2. $^7\text{Li}(^7\text{Li}, 4n)^{10}\text{C}$ $Q_m = -18.172$

See (1974CE06).

3. $^9\text{Be}(p, \pi^-)^{10}\text{C}$ $Q_m = -136.633$

At $E_p = 185$ MeV the π^- spectrum shows groups corresponding to $^{10}\text{C}^*(0, 3.36 \pm 0.07, 5.28 \pm 0.06, 6.63 \pm 0.15)$. Angular distributions have been obtained for the π^- corresponding to these four states. The π^+/π^- intensity ratio is usually $\gg 1$ for analog states in ^{10}Be and ^{10}C (1973DA09). The population of $^{10}\text{Be}^*(0, 3.35, 5.28)$ is also reported at $E_p = 613$ MeV (1978CO15). See also (1974DI20, 1975RE01, 1976DI10, 1976NO1D; theor.).

‡ Note added in proof: $Q_0 = -23360.74 \pm 0.5$ keV (J.A. Nolen, private communication): this leads to an atomic mass excess of 15699.9 ± 0.5 keV for ^{10}C .

Table 10.22: Energy levels of ^{10}C

E_x (MeV \pm keV)	$J^\pi; T$	τ or $\Gamma_{\text{c.m.}}$ (keV)	Decay	Reactions
g.s.	$0^+; 1$	$\tau_{1/2} = 19.255 \pm 0.053$ sec	β^+	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
3.3508 ± 0.9	2^+	$\tau_m = 155 \pm 25$ fsec	γ	3, 5, 6, 9, 10, 12
5.22 ± 40	^a	$\Gamma = 225 \pm 45$ keV		3, 5, 6, 10
5.38 ± 70	^a	300 ± 60		3, 5, 6, 10
6.580 ± 20	(2^+)	200 ± 40		3, 4, 6, 10

^a One of these two states is presumably a 2^+ state.

4. $^9\text{Be}(^3\text{He}, 2n)^{10}\text{C}$ $Q_m = -5.566$

See (1974MO23).

5. $^{10}\text{B}(p, n)^{10}\text{C}$ $Q_m = -4.434$

$E_{\text{thresh.}} = 4880.6 \pm 0.6$ keV (1974RO21); the mean of this measurement and the earlier measurement of (1966FR09) leads to $Q_0 = -4432.84 \pm 0.6$ keV (1974RO21). See also (1976FR1D).

The first excited state of ^{10}C is located at $E_x = 3.3527 \pm 0.0015$ MeV (1969PA09; from γ -decay). τ_m for $^{10}\text{C}^*(3.35) = 155 \pm 25$ fsec; $\Gamma_\gamma = 4.25 \pm 0.69$ meV (1968FI09). Angular distributions have been measured for the n_0 and n_1 groups and for the neutrons corresponding to $^{10}\text{C}^*(5.2 \pm 0.3)$ at $E_p = 30$ and 50 MeV. The excitation of $^{10}\text{C}^*(6.5 \pm 0.3, 8.3 \pm 0.3, 8.9 \pm 0.3)$ is also reported (1970CL01). See also ^{11}C in (1980AJ01).

6. $^{10}\text{B}(^3\text{He}, t)^{10}\text{C}$ $Q_m = -3.670$

Angular distributions have been measured at $E(^3\text{He}) = 14$ MeV (1970NU02; t_0) and 217 MeV (1976WI05; t_0, t_1 and t to $^{10}\text{C}^*(5.6)$). The latter have been compared with microscopic calculations using a central + tensor interaction [$J^\pi = 0^+, 2^+, 2^+$] (1976WI05). The previously reported structures at 5.28 ± 0.06 and 6.58 ± 0.06 MeV (1966MA36) are best fitted by $E_x = 5.22 \pm 0.04$ [$\Gamma = 225 \pm 45$ keV], 5.38 ± 0.07 [300 ± 60 keV] and 6.580 ± 0.020 MeV [190 ± 35 keV] (1975SC27). [It is not clear which of the 5.2–5.4 MeV states is the 2^+ state studied by (1976WI05).] See also (1974AJ01) and ^{13}N in (1981AJ01).

$$7. {}^{10}\text{B}({}^6\text{Li}, {}^6\text{He}){}^{10}\text{C} \quad Q_{\text{m}} = -7.158$$

See (1974AJ01).

$$8. {}^{12}\text{C}(\gamma, 2\text{n}){}^{10}\text{C} \quad Q_{\text{m}} = -31.846$$

See (1977JO02) and ${}^{12}\text{C}$ in (1980AJ01).

$$9. {}^{12}\text{C}(\pi^+, \text{d}){}^{10}\text{C} \quad Q_{\text{m}} = 110.728$$

At $E_{\pi^+} = 49.3$ MeV $d\sigma/d\Omega_{\text{lab}} = 0.65 \pm 0.25$ $\mu\text{b/sr}$ ($\theta = 30^\circ$) for the transitions to ${}^{10}\text{C}^*(0+3.4)$ (1978AM01).

$$10. {}^{12}\text{C}(\text{p}, \text{t}){}^{10}\text{C} \quad Q_{\text{m}} = -23.364$$

Angular distributions have been reported at $E_{\text{p}} = 30.0$ to 54.1 MeV [see (1974AJ01)] and at 51.9 MeV (1977YA10; t to ${}^{12}\text{C}^*(0, 3.35, 5.28, 6.6)$) and 80 MeV (1977AN1E; t to ${}^{12}\text{C}^*(0, 3.35, 5.3)$). $L = 0, 2$ and 2 for ${}^{10}\text{C}^*(0, 3.35, 5.28 \pm 0.06)$, and therefore $J^\pi = 0^+, 2^+$ and 2^+ : see (1967BE27, 1977YA10) but note that the “ 5.28 MeV” state is probably unresolved [see reaction 6 and ${}^{10}\text{Be}$]. At $E_{\text{p}} = 51.9$ MeV ${}^{10}\text{C}^*(0, 3.4)$ are strongly excited and states at $E_{\text{x}} = 5.28, 5.55$ and 6.6 MeV [$L = 2 \rightarrow J^\pi = 2^+$] are weakly populated. The (p, t) angular distributions are compared with those of the (p, ${}^3\text{He}$) reaction to analog states in ${}^{10}\text{Be}$ (1977YA10).

The excitation energy of ${}^{10}\text{C}^*(3.4)$ is 3350.0 ± 1.0 keV (1974BE66). (1967BE27) find $E_{\text{x}} = 6.61 \pm 0.06$ MeV, $\Gamma_{\text{c.m.}} = 300 \pm 50$ keV. See also (1974KA15, 1977BA2L) [§]

$$11. {}^{12}\text{C}({}^{12}\text{C}, {}^{10}\text{C}){}^{14}\text{C} \quad Q_{\text{m}} = -18.723$$

See ${}^{14}\text{C}$ in (1976AJ04).

$$12. {}^{13}\text{C}({}^3\text{He}, {}^6\text{He}){}^{10}\text{C} \quad Q_{\text{m}} = -15.241$$

[§] Note added in proof: $Q_0 = -23360.74 \pm 0.5$ keV (J.A. Nolen, private communication): this leads to an atomic mass excess of 15699.9 ± 0.5 keV for ${}^{10}\text{C}$.

At $E(^3\text{He}) = 70.3$ MeV the angular distributions of the ^6He ions corresponding to the population of $^{10}\text{C}^*(0, 3.35)$ have been measured. The group to $^{10}\text{C}^*(3.35)$ is much more intense than the ground state group: multi-step processes may be important (1973KA16). (1976DE27) suggest, on the basis of an FRDWBA analysis, that the process can be interpreted as a direct cluster transfer to both final states. See also (1974AJ01).

13. $^{14}\text{N}(^3\text{He}, ^7\text{Li})^{10}\text{C}$ $Q_m = -12.816$

See (1971DE37).

$^{10}\text{N}, ^{10}\text{O}$
(Not illustrated)

Not observed: see (1974IR04, 1975BE31; theor.).

$^{10}\text{F}, ^{10}\text{Ne}$
(Not illustrated)

Not observed: see (1975BE31; theor.).

References

(Closed 1978)

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.

- 1949RA02 V. K. Rasmussen, W.F. Hornyak and T. Lauritsen, Phys. Rev. 76 (1949) 581
- 1949TH05 R.G. Thomas, S. Rubin, W.A. Fowler and C.C. Lauritsen, Phys. Rev. 75 (1949) 1612
- 1950WU1A Wu, Rev. Mod. Phys. 22 (1950) 386
- 1951BO45 C.K. Bockelman, D.W. Miller, R.K. Adair and H.H. Barschall, Phys. Rev. 84 (1951) 69
- 1951NE03 J.A. Neuendorffer, D.R. Inglis and S.S. Hanna, Phys. Rev. 82 (1951) 75
- 1952HA10 T.M. Hahn, C.W. Snyder, H.B. Willard, J.K. Bair, E.D. Klema, J.D. Kington and F.P. Green, Phys. Rev. 85 (1952) 934
- 1953BO70 C.K. Bockelman, C.P. Browne, W.W. Buechner and A. Sperduto, Phys. Rev. 92 (1953) 665
- 1953MA1A Mackin, Thesis, CalTech (1953)
- 1953PA22 E.B. Paul and H.E. Gove, Proc. Roy. Soc. Canada 47 (1953) 145A
- 1955WI25 H.B. Willard, J.K. Bair and J.D. Kington, Phys. Rev. 98 (1955) 669
- 1956CL69 A.B. Clegg, Phil. Mag. 1 (1956) 1116
- 1956DE33 G. Dearnaley, Phil. Mag. 1 (1956) 821
- 1956MA55 J.B. Marion, Phys. Rev. 103 (1956) 713
- 1956MO90 F.S. Mozer, Phys. Rev. 104 (1956) 1386
- 1956WE37 G. Weber, L.W. Davis and J.B. Marion, Phys. Rev. 104 (1956) 1307
- 1957ME27 L. Meyer-Schutzmeister and S.S. Hanna, Phys. Rev. 108 (1957) 1506
- 1957ST95 P.H. Stelson and E.C. Campbell, Phys. Rev. 106 (1957) 1252
- 1958ME81 W.E. Meyerhof and L.F. Chase, Jr., Phys. Rev. 111 (1958) 1348
- 1959AJ76 F. Ajzenberg and T. Lauritsen, Nucl. Phys. 11 (1959) 1
- 1959MA20 J.B. Marion and J.S. Levin, Phys. Rev. 115 (1959) 144
- 1959ME1A Meyerhof, Tanner and Hudson, Phys. Rev. 115 (1959) 1227
- 1959WA16 E.K. Warburton, Phys. Rev. 113 (1959) 595
- 1960HI08 S. Hinds and R. Middleton, Proc. Phys. Soc. (London) 75 (1960) 754

1960KL03 P.R. Klein, N. Cindro, L.W. Swenson and N.S. Wall, Nucl. Phys. 16 (1960) 374
 1960SE12 R. Seltz and D. Magnac-Valette, Compt. Rend. 251 (1960) 2006
 1961BA53 R. Bass, T.W. Bonner and H.P. Haenni, Nucl. Phys. 23 (1961) 122
 1961CL09 A.B. Clegg, K.J. Foley, G.L. Salmon and R.E. Segel, Proc. Phys. Soc. (London) 78 (1961) 681
 1961FO07 D.B. Fossan, R.L. Walter, W.E. Wilson and H.H. Barschall, Phys. Rev. 123 (1961) 209
 1961JA19 von L. Jarczyk, J. Lang, R. Muller and W. Wolffi, Helv. Phys. Acta 34 (1961) 483
 1961LA1A Lane, Langsdorf, Monahan and Elwyn, Ann. Phys. 12 (1961) 135
 1961SP02 E.L. Sprenkel, J.W. Olness and R.E. Segel, Phys. Rev. Lett. 7 (1961) 174
 1961TA02 N.W. Tanner and S.S. Hanna, Nucl. Phys. 23 (1961) 319
 1961VA43 A.K. Val-ter, P.I. Vatsset, L.Y. Kolesnikov, S.G. Tonapetyan, K.K. Chernyavskii and A.I. Shpetnyi, Atomn. Energ. (USSR) 10 (1961) 577; Sov. J. At. Energy 10 (1962) 574
 1962AL1A Altman, MacDonald and Marion, Nucl. Phys. 35 (1962) 85
 1962AR01 B.H. Armitage and R.E. Meads, Phys. Lett. 1 (1962) 284; Erratum Phys. Lett. 2 (1962) 164
 1962AR02 B.H. Armitage and R.E. Meads, Nucl. Phys. 33 (1962) 494
 1962DE10 G. Dearnaley, D.S. Gemmell and S.S. Hanna, Nucl. Phys. 36 (1962) 71
 1962EL01 A.J. Elwyn and R.O. Lane, Nucl. Phys. 31 (1962) 78
 1962EL06 R.J. Ellison and B. Dickinson, Nucl. Phys. 35 (1962) 606
 1962KJ05 J. Kjellman, A. Nilsson and S. Schwarz, Ark. Fys. 21 (1962) 169
 1962ME1A Mehta and McIldowie, Nucl. Phys. 33 (1962) 502
 1962SE1A Serov and Guzhovskii, Atomn. Energ. (USSR) 12 (1962) 5
 1963BL20 H.R. Blieden, G.M. Temmer and K.L. Warsh, Nucl. Phys. 49 (1963) 209
 1963DR02 J.E. Draper and C.O. Bostrom, Nucl. Phys. 47 (1963) 108
 1963FU11 B. Furubayashi, E. Teranishi and M. Kageyama, J. Phys. Soc. Jpn. 18 (1963) 1235
 1963LE03 J.C. Legg, Phys. Rev. 129 (1963) 272
 1963ME08 M.K. Mehta, W.E. Hunt, H.S. Plendl and R.H. Davis, Nucl. Phys. 48 (1963) 90
 1963WA17 E.K. Warburton, D.E. Alburger and D.H. Wilkinson, Phys. Rev. 132 (1963) 776
 1964AR04 B.H. Armitage and R.E. Meads, Phys. Lett. 8 (1964) 346
 1964BO13 R.O. Bondelid and J.W. Butler, Nucl. Phys. 53 (1964) 618
 1964HO02 W.F. Hornyak, C.A. Ludemann and M.L. Roush, Nucl. Phys. 50 (1964) 424

1964LA04 R.O. Lane, A.J. Elwyn and A. Langsdorf, Jr., Phys. Rev. 133 (1964) B409
 1964WA05 E.K. Warburton, D.E. Alburger, A. Gallmann, P. Wagner and L.F. Chase, Jr., Phys. Rev. 133 (1964) B42
 1965BU10 S.G. Buccino and A.B. Smith, Phys. Lett. 19 (1965) 234
 1965FO07 P.D. Forsyth and R.R. Perry, Nucl. Phys. 67 (1965) 517
 1965GO05 S. Gorodetzky, A. Gallmann and R. Rebmeister, Phys. Rev. 137 (1965) B1466
 1965JA1A Jacmart, Cahiers Phys. (France) 19 (1965) 1
 1965KA14 S. Kakigi, J. Phys. Soc. Jpn. 20 (1965) 1967
 1965MO1K S. Morita, T. Tohei, T. Nakagawa, T. Hasegawa, H. Ueno and C.-C. Hsu, Nucl. Phys. 66 (1965) 17
 1965PA02 P. Paul, S.L. Blatt and D. Kohler, Phys. Rev. 137 (1965) B493
 1965PA03 P. Paul, S.L. Blatt and D. Kohler, Phys. Rev. 137 (1965) B499
 1965SH1A Shumilov, Klyucharev and Rutkevich, Yad. Fiz. 2 (1965) 1030
 1966AL06 D.E. Alburger, P.D. Parker, D.J. Bredin, D.H. Wilkinson, P.F. Donovan, A. Gallmann, R.E. Pixley, L.F. Chase, Jr. and R.E. McDonald, Phys. Rev. 143 (1966) 692
 1966DI04 G.U. Din and J.L. Weil, Nucl. Phys. 86 (1966) 509
 1966FI01 T.R. Fisher, S.S. Hanna and P. Paul, Phys. Rev. Lett. 16 (1966) 850
 1966FO05 P.D. Forsyth, H.T. Tu and W.F. Hornyak, Nucl. Phys. 82 (1966) 33
 1966FO08 P.D. Forsyth, A.R. Knudson and F.C. Young, Nucl. Phys. 85 (1966) 153
 1966FR09 J.M. Freeman, J.G. Jenkin and G. Murray, Phys. Lett. 22 (1966) 177
 1966GR18 R.C. Greenwood, Phys. Lett. 23 (1966) 482
 1966KI09 K.G. Kibler, Phys. Rev. 152 (1966) 932
 1966LA04 T. Lauritsen and F. Ajzenberg-Selove, Nucl. Phys. 78 (1966) 1
 1966MA36 N. Mangelson, F. Ajzenberg-Selove, M. Reed and C.C. Lu, Nucl. Phys. 88 (1966) 137
 1966RA29 R.E. Rand, R. Frosch and M.R. Yearian, Phys. Rev. 144 (1966) 859; Erratum Phys. Rev. 148 (1966) 1246
 1966SC16 G. Schirmer, H. Pose and H. Hansgen, Nucl. Phys. 84 (1966) 201
 1966SE02 R.E. Segel and R.H. Siemssen, Phys. Lett. 20 (1966) 295
 1966SE03 R.E. Segel, P.P. Singh, S.S. Hanna and M.A. Grace, Phys. Rev. 145 (1966) 736.
 1966SI02 R.H. Siemssen, G.C. Morrison, B. Zeidman and H. Fuchs, Phys. Rev. Lett. 16 (1966) 1050
 1966SP02 E. Spamer, Z. Physik 191 (1966) 24
 1966ST12 T. Stovall, J. Goldemberg and D.B. Isabelle, Nucl. Phys. 86 (1966) 225

- 1966TY01 H. Tyren, S. Kullander, O. Sundberg, R. Ramachandran, P. Isacson and T. Berggren, Nucl. Phys. 79 (1966) 321; Erratum Nucl. Phys. A119 (1968) 692
- 1966WA10 E.K. Warburton, J.W. Olness, K.W. Jones, C. Chasman, R.A. Ristinen and D.H. Wilkinson, Phys. Rev. 148 (1966) 1072
- 1966WA1C Warburton and Alburger, Nucl. Spin-Parity Assign., Ed. Gove (Academic Press, 1966) 114
- 1966YO1A Young et al., Nucl. Instrum. Meth. Phys. Res. 44 (1966) 109
- 1967BE27 W. Benenson, G.M. Crawley, J.D. Dreisbach and W.P. Johnson, Nucl. Phys. A97 (1967) 510
- 1967CR04 M.A. Crosby and J.C. Legg, Nucl. Phys. A95 (1967) 639
- 1967FI01 A.A. Fife, G.C. Neilson and W.K. Dawson, Nucl. Phys. A91 (1967) 164
- 1967GA06 D.S. Gale and J.M. Blair, Phys. Rev. 161 (1967) 1061
- 1967KI03 K.G. Kibler, Phys. Rev. 155 (1967) 1110
- 1967LO1B Loiseaux, Maison and Langevin, J. Phys. 28 (1967) 11
- 1967ME08 V. Meyer, R.E. Pixley and P. Truol, Nucl. Phys. A101 (1967) 321
- 1967PA01 P. Paul, T.R. Fisher and S.S. Hanna, Phys. Lett. B24 (1967) 51
- 1967PA03 G. Paic, D. Rendic and P. Tomas, Nucl. Phys. A96 (1967) 476
- 1967PU04 J.D. Purvis, F. Ajzenberg-Selove and L.M. Polsky, Phys. Rev. 162 (1967) 1005
- 1967SI1A R.H. Siemssen and D. Dehnhard, Phys. Rev. Lett. 19 (1967) 377
- 1967TA1A Tamura, Phys. Rev. Lett. 19 (1967) 321
- 1968DO01 D.J. Donahue, M.J. Wozniak, R.L. Hershberger, J.E. Cummings and J.A. Lonergan, Phys. Rev. 165 (1968) 1071
- 1968FI09 T.R. Fisher, S.S. Hanna, D.C. Healey and P. Paul, Phys. Rev. 176 (1968) 1130
- 1968KU04 L.A. Kull and E. Kashy, Phys. Rev. 167 (1968) 963
- 1968MA18 J.R. MacDonald, D.F.H. Start and D.H. Wilkinson, Nucl. Phys. A113 (1968) 129
- 1968MI10 D. Miljanic, M. Furic and V. Valkovic, Nucl. Phys. A119 (1968) 379
- 1968OK06 Y. Okuma, J. Phys. Soc. Jpn. 25 (1968) 1
- 1968OK1B Okuma, J. Phys. Soc. Jpn. 24 (1968) 677
- 1968SH21 A.K. Shardanov and B.A. Yurev, Yad. Fiz. 8 (1968) 424; Sov. J. Nucl. Phys. 8 (1969) 245
- 1968SQ01 G.T.A. Squier, E.A. McClatchie, A.R. Johnston, R.J. Batten, J.B.A. England and F.G. Kingston, Nucl. Phys. A119 (1968) 369
- 1968TA1A T. Tamura, Phys. Rev. 165 (1968) 1123

- 1968VO1A W. Von Oertzen, H.H. Gutbrod, M. Muller, U. Voos and R. Bock, Phys. Lett. B26 (1968) 291
- 1968WA15 E.K. Warburton, J.W. Olness, S.D. Bloom and A.R. Poletti, Phys. Rev. 171 (1968) 1178
- 1969AL17 D.E. Alburger, E.K. Warburton, A. Gallmann and D.H. Wilkinson, Phys. Rev. 185 (1969) 1242
- 1969BA05 D. Bachelier, M. Bernas, I. Brissaud, C. Detraz and P. Radvanyi, Nucl. Phys. A126 (1969) 60
- 1969BR13 D.R. Brown, S.M. Ferguson and D.H. Wilkinson, Nucl. Phys. A135 (1969) 159
- 1969CA1A R.R. Carlson and H.W. Wyborny, Phys. Rev. 178 (1969) 1529
- 1969CH1A B.T. Chertok, Phys. Rev. 187 (1969) 1340
- 1969DE10 D. Dehnhard, N. Williams and J.L. Yntema, Phys. Rev. 180 (1969) 967; Erratum Phys. Rev. C1 (1970) 366
- 1969FI1A Filippov, Acad. Sci. Ikranian, SSR, Inst. Theor. Phys., Preprint ITF 69 63 (1969)
- 1969FR02 J.M. Freeman, J.G. Jenkin and G. Murray, Nucl. Phys. A124 (1969) 393
- 1969GA06 R.B. Galloway and D.G. Vass, Nucl. Phys. A127 (1969) 538
- 1969KR03 E. Krubasik, H. Voit, E. Blatt, H.-D. Helb and G. Ischenko, Z. Phys. 219 (1969) 185
- 1969MO29 T. Mo and W.F. Hornyak, Phys. Rev. 187 (1969) 1220
- 1969OR01 H. Orihara, T. Nakagawa, H. Ueno, T. Tohei, T. Yamaya, Y. Nakagome, M. Baba and S. Morita, Nucl. Phys. A139 (1969) 226
- 1969PA09 R.A. Paddock, S.M. Austin, W. Benenson, I.D. Proctor and F.S. Amant, Phys. Rev. 182 (1969) 1104
- 1969RO12 M.L. Roush, F.C. Young, P.D. Forsyth and W.F. Hornyak, Nucl. Phys. A128 (1969) 401
- 1969SC05 W. Scobel, Z. Naturforsch. A24 (1969) 289
- 1969SI12 J.D. Silverstein and G.H. Herling, Phys. Rev. 181 (1969) 1512
- 1969TO1A I.S. Towner, Nucl. Phys. A126 (1969) 97
- 1969VO10 U.C. Voos, W. von Oertzen and R. Bock, Nucl. Phys. A135 (1969) 207
- 1969WE10 K.J. Wetzel, Phys. Rev. 186 (1969) 1292
- 1969YO01 F.C. Young and W.F. Hornyak, Nucl. Phys. A124 (1969) 469
- 1970AJ04 F. Ajzenberg-Selove, Nucl. Phys. A152 (1970) 1
- 1970AN1B Andreev et al., Sov. J. Nucl. Phys. 10 (1970) 521
- 1970AU02 D.L. Auton, Nucl. Phys. A157 (1970) 305
- 1970BE1B Berurtey, Catollin and Schnabel, J. Phys. 31 (1970) C2

- 1970CL01 A.S. Clough, C.J. Batty, B.E. Bonner and L.E. Williams, Nucl. Phys. A143 (1970) 385
- 1970FI1B Fisher, Thesis, Stanford Univ. (1970); Phys. Abs. 67856 (1971)
- 1970GA01 A. Gallmann, G. Frick, B. Heusch, F. Haas and E.K. Warburton, Nucl. Phys. A143 (1970) 326
- 1970GO1B Goldfarb, Nucl. Reactions Induced by Heavy Ions, Heidelberg, 1969 (North-Holland, 1970) 115
- 1970NU02 F. Nusslin and P. Braun-Munzinger, Z. Phys. 240 (1970) 217
- 1970SO03 Y.I. Sorokin, A.K. Shardanov, V.G. Shevchenko and B.A. Yurev, Yad. Fiz. 11 (1970) 8; Sov. J. Nucl. Phys. 11 (1970) 4
- 1971BA41 M. Balakrishnan, M.K. Mehta and A.S. Divatia, Nuovo Cim. A1 (1971) 205
- 1971BI12 H.G. Bingham, K.W. Kemper and N.R. Fletcher, Nucl. Phys. A175 (1971) 374
- 1971DE37 C. Detraz, C.D. Zafiratos, C.E. Moss and C.S. Zaidins, Nucl. Phys. A177 (1971) 258
- 1971GL07 Y.A. Glukhov, B.G. Novatskii, A.A. Ogloblin, S.B. Sakuta, D.N. Stepanov and V.I. Chuev, Yad. Fiz. 13 (1971) 277; Sov. J. Nucl. Phys. 13 (1971) 154
- 1971KN05 H. Knoth, P.H. Barker, A. Huber, U. Matter, P.M. Cockburn and P. Marmier, Nucl. Phys. A172 (1971) 25
- 1971LI11 M. Liu, W. von Oertzen, J.C. Jacmart, F. Pougheon, M. Riou, J.C. Roynette and C. Stephan, Nucl. Phys. A165 (1971) 118
- 1971LI20 S.C. Ling and S.L. Blatt, Nucl. Phys. A174 (1971) 375
- 1971MI12 D. Miljanic and V. Valkovic, Nucl. Phys. A176 (1971) 110
- 1971PA10 B.H. Patrick, H.A. Medicus, G.K. Mehta, E.M. Bowey and D.B. Gayther, Phys. Lett. B34 (1971) 488
- 1971YO05 F.C. Young, R.A. Lindgren and W. Reichart, Nucl. Phys. A176 (1971) 289
- 1972AV01 R. Avida, I. Ben-Zvi, G. Goldring, S.S. Hanna, P.N. Tandon and Y. Wolfson, Nucl. Phys. A182 (1972) 359
- 1972DA26 S. Dahlgren, A. Johansson, P.-U. Renberg and G. Tibell, Phys. Scr. 6 (1972) 5
- 1972GO1A D.R. Goosman and D.E. Alburger, Phys. Rev. C5 (1972) 1893
- 1972HA63 S.S. Hanna, M. Hass, Z. Shkedi and Y.S. Horowitz, Nucl. Phys. A195 (1972) 91
- 1972MA21 C. Maples and J. Cerny, Phys. Lett. B38 (1972) 504
- 1972ME07 F. Merchez, J. Arvieux, T. Honda and S. Morita, Nucl. Phys. A183 (1972) 417
- 1972PA1C Parker, Astrophys. J. 175 (1972) 261
- 1972RE07 M.J. Renan, J.P.F. Sellschop, R.J. Keddy and D.W. Mingay, Phys. Rev. C6 (1972) 12
- 1972RO03 D.C. Robinson, J.M. Freeman and T.T. Thwaites, Nucl. Phys. A181 (1972) 645

- 1972RU03 C. Rudy, R. Vandenbosch, P. Russo and W.J. Braithwaite, Nucl. Phys. A188 (1972) 430.
- 1972SC21 D.K. Scott, P.N. Hudson, P.S. Fisher, C.U. Cardinal, N. Anyas-Weiss, A.D. Panagiotou and P.J. Ellis, Phys. Rev. Lett. 28 (1972) 1659
- 1972VA02 L. van der Zwan and K.W. Geiger, Nucl. Phys. A180 (1972) 615
- 1972VO17 H.J. Votava and W.J. Thompson, Phys. Lett. B41 (1972) 405
- 1972WE08 K.A. Weber, K. Meier-Ewert, H. Schmidt-Bocking and K. Bethge, Nucl. Phys. A186 (1972) 145
- 1972YA06 M. Yasue, T. Ohsawa, N. Fujiwara, S. Kakigi, D.C. Nguyen and S. Yamashita, J. Phys. Soc. Jpn. 33 (1972) 265
- 1973AT01 M.A. Atta and M.C. Scott, J. Nucl. Energy 27 (1973) 875
- 1973AU1A Augustson and Menlove, Trans. Amer. Nucl. Soc. 17 (1973) 494
- 1973BA81 L.K. Batist, E.E. Berlovich, Y.S. Blinnikov, Y.V. Elkin, Y.N. Novikov, B.M. Ovchinnikov and V.K. Tarasov, Izv. Akad. Nauk SSSR Ser. Fiz. 37 (1973) 1944; Bull. Acad. Sci. USSR Phys. Ser. 37 (1974) 124
- 1973BI1B Biro, Sudar, Csikai and Dezhov, Neitronnaya Fiz., III, 1973 (Obninsk USSR, Inst. Phys. & Power Eng., 1974) 85
- 1973BL1B Blatt, Suffert, Degre and Schaeffer, Asilomar (1973) Paper 884
- 1973BO1C Bouten, Bouten and Depuydt. Recent Devts. in Theor. Nucl. Phys., La Toussuire, 1973 (Villeurbanne, Franco Inst. Nucl. Phys., 1973) S1-1; Phys. Abs. 2783 (1974)
- 1973BR1C Bromley, in Munich 2 (1973) 22
- 1973CL1D Clements, Rept. AERE-R-7600 (1973); Phys. Abs. 40027 (1974)
- 1973CO1B Colgate, Explosive Nucleosynthesis (Univ. Texas Press, 1973) p. 248
- 1973DA09 S. Dahlgren, P. Grafstrom, B. Hoistad and A. Asberg, Nucl. Phys. A204 (1973) 53
- 1973GA19 S. Gamba, G. Ricco and G. Rottigni, Nucl. Phys. A213 (1973) 383
- 1973GO41 Y.P. Gorin, S.P. Denisov, S.V. Donskov, R.N. Krasnokutskii, A.I. Petrukhin, Y.D. Prokoshkin and D.A. Stoyanova, Yad. Fiz. 18 (1973) 336; Sov. J. Nucl. Phys. 18 (1974) 173
- 1973HO10 C.G. Hoot, D.K. Olsen, R.E. Brown, J.R. Maxwell and A. Scott, Nucl. Phys. A203 (1973) 339
- 1973HU09 R.J. Hughes and E.G. Muirhead, Nucl. Phys. A215 (1973) 147
- 1973KA16 E. Kashy, W. Benenson, I.D. Proctor, P. Hauge and G. Bertsch, Phys. Rev. C7 (1973) 2251
- 1973MA59 Y.G. Mashkarov, A.S. Deineko, I.I. Zalyubovskii, R.P. Slabospitskii and B.S. Bezvershuk, Izv. Akad. Nauk SSSR Ser. Fiz. 37 (1973) 1729; Bull. Acad. Sci. USSR Phys. Ser. 37 (1974) 143

- 1973MU14 S.F. Mughabghab and D.I. Garber, BNL 325, 3rd Edition, Vol. 1 (1973)
- 1973MU1B Mukgopadhyay, Lett. Nuovo Cim. 7 (1973) 460
- 1973OG1A Ogloblin, Sov. J. Part. Nucl. 3 (1973) 467
- 1973PA14 Y.S. Park, A. Niiler and R.A. Lindgren, Phys. Rev. C8 (1973) 1557; Erratum Phys. Rev. C9 (1974) 1673
- 1973RO24 U. Rohrer and L. Brown, Nucl. Phys. A210 (1973) 465
- 1973SC01 W. Schimmerling, T.J. Devlin, W.W. Johnson, K.G. Vosburgh and R.E. Mischke, Phys. Rev. C7 (1973) 248
- 1973SI27 A.J. Sierk and T.A. Tombrello, Nucl. Phys. A210 (1973) 341
- 1973SK1A Skopik, Shin, Horniachek and Kondu, Nucl. Phys. A197 (1973) 185
- 1973SR1A Srivastava and Sah, Indian J. Pure Appl. Phys. 13 (1973) 361; Phys. Abs. 19462 (1974)
- 1973SZ07 S. Szegedi, Acta Phys. Acad. Sci. Hung. (Hungary) 34 (1973) 215
- 1973TA30 K. Takahashi, M. Yamada and T. Kondoh, At. Data Nucl. Data Tables 12 (1973) 101
- 1973TI1A Tinsley, Explosive Nucleosynth. (Univ. Texas Press, 1973) p. 22
- 1973TR1B Truran, in Cosmochem., Ed. Cameron (Reidel Pub. Co., 1973) 23
- 1973VO02 H.J. Votava, T.B. Clegg, E.J. Ludwig and W.J. Thompson, Nucl. Phys. A204 (1973) 529; Erratum Nucl. Phys. A217 (1973) 628
- 1973VO1D Volkov, in Munich 2 (1973) 280
- 1973WE1D Webber, Lezniak, Kish and Damle, Astrophys. Space Sci. 24 (1973) 17
- 1974AD1C S.L. Adler, S. Nussinov and E.A. Paschos, Phys. Rev. D9 (1974) 2125
- 1974AJ01 F. Ajzenberg-Selove and T. Lauritsen, Nucl. Phys. A227 (1974) 1
- 1974AN27 R.E. Anderson, J.J. Kraushaar, M.E. Rickey and W.R. Zimmerman, Nucl. Phys. A236 (1974) 77
- 1974AN36 N. Anyas-Weiss, J.C. Cornell, P.S. Fisher, P.N. Hudson, A. Menchaca-Rocha, D.J. Millener, A.D. Panagiotou, D.K. Scott, D. Strottman, D.M. Brink et al., Phys. Rept. 12 (1974) 201
- 1974AS07 J. Asai and H. Ogata, Nucl. Phys. A233 (1974) 55
- 1974AU01 R.H. Augustson and H.O. Menlove, Nucl. Sci Eng. 54 (1974) 190
- 1974AU1A Audouze and Tinsley, Astrophys. J. 192 (1974) 487
- 1974AZ01 G. Azuelos, J.E. Crawford and J.E. Kitching, Phys. Rev. C9 (1974) 1213
- 1974BA15 G.C. Ball, J.G. Costa, W.G. Davies, J.S. Forster, J.C. Hardy and A.B. McDonald, Phys. Lett. B49 (1974) 33
- 1974BA70 G. Baroni, S. Di Liberto, S. Petrera and G. Romano, Nucl. Phys. A231 (1974) 521

- 1974BE66 W. Benenson and E. Kashy, Phys. Rev. C10 (1974) 2633
- 1974BI14 J. Birchall, H.E. Conzett, J. Arvieux, W. Dahme and R.M. Larimer, Phys. Lett. B53 (1974) 165
- 1974BO1E Bormann, Neuert and Scobel, IAEA, STI/DOC/10/156 (1974) 87
- 1974BO1P Bouten and Bouten, Int. Conf. Nucl. Struct. Spectrosc., Amsterdam 1974 (Amsterdam, Scolars Press 1974) 57
- 1974BO1U Bornec et al., Meson-Nucl. Phys., 1976 (AIP 1976) 260
- 1974BO29 M. Bouten and M.C. Bouten, Nucl. Phys. A228 (1974) 314
- 1974BO42 I. Bondouk, F. Asfour and F. Machali, Rev. Roum. Phys. 19 (1974) 551
- 1974BO45 I.I. Bondouk, F. Asfour and F. Machali, Atomkernenergie 24 (1974) 62
- 1974BO48 I.I. Bondouk, F. Asfour and F. Machali, Rev. Roum. Phys. 19 (1974) 1053
- 1974BO54 M. Bouten and M-C. Bouten, Czech. J. Phys. B24 (1974) 1277
- 1974BU05 I.F. Bubb, S.N. Bunker, M. Jain, J.W. Leonard, A. McIlwain, K.I. Roulston, K.G. Standing, D.O. Wells and B.G. Whitmore, Can. J. Phys. 52 (1974) 648
- 1974BU06 C.E. Busch, T.B. Clegg, S.K. Datta and E.J. Ludwig, Nucl. Phys. A223 (1974) 183
- 1974BU1A Bulow and Forkman, IAEA, STI/DOC/10/156 (1974) 475
- 1974CA1G Carruth, Larson, Gangotena and French, Bull. Amer. Phys. Soc. 19 (1974) 700
- 1974CA1H Cantwell et al., Nucl. Phys. A236 (1974) 445
- 1974CA1J Calamand, IAEA, STI/DOC/10/156 (1974) 273
- 1974CE06 J. Cerny, R.B. Weisenmiller, N.A. Jelley, K.H. Wilcox and G.J. Wozniak, Phys. Lett. B53 (1974) 247.
- 1974CE1A Cerny, in Nashville Vol. 2 (1974) 483
- 1974CH1L Chiang et al., Acta Phys. Sin. (China) 23 (1974) 362
- 1974DA18 N.E. Davison, M.J. Canty, D.A. Dohan and A. McDonald, Phys. Rev. C10 (1974) 50
- 1974DA27 S. Dahlgren and P. Grafstrom, Phys. Scr. 10 (1974) 104
- 1974DE1E De Jager, De Vries and De Vries, At. Data Nucl. Data Tables 14 (1974) 479
- 1974DI20 M. Dillig and M.G. Huber, Lett. Nuovo Cim. 11 (1974) 728
- 1974DO1G Dollhopf, Perdrisat, Kitching and Olsen, Bull. Amer. Phys. Soc. 19 (1974) 43
- 1974EN10 R. Engfer, H. Schneuwly, J.L. Vuilleumier, H.K. Walter and A. Zehnder, At. Data Nucl. Data Tables 14 (1974) 509
- 1974FO22 J.L.C. Ford, Jr., K.S. Toth, G.R. Satchler, D.C. Hensley, L.W. Owen, R.M. DeVries, R.M. Gaedke, P.J. Riley and S.T. Thornton, Phys. Rev. C10 (1974) 1429
- 1974FR02 E. Friedland, H.W. Alberts and J.C. van Staden, Z. Phys. 267 (1974) 97

- 1974GO1J Goosman, Nucl. Instrum. Meth. Phys. Res. 116 (1974) 445
- 1974GU13 V.B. Gubin and E.A. Romanovskii, Izv. Akad. Nauk SSSR Ser. Fiz. 38 (1974) 752; Bull. Acad. Sci. USSR Phys. Ser. 38 (1974) 76
- 1974GU23 I.R. Gulamov, E.A. Romanovskii and T.I. Spasskaya, Izv. Akad. Nauk SSSR Ser. Fiz. 38 (1974) 860; Bull. Acad. Sci. USSR Phys. Ser. 38 (1974) 173
- 1974GU24 V.B. Gubin and E.A. Romanovskii, Izv. Akad. Nauk SSSR Ser. Fiz. 38 (1974) 144; Bull. Acad. Sci. USSR Phys. Ser. 38 (1974) 125
- 1974HA1C Hanna, Int. Conf. Nucl. Struct. Spectrosc., Pt. II, Amsterdam, 1974 (Amsterdam, Scholars Press, 1974) 249
- 1974HE1E Hermsdorf et al., ZFK 277 (1974)
- 1974HU14 J. Hufner, L. Tauscher and C. Wilkin, Nucl. Phys. A231 (1974) 455
- 1974HY01 M. Hyakutake, M. Sonoda, A. Katase, Y. Wakuta, M. Matoba, H. Tawara and I. Fujita, J. Nucl. Sci. Tech. (Japan) 11 (1974) 407
- 1974IR04 J.M. Irvine, G.S. Mani and M. Vallieres, Czech. J. Phys. B24 (1974) 1269
- 1974JA11 W.W. Jacobs, D. Bodansky, D. Chamberlin and D.L. Oberg, Phys. Rev. C9 (1974) 2134
- 1974JO01 P.L. Jolivette, Phys. Rev. C9 (1974) 16
- 1974JO13 L.W. Jones, C.A. Ayre, H.R. Gustafson, M.J. Longo and P.V. Ramana Murthy, Phys. Rev. Lett. 33 (1974) 1440
- 1974KA15 E. Kashy, W. Benenson and J.A. Nolen, Jr., Phys. Rev. C9 (1974) 2102
- 1974KA34 M.C. Karadeniz, J. Phys. A7 (1974) 2284
- 1974KE06 K.W. Kemper, S. Cotanch, G.E. Moore, A.W. Obst, R.J. Puigh and R.L. White, Nucl. Phys. A222 (1974) 173
- 1974KO1G Kohler and Bethge, Proc. Conf. Reactions Between Complex Nucl., Vol. 1 (North-Holland, 1974) 35
- 1974KO24 S.D. Kostyuchenkov, V.M. Lebedev, A.V. Spasskii and I.B. Teplov, Vestn. Mosk. Univ. Fiz. Astron. 15 (1974) 424
- 1974KO35 E. Kondaiiah, J. Phys. 7A (1974) 1457
- 1974LA18 H. Laumer, S.M. Austin and L.M. Panggabean, Phys. Rev. C10 (1974) 1045
- 1974LE12 Y. Le Bornec, B. Tatischeff, L. Bimbot, I. Brissaud, J.P. Garron, H.D. Holmgren, F. Reide and N. Willis, Phys. Lett. B49 (1974) 434
- 1974LE14 V.M. Lebedev, A.V. Spassky, I.B. Teplov and N.S. Zelenskaya, Nucl. Phys. A223 (1974) 351
- 1974LI15 B.J. Lieb and H.O. Funsten, Phys. Rev. C10 (1974) 1753
- 1974LO1B Lorenzen and Brune, IAEA, STI/DOC/10/156 (1974) 325

- 1974MC19 W.F. McGill, R.F. Carlson, T.H. Short, J.M. Cameron, J.R. Richardson, I. Slaus, W.T.H. van Oers, J.W. Verba, D.J. Margaziotis and P. Doherty, *Phys. Rev. C* 10 (1974) 2237
- 1974MI06 G.A. Miller, *Nucl. Phys. A* 224 (1974) 269
- 1974MO23 C.E. Moss and C.S. Zaidins, *Nucl. Phys. A* 235 (1974) 11
- 1974MU13 N.C. Mukhopadhyay and F. Cannata, *Phys. Lett. B* 51 (1974) 225
- 1974NI1A N.N. Nikolaev and M.Zh. Shmatikov, *Phys. Lett. B* 52 (1974) 293
- 1974RA09 G.M. Raisbeck and F. Yiou, *Phys. Rev. C* 9 (1974) 1385
- 1974RE1A Reeves, *Ann. Rev. Astron. Astrophys.* 12 (1974) 437
- 1974RI1A Rickey et al., *Bull. Amer. Phys. Soc.* 19 (1974) 1007
- 1974RO21 D.C. Robinson and P.H. Barker, *Nucl. Phys. A* 225 (1974) 109
- 1974SC1C Schwartz, Schrack and Heaton, *NBS Monograph* 138 (1974)
- 1974SC1D Schramm, *Ann. Astron. Astrophys.* 12 (1974) 383
- 1974SE1B Serov, *Izv. Akad. Nauk SSSR Ser. Fiz.* 38 (1974) 84
- 1974SHYR V.S. Shirley and C.M. Lederer, *LBL-3450* (1974)
- 1974SO1D Sorriaux, Rubio and Boudet, *Nucl. Instrum. Meth. Phys. Res.* 118 (1974) 213
- 1974ST01 H. Stocker and C.P. Browne, *Phys. Rev. C* 9 (1974) 102
- 1974ST13 H. Stehle, H. Eichner, H.J. Helten, H. Klein, H. Kretzer, K. Prescher and W.W. Wohlfarth, *Nucl. Phys. A* 228 (1974) 229
- 1974TA18 L. Tauscher and W. Schneider, *Z. Phys.* 271 (1974) 409
- 1974TA20 V.K. Tartakovsky, A.V. Fursaev and Y.V. Kobrinsky, *Ukr. Fiz. Zh.* 19 (1974) 1821; *Phys. Abs.* 9067 (1975)
- 1974TH01 C. Thibault and R. Klapisch, *Phys. Rev. C* 9 (1974) 793
- 1974VA03 S.S. Vasilev, B.S. Galakhmatova, V.B. Gubin, T.N. Mikhaleva, E.A. Romanovskii, D.L. Chuprunov, A.S. Demyanova and L.I. Nikitina, *Yad. Fiz.* 19 (1974) 28; *Sov. J. Nucl. Phys.* 19 (1974) 14
- 1974VA1E Van Sen et al., *Int. Conf. Nucl. Struct. Spectrosc.*, Amsterdam, 1974 (Amsterdam, Scholars Press, 1974) 180
- 1974WE11 D.R. Weaver and J. Walker, *J. Phys. D* 7 (1974) 1122
- 1974WI02 D.H. Wilkinson and B.E.F. Macefield, *Nucl. Phys. A* 232 (1974) 58
- 1974WI21 L.W.J. Wild and G.B. Crinean, *Aust. J. Phys.* 27 (1974) 663
- 1974WO1C Wozniak, *LBL 2999* (1974)
- 1974YA05 M. Yasue, *J. Phys. Soc. Jpn.* 36 (1974) 1254
- 1974YA1C Yasue et al., *Bull. Inst. Chem. Res. Kyoto Univ.* 52 (1974) 177

- 1974ZH01 M.A. Zhusupov, E.Z. Magzumov and V.I. Markov, Phys. Lett. B48 (1974) 84
- 1975AB1D Abdul-Magd, Prog. Theor. Phys. 53 (1975) 997
- 1975AD04 J.-O. Adler, G.G. Jonsson and K. Lindgren, Nucl. Phys. A239 (1975) 440
- 1975AJ02 F. Ajzenberg-Selove, Nucl. Phys. A248 (1975) 1
- 1975AN1C Antolkovic and Turk, in Clustering Phenomena in Nuclei, II, ORO-4856-26 (1975) 307
- 1975AU02 W. Auwarter and V. Meyer, Nucl. Phys. A242 (1975) 129
- 1975AU1C August et al., Bull. Amer. Phys. Soc. 20 (1975) 1181
- 1975AZ02 S.A. Azimov, U.R. Arifkhanov, M. Gulyamov, B.I. Islamov, T. Iskhakov, A.M. Mukhamedzhanov, E. Ergashov, Y.I. Faizullaev and R. Yarmukhamedov, Yad. Fiz. 22 (1975) 225; Sov. J. Nucl. Phys. 22 (1976) 115
- 1975BA05 S. Barshay, C.B. Dover and J.P. Vary, Phys. Rev. C11 (1975) 360
- 1975BA1H Balashov, in Clustering Phenomena in Nucl, II, ORO-4856-26 (1975) 281
- 1975BA1Q Batist et al., Sov. J. Nucl. Phys. 20 (1975) 453
- 1975BA52 H.W. Baer, J.A. Bistirlich, N. de Botton, S. Cooper, K.M. Crowe, P. Truol and J.D. Vergados, Phys. Rev. C12 (1975) 921
- 1975BE31 M. Beiner, R.J. Lombard and D. Mas, Nucl. Phys. A249 (1975) 1
- 1975BI07 T. Biro, S. Sudar, Z. Miligy, Z. Dezso and J. Csikai, J. Inorg. Nucl. Chem. 37 (1975) 1583
- 1975BL10 J.S. Blair, M.P. Baker and H.S. Sherif, Phys. Lett. B60 (1975) 25
- 1975BO55 I.I. Bondouk, F. Asfour, Z. Saleh and F. Machali, Rev. Roum. Phys. 20 (1975) 1095
- 1975BO56 I. Bondouk, F. Asfour, F. Machali and Z. Saleh, Rev. Roum. Phys. 20 (1975) 1111
- 1975BU27 N.T. Burtebaev, A.D. Vongai, Y.A. Glukhov, A.D. Duisebaev, T.A. Dmitrieva, G.N. Ivanov, I.I. Kuzmin, S.V. Laptev, N.S. Zelenskaya, A.A. Ogloblin et al., Izv. Akad. Nauk SSSR Ser. Fiz. 39 (1975) 2160; Bull. Acad. Sci. USSR Phys. Ser. 39 (1975) 131
- 1975CA1L Carlson et al., Nucl. Instrum. Meth. Phys. Res. 123 (1975) 509
- 1975CI1B Ciric et al., Fiz. (Yugoslavis) Suppl. 7 (1975) 64
- 1975CL01 D. Clement, E.J. Kanellopoulos and K. Wildermuth, Phys. Lett. B55 (1975) 19
- 1975CL1C Clement, Kanellopoulos and Wildermuth, Acta Phys. Austriaca 42 (1975) 29
- 1975CO15 M. Conjeaud, S. Harar, E.F. Da Silveira and C. Volant, Nucl. Phys. A250 (1975) 182
- 1975CO1E Cork, in LASL, AIP Conf. Proc. 26 (1975) 598
- 1975DI04 H. Dirim, J.P. Elliott and J.A. Evans, Nucl. Phys. A244 (1975) 301
- 1975DI08 G. Dietl, G. Gruber, H. Schmidt-Bocking and K. Bethge, Nucl. Phys. A250 (1975) 322

- 1975EP02 B.W. Epperlein, O. Lutz and A. Schwenk, *Z. Naturforsch.* 30A (1975) 955
- 1975FA1A Fagg, *Rev. Mod. Phys.* 47 (1975) 683
- 1975FO19 W.A. Fowler, G.R. Caughlan and B.A. Zimmerman, *Ann. Rev. Astron. Astrophys.* 13 (1975) 69
- 1975GA1D Garcia-Munoz, Mason and Simpson, *Astrophys. J.* 201 (1975) L141
- 1975GI1B Gibson et al., *Bull. Amer. Phys. Soc.* 20 (1975) 1193
- 1975GR13 D.E. Greiner, P.J. Lindstrom, H.H. Heckman, B. Cork and F.S. Bieser, *Phys. Rev. Lett.* 35 (1975) 152
- 1975HA45 J.C. Hardy and I.S. Towner, *Nucl. Phys.* A254 (1975) 221
- 1975HO01 R.J. Holt, F.W.K. Firk, G.T. Hickey and R. Nath, *Nucl. Phys.* A237 (1975) 111
- 1975HO1F Hollandsworth, Bucher, Youngblood and Niiler, *Rept. BRL-1764* (1975); *Phys. Abs.* 982 (1976)
- 1975HU18 S.-L. Huang, W.-S. Hsu and Y.-C. Liu, *Chin. J. Phys. (Taiwan)* 13 (1975) 252
- 1975HU1D Hufner, *Phys. Rept.* C21 (1975) 1
- 1975JE02 N.A. Jelley, J. Cerny, D.P. Stahel and K.H. Wilcox, *Phys. Rev.* C11 (1975) 2049
- 1975JE04 H. Jeremie and J. Baltar, *Can. J. Phys.* 53 (1975) 2639
- 1975KA1F Kanda, Kadotani and Aizawa, *J. Nucl. Sci. Tech.* 12 (1975) 601
- 1975KN1C B. Knapp, W. Lee, P. Leung, S.D. Smith, A. Wijangco, J. Knauer, D. Yount, D. Nease, J. Bronstein, R. Coleman et al., *Phys. Rev. Lett.* 34 (1975) 1044
- 1975KR14 S. Krol and S. Szpikowski, *Acta Phys. Pol.* B6 (1975) 409
- 1975KU01 D. Kurath and D.J. Millener, *Nucl. Phys.* A238 (1975) 269
- 1975KU15 J.A. Kuehner, P.W. Green, G.D. Jones and D.T. Petty, *Phys. Rev. Lett.* 35 (1975) 423
- 1975MA1H Mashkarov, Chegoryan and Zalyubovskii, *Izv. Akad. Nauk SSSR Ser. Fiz.* 39 (1975) 560
- 1975MC18 M.W. McNaughton, N.S.P. King, F.P. Brady, J.L. Romero and T.S. Subramanian, *Nucl. Instrum. Meth. Phys. Res.* 130 (1975) 555
- 1975ME1E Meneguizzi and Reeves, *Astron. Astrophys.* 40 (1975) 91, 99
- 1975MU1A Muller, Henkelmann and Boroffka, *Nucl. Instrum. Meth.* 129 (1975) 557
- 1975MU1B Murthy, *Nucl. Phys.* B92 (1975) 269
- 1975NA15 K.G. Nair, H. Voit, C.W. Towsley, M. Hamm, J.D. Bronson and K. Nagatani, *Phys. Rev.* C12 (1975) 1575
- 1975OB01 D.L. Oberg, D. Bodansky, D. Chamberlin and W.W. Jacobs, *Phys. Rev.* C11 (1975) 410
- 1975RA12 G.M. Raisbeck and F. Yiou, *Phys. Rev. Lett.* 35 (1975) 155

- 1975RA14 G.M. Raisbeck, J. Lestringuez and F. Yiou, Phys. Lett. B57 (1975) 186
- 1975RA21 G.M. Raisbeck, P. Boerstling, R. Klapisch and T.D. Thomas, Phys. Rev. C12 (1975) 527
- 1975RA37 S. Raman, T.A. Walkiewicz and H. Behrens, At. Data Nucl. data Tables 16 (1975) 451
- 1975RE01 A. Reitan, Nucl. Phys. A237 (1975) 465
- 1975RE1C Remaud and Laskar, in Clustering Phenom. in Nucl., II, ORO-4856-26 (1975) 232
- 1975RO1G Rosen, in Lasl, AIP Conf. Proc. 26 (1975) 265
- 1975SC27 M.J. Schneider, B.W. Ridley, M.E. Rickey, J.J. Kraushaar and W.R. Zimmerman, Phys. Rev. C12 (1975) 335
- 1975SC41 U. Schwinn, G. Mairle, G.J. Wagner and C. Ramer, Z. Phys. A275 (1975) 241
- 1975SE1G Sellyey, Ferguson and Bernstein, Bull. Amer. Phys. Soc. 20 (1975) 1164
- 1975SL02 I. Slaus, D.J. Margaziotis, R.F. Carlson, W.T.H. van Oers and J.R. Richardson, Phys. Rev. C12 (1975) 1093
- 1975SR01 M.L. Srivastava and J.P. Sah, Indian J. Pure Appl. Phys. 13 (1975) 243
- 1975SZ03 L. Szybisz, Z. Phys. A273 (1975) 277
- 1975TA1C Tauscher, in LASL, AIP Conf. Proc. 26 (1975) 541
- 1975TR1A Trimble, Rev. Mod. Phys. 47 (1975) 877
- 1975VE05 J.D. Vergados, Phys. Rev. C12 (1975) 1278
- 1975WA06 P. Wagner, R.M. Freeman, A. Gallman and E.K. Warburton, Phys. Rev. C11 (1975) 1459
- 1975WI26 K.H. Wilcox, R.B. Weisenmiller, G.J. Wozniak, N.A. Jelley, D. Ashery and J. Cerny, Phys. Lett. B59 (1975) 142.
- 1975ZA08 N.I. Zaika, Y.V. Kibkalo, A.V. Mokhnach, O.F. Nemets, V.S. Semenov, F.P. Tokarev and P.L. Shmarin, Yad. Fiz. 21 (1975) 460; Sov. J. Nucl. Phys. 21 (1975) 241
- 1975ZE01 A.M. Zebelman, A.M. Poskanzer, J.D. Bowman, R.G. Sextro and V.E. Viola, Jr., Phys. Rev. C11 (1975) 1280
- 1975ZW01 Zwiegliniski, Saganek, Sledzinska and Wilhelmi, Nucl. Phys. A250 (1975) 93
- 1976AJ01 F. Ajzenberg-Selove, C.F. Maguire, D.L. Hendrie, D.K. Scott and J. Mahoney, Phys. Rev. C13 (1976) 46
- 1976AJ04 F. Ajzenberg-Selove, Nucl. Phys. A268 (1976) 1
- 1976AR1F Arnould, in Polariz., Zurich, 1975 (Birkhauser Verlag, 1976) 503
- 1976AS1B Aslanides, Meson-Nucl. Phys., 1976 (AIP, 1976) 204
- 1976AU1B Audouze and Lequeux, Astron. Astrophys. 49 (1976) 133

- 1976AU1C Audouze, Meneguzzi and Reeves, in Spallation Nucl. Reactions & Their Applic., Shen/Marker Eds. (D. Reidel, Holland 1976) 113
- 1976AU1D Auchampaugh, Plattard, Extermann and Ragan, in Lowell Conf., CONF-760715-P2 (1976) 1389
- 1976BA1Q Baker et al., in Polariz., Zurich, 1975 (Birkhauser Verlag, 1976) 628
- 1976BA1R Bacher et al., Bull. Amer. Phys. Soc. 21 (1976) 983
- 1976BE1E Behrens and Lzybisz, Phys. Data (1976) (ZAED)
- 1976BE1G Berlovich, Izv. Akad. Nauk SSSR Ser. Fiz. 40 (1976) 756
- 1976BE1H Berman, Preprint UCRL-78482 (1976)
- 1976BE1K Bertini, in Spallation Nucl. Reactions and Their Appl., Eds., Shen and Merker (D. Reidel, The Netherlands, 1976) p. 27
- 1976BE1M Bentheim et al., Z. Phys. A279 (1976) 163
- 1976BI10 P.G. Bizzeti and A. Perego, Phys. Lett. B64 (1976) 298
- 1976BI1B Bilpuch et al., in Lowell Conf. 760715-P2 (1976) 1309
- 1976BL1B Blair, Baker and Sherif, in Polariz., Zurich, 1975 (Birkhauser Verlag, 1976) 636
- 1976BO1E Boesgaard, Publ. Astron. Soc. Pac. 88 (1976) 353
- 1976BU16 M. Buenerd, C.K. Gelbke, B.G. Harvey, D.L. Hendrie, J. Mahoney, A. Menchaca-Rocha, C. Olmer and D.K. Scott, Phys. Rev. Lett. 37 (1976) 1191
- 1976BY1A Byrd et al., Bull. Amer. Phys. Soc. 21 (1976) 637
- 1976CH28 A. Chevarier, N. Chevarier, A. Demeyer, P. Martin and P. de Saintignon, Nucl. Phys. A274 (1976) 223
- 1976CO1B Colgate, Audouze and Fowler, OAP-458 (1976)
- 1976CR1B Crostwaithe, Clark, Donoghue and Morgan, Bull. Amer. Phys. Soc. 21 (1976) 925
- 1976DA15 S.E. Darden, G. Murillo and S. Sen, Nucl. Phys. A266 (1976) 29
- 1976DA1F Davis, in Spallation Nucl. Reactions & Their Appl., Eds., Shen and Merker (D. Reidel Pub. Co., Netherlands, 1976) 207
- 1976DE15 R. de Swiniarski, F.G. Resmini, C. Glashausser and A.D. Bacher, Helv. Phys. Acta 49 (1976) 227
- 1976DE1D Deloff and Law, Meson-Nucl. Phys., 1976 (AIP, 1976) 544, 546
- 1976DE27 G. Delic and D. Kurath, Phys. Rev. C14 (1976) 619
- 1976DE34 A.E. Denisov, R.P. Kolalis, V.S. Sadkovskii and G.A. Feofilov, Yad. Fiz. 24 (1976) 249; Sov. J. Nucl. Phys. 24 (1976) 129
- 1976DI10 M. Dillig and M.G. Huber, Lett. Nuovo Cim. 16 (1976) 293
- 1976DI13 F.S. Dietrich, L.F. Hansen and R.P. Koopman, Nucl. Sci. Eng. 61 (1976) 267

- 1976DU05 J. Dubach, J.H. Koch and T.W. Donnelly, Nucl. Phys. A271 (1976) 279
- 1976EA1A Earwacker and Walker, in Lowell CONF-760715-P2 (1976)
- 1976ED1A Edge, Tompkins and Glenn, Nuovo Cim. A31 (1976) 641
- 1976EG1A Egelhof et al., in Polariz., Zurich, 1975 (Birkhauser Verlag, 1976) 825
- 1976EN02 H.D. Engelhardt, C.W. Lewis and H. Ullrich, Nucl. Phys. A258 (1976) 480
- 1976EP1A Epsteain, Arnett and Schramm, Astrophys. J. Suppl. 31 (1976) 111
- 1976FA13 L.W. Fagg, R.A. Lindgren, W.L. Bendel and E.C. Jones, Jr., Phys. Rev. C14 (1976) 1727
- 1976FR1D Freeman et al., At. Masses & Fund. Constants, Eds. Sanders and Wapstra (Plenum Press, 1976) 126
- 1976FU06 G.H. Fuller, J. Phys. Chem. Ref. Data 5 (1976) 835
- 1976FU1B Fukui, Enge and Beaujean, Z. Phys. A277 (1976) 99
- 1976GA34 N. Gabr and H.H. Hackenbroich, Acta Phys. Austr. 46 (1976) 9
- 1976GAYV D.I. Garber and R.R. Kinsey, BNL 325, Vol. 2 (1976)
- 1976GI01 W.R. Gibbs, B.F. Gibson, A.T. Hess, G.J. Stephenson, Jr. and W.B. Kaufmann, Phys. Rev. Lett. 36 (1976) 85
- 1976GI1C Ginzburg and Ptjskin, Rev. Mod. Phys. 48 (1976) 161
- 1976HA1F Hainebach, Schramm and Blake, Astrophys. J. 205 (1976) 920
- 1976HI05 M.D. High and B. Cujec, Nucl. Phys. A259 (1976) 513
- 1976HO1B Hogue et al., Bull. Amer. Phys. Soc. 21 (1976) 188
- 1976HU05 A. Huck, G. Klotz and G. Walter, Nucl. Instrum. Meth. 133 (1976) 125
- 1976HU1B Hutcheaon et al., Bull. Amer. Phys. Soc. 21 (1976) 775
- 1976IR02 M. Irshad, J. Asai, S. Sen, R. Pigeon and R.J. Slobodrian, Nucl. Phys. A265 (1976) 349
- 1976IR1B Irvine et al., Ann. Phys. 102 (1976) 129
- 1976JO1A Jones and Okazaki, Bull. Amer. Phys. Soc. 21 (1976) 817
- 1976KA1E Kassen, Egelhof and Steffens, in Polariz., Zurich, 1975 (Birkhauser Verlag, 1976) 873
- 1976KA23 O. Karban, A.K. Basak, J.B.A. England, G.C. Morrison, J.M. Nelson, S. Roman and G.G. Shute, Nucl. Phys. A269 (1976) 312
- 1976KN04 U. Kneissl, K.H. Leister, H.O. Neidel and A. Weller, Nucl. Phys. A264 (1976) 30
- 1976KO03 V.I. Komarov, G.E. Kosarev, E.S. Kuzmin, A.G. Molokanov, G.P. Reshetnikov, O.V. Savchenko and S. Tesch, Nucl. Phys. A256 (1976) 362
- 1976LE1F Lefort, Rept. Prog. 39 (1976) 129

- 1976LE1K Lebedev et al., in Contrib. to Dubna Conf. on Selected Topics in Nucl. Struct., Vol. 1, JINR D-9682 (1976) 98
- 1976LI08 P.W. Lisowski, R.L. Walter, C.E. Busch and T.B. Clegg, Nucl. Phys. A264 (1976) 188
- 1976LI1J Lisowski et al., in Polariz., Zurich, 1975 (Birkhauser Verlag, 1976) 499
- 1976LI1K Lingenfelter, in Spallation Nucl. Reactions & Their Applic., Eds. Shen and Merker (D. Reidel Pub. Co., Netherlands, 1976) 193
- 1976LI26 E. Lipparini, S. Stringari and M. Traini, Nuovo Cim. A34 (1976) 48
- 1976MA04 F. Malaguti and P.E. Hodgson, Nucl. Phys. A257 (1976) 37
- 1976MA43 R. Madey, F.M. Waterman and A.R. Baldwin, Phys. Rev. C14 (1976) 801
- 1976MA50 R.G. Markham and M.A.M. Shahabuddin, Phys. Rev. C14 (1976) 2037
- 1976MA58 Y.G. Mashkarov, A.S. Deineko, R.P. Slabospitskii and I.I. Zalyubovskii, Izv. Akad. Nauk SSSR Ser. Fiz. 40 (1976) 1218; Bull. Acad. Sci. USSR Phys. Ser. 40 (1976) 100
- 1976MA64 Y.G. Mashkarov, A.S. Deineko and R.P. Slabospitskii, Izv. Akad. Nauk SSSR Ser. Fiz. 40 (1976) 2189; Bull. Acad. Sci. USSR Phys. Ser. 40 (1976) 140
- 1976MI13 T. Mikumo, I. Kohno, K. Katori, T. Motobayashi, S. Nakajima, M. Yoshie and H. Kamitsubo, Phys. Rev. C14 (1976) 1458
- 1976MI1B Miranda, Shapiro and Chou, Bull. Amer. Phys. Soc. 21 (1976) 47
- 1976MO1B Moss, Brown and Cornelius, Bull. Amer. Phys. Soc. 21 (1976) 990
- 1976NA11 M.N. Namboodiri, E.T. Chulick and J.B. Natowitz, Nucl. Phys. A263 (1976) 491
- 1976NO1D Noble, Meson-Nucl. Phys.-1976 (AIP, 1976) 221
- 1976NO1E Northcliffe, in Lowell Conf., CONF-760715-P1 (1976) 808
- 1976OS04 R. Ost, N.E. Sanderson, S. Mordechai, J.B.A. England, B.R. Fulton, J.M. Nelson and G.C. Morrison, Nucl. Phys. A265 (1976) 142
- 1976PE1A C. Perron, Phys. Rev. C14 (1976) 1108
- 1976PO02 J.E. Poling, E. Norbeck and R.R. Carlson, Phys. Rev. C13 (1976) 648
- 1976RA1C Raisbeck and Yiou, Spallation Nucl. Reactions & Their Appl., Eds., Shen and Merker (D. Reidel, Netherlands, 1976) 83
- 1976RA1F J. Ranft and G. Ranft, Phys. Rev. Lett. 36 (1976) 988
- 1976RO04 R.G.H. Robertson, W. Benenson, E. Kashy and D. Mueller, Phys. Rev. C13 (1976) 1018
- 1976RO05 U. Rohrer and L. Brown, Nucl. Phys. A261 (1976) 141
- 1976RO10 J.L. Romero, F.P. Brady and J.A. Jungerman, Nucl. Instrum. Meth. 134 (1976) 537
- 1976RO12 C.T. Roche, R.G. Clark, G.J. Mathews and V.E. Viola, Jr., Phys. Rev. C14 (1976) 410

- 1976RO14 C. Rogers, Nucl. Phys. A271 (1976) 447
- 1976SC1F Schramm, Bull. Amer. Phys. Soc. 21 (1976) 603
- 1976SH01 Y. Shamaï, J. Alster, D. Ashery, S. Cochavi, M.A. Moinester, A.I. Yavin, E.D. Arthur and D.M. Drake, Phys. Rev. Lett. 36 (1976) 82
- 1976SH1J Sherif, in Polariz. Zurich, 1975 (Birkhauser Verlag, 1976) 189
- 1976SI1C Simpson, Bull. Amer. Phys. Soc. 21 (1976) 602
- 1976SI1D Silberberg, Tsao and Shapiro, in Spallation Nucl. Reactions & Their Appl., Eds., Shen and Mercer (D. Reidel, Netherlands, 1976) p. 49
- 1976SM02 W. Smolec, S. Burzynski, K. Rusek, I.M. Turkiewicz, J. Turkiewicz and P. Zupranski, Nucl. Phys. A257 (1976) 397
- 1976ST12 R.G. Stokstad, Z.E. Switkowski, R.A. Dayras and R.M. Wieland, Phys. Rev. Lett. 37 (1976) 888
- 1976VA07 A. van der Woude and R.J. de Meijer, Nucl. Phys. A258 (1976) 199
- 1976VA29 G.V. Valskii, Yad. Fiz. 24 (1976) 270; Sov. J. Nucl. Phys. 24 (1976) 140
- 1976VE1A Veeseer and Arthur, in Lowell Conf., CONF-760715-P2, Vol. 2 (1976) 1351
- 1976VI1A Vidal-Quadras et al., Nuovo Cim. B34 (1976) 380
- 1976VO1C Voinova, INDC(CCP)-93/N (1976)
- 1976WA1B Walter, in Polariz., Zurich, 1975 (Birkhauser Verlag, 1976) 377
- 1976WA1C Walter and Lisowski, in Lowell Conf., CONF-760715-P2 (1976) p. 1061
- 1976WE09 R.B. Weisenmiller, N.A. Jelley, K.H. Wilcox, G.J. Wozniak and J. Cerny, Phys. Rev. C13 (1976) 1330
- 1976WI05 N. Willis, I. Brissaud, L. Bimbot, Y. Le Bornec and B. Tatischeff, Nucl. Phys. A261 (1976) 45
- 1976WO11 G.J. Wozniak, D.P. Stahel, J. Cerny and N.A. Jelley, Phys. Rev. C14 (1976) 815
- 1976ZE04 A.F. Zeller, M.E. Williams-Norton, R.J. Puigh, G.E. Moore, K.W. Kemper and G.M. Hudson, Phys. Rev. C14 (1976) 2162
- 1977AM1B Amann et al., Bull. Amer. Phys. Soc. 22 (1977) 1007
- 1977AN1E Anderson et al., Bull. Amer. Phys. Soc. 22 (1977) 998
- 1977AN21 I. Angeli and M. Csatlos, Nucl. Phys. A288 (1977) 480
- 1977AR06 A.G. Artukh, G.F. Gridnev, V.L. Mikheev and V.V. Volkov, Nucl. Phys. A283 (1977) 350
- 1977AS1D Aslanides et al., in Tokyo (1977), Contrib. Papers p. 844
- 1977AS1E Aslanides et al., in Proc. Zurich-Sin. (1977) 17
- 1977AU1B Austin, MSUCL-254 (1977)

- 1977AV01 V.V. Avdeychikov, V.I. Bogatin and O.V. Lozhkin, *Yad. Fiz.* 25 (1977) 3; *Sov. J. Nucl. Phys.* 25 (1977) 1
- 1977AZ02 G. Azuelos and J.E. Kitching, *Nucl. Phys.* A285 (1977) 19
- 1977BA11 F.C. Barker and G.T. Hickey, *J. Phys. (London)* G3 (1977) L23
- 1977BA1N D. Baye, J. Deenen and Y. Salmon, *Nucl. Phys.* A289 (1977) 511
- 1977BA1P Batusov and Eramzhyan, *Fiz. Elem. Chastits At. Yad. (USSR)* 8 (1977) 229
- 1977BA1Q Baer, in *High Energy Phys. & Nucl. Struct., Zurich 1977* (Birkhauser Verlag, 1977) 245
- 1977BA2E Bansal and Kumar, *Pramana* 9 (1977) 273
- 1977BA2G Barnes, *Proc. Int. Conf. Nucl. Struct., Tokyo (1977)*; *J. Phys. Soc. Jpn. Suppl.* 44 (1978) 783
- 1977BA2H Bacher et al., in *Tokyo (1977)*, *Contrib. Papers* p. 812
- 1977BA2K Bains and Galloway, *Nucl. Instrum. Meth. Phys. Res.* 143 (1977) 295
- 1977BA2L Barker and Nolen, in *Tokyo (1977)*, *Contrib. Papers* p. 155
- 1977BA51 B. Bassalleck, W.-D. Klotz, F. Takeutchi, H. Ullrich and M. Furic, *Phys. Rev.* C16 (1977) 1526
- 1977BE1W Bent, Debevec, Pile and Pollock, *Bull. Amer. Phys. Soc.* 22 (1977) 81
- 1977BI1D Bizzeti, *Nucl. Instrum. Meth. Phys. Res.* 146 (1977) 285
- 1977BO1V Bouten, Flerackers and Bouten, in *Tokyo (1977)*, *Contrib. Papers* p. 153
- 1977BO29 I.I. Bondouk and S. Saad, *Atomkernenergie* 29 (1977) 270
- 1977BR1J Brajnik et al., *Fiz. (Yugoslavia)* 9, *Suppl.* 1 (1977) 48; *Phys. Abs.* 13056 (1978)
- 1977BY1A Byrd, Lisowski, Tornow and Walter, *Bull. Amer. Phys. Soc.* 22 (1977) 587
- 1977CA1E Carter et al., in *Proc., Zurich-Sin (1977)* p. 318
- 1977CI1A Ciric et al., *Fizika (Yugoslavia)* 9, *Suppl.* 1 (1977) 39; *Phys. Abs.* 17216 (1978)
- 1977CO17 J.D. Cossairt, W.S. Burns and R.A. Kenefick, *Nucl. Phys.* A287 (1977) 13
- 1977CO1G Colombo et al., in *Tokyo (1977)*, *Contrib. Papers* p. 490
- 1977DE08 C. Detraz, *Phys. Lett.* B66 (1977) 333
- 1977DO06 G.E. Dogotar, R.A. Eramzhyan, H.R. Kissener and R.A. Sakaev, *Nucl. Phys.* A282 (1977) 474
- 1977DR09 D.M. Drake, G.F. Auchampaugh, E.D. Arthur, C.E. Ragan and P.G. Young, *Nucl. Sci. Eng.* 63 (1977) 401
- 1977DW1A Dwyer and Meyer, *Bull. Amer. Phys. Soc.* 22 (1977) 600
- 1977FE1B Feshbach, in *High Energy Phys. & Nucl. Struct., Zurich 1977* (Birkhauser Verlag, 1977) 291

- 1977FL05 E. Flerackers, G. Knuyt and M. Bouten, Phys. Lett. B67 (1977) 139
- 1977FO04 P. Fontes, Phys. Rev. C15 (1977) 2159
- 1977GA1C Garcia-Munoz, Mason and Simpson, Astrophys. J. 217 (1977) 859
- 1977GO07 J. Gosset, H.H. Gutbrod, W.G. Meyer, A.M. Poskanzer, A. Sandoval, R. Stock and G.D. Westfall, Phys. Rev. C16 (1977) 629
- 1977GO1C Gomez del Campo et al., Bull. Amer. Phys. Soc. 22 (1977) 1019
- 1977GR04 J.Y. Grossiord, M. Bedjidian, A. Guichard, M. Gusakov, J.R. Pizzi, T. Delbar, G. Gregoire and J. Lega, Phys. Rev. C15 (1977) 843
- 1977GU14 M.G. Gulyamov, B.S. Mazitov, G.A. Radyuk, E.I. Rasulov and R. Yarmukhamedov, Izv. Akad. Nauk SSSR Ser. Fiz. 41 (1977) 2214; Bull. Acad. Sci. USSR Phys. Ser. 41 (1977) 189
- 1977HA1L Hagen, Fisher and Ormes, Astrophys. J. 212 (1977) 262
- 1977HI01 M.D. High and B. Cujec, Nucl. Phys. A278 (1977) 149
- 1977HO1B Hoistad, in High Energy Phys. Nucl. Struct., Zurich 1977 (Birkhauser Verlag, 1977) 215
- 1977IZ01 T. Izumoto, Nucl. Phys. A275 (1977) 342
- 1977JA14 H.U. Jager and M. Kirchbach, Nucl. Phys. A291 (1977) 52
- 1977JO02 B. Johnsson, M. Nilsson and K. Lindgren, Nucl. Phys. A278 (1977) 365
- 1977KE09 K.W. Kemper, G.E. Moore, R.J. Puigh and R.L. White, Phys. Rev. C15 (1977) 1726
- 1977KI04 A. Kiss, E. Koltay, G. Szabo and L. Vegh, Nucl. Phys. A282 (1977) 44
- 1977KI1H Kish, Kolati, Nako and Sabo, Izv. Akad. Nauk SSSR Ser. Fiz. 41 (1977) 1975
- 1977KO1L Kohl, Parkison and Withbroe, Astrophys. J. 212 (1977) L101
- 1977KO1M Komarov et al., in Proc. Zurich-Sin (1977) 136
- 1977KO1N Kostin, Kopanets and Koval, Izv. Akad. Nauk SSSR Ser. Fiz. 41 (1977) 153
- 1977KO27 W. Kohler, G. Gruber, A. Steinhauser and K. Bethge, Nucl. Phys. A290 (1977) 233
- 1977KU1D R. Kullberg, K. Kristiansson, B. Lindkvist and I. Otterlund, Nucl. Phys. A280 (1977) 491
- 1977LO10 M.A. Lone, C.B. Bigham, J.S. Fraser, H.R. Schneider, T.K. Alexander, A.J. Ferguson and A.B. McDonald, Nucl. Instrum. Meth. 143 (1977) 331
- 1977MA1H Mason, Garcia-Munoz and Simpson, Bull. Amer. Phys. Soc. 22 (1977) 567
- 1977MA35 V.B. Mandelzweig, Nucl. Phys. A292 (1977) 333
- 1977MO1C Moyle, Glagola, Matthews and Viola, Bull. Amer. Phys. Soc. 22 (1977) 998
- 1977MO1H Motobayashi, Kohno, Odi and Nakajima, in Tokyo (1977), Contrib. Papers p. 628

- 1977MO1J Motobayashi, Khono, Odi and Nakajima, Proc. Int. Conf. Nucl. Struct., Tokyo (1977); J. Phys. Soc. Jpn. Suppl. 44 (1978) 283
- 1977MU1A Mukhopadhyay, Phys. Rept. C30 (1977) 1
- 1977MU1B Muller, Science 196 (1977) 489
- 1977NA20 K.L. Narayana and C.I. Patil, Acta Phys. Pol. B8 (1977) 401
- 1977OK1C Okabe, in Tokyo (1977), Contrib. Papers p. 154
- 1977PA25 L.A. Parks, K.W. Kemper, A.H. Lumpkin, R.I. Cutler, L.H. Harwood, D. Stanley, P. Nagel and F. Petrovich, Phys. Lett. B70 (1977) 27
- 1977PH02 D.-L. Pham and R. de Swiniarski, Nuovo Cim. A41 (1977) 543
- 1977PI1C Pile, Bent, Debevec and Pollock, Bull. Amer. Phys. Soc. 22 (1977) 590
- 1977PR1D Praderie, Boesgaard, Milliard and Pitois, Astrophys. J. 214 (1977) 130
- 1977RI08 W.A. Richter and P.R. de Kock, Z. Phys. A282 (1977) 207
- 1977SC1D Schramm and Wagoner, Ann. Rev. Nucl. Sci. 27 (1977) 37
- 1977SE1D Seya et al., in Tokyo (1977), Contrib. Papers p. 149
- 1977SH1D Shimoda et al., in Tokyo (1977), Contrib. Papers p. 703
- 1977SI1D Silberberg and Tsao, Astrophys. J. Suppl. 35 (1977) 129
- 1977SM06 G.R. Smith, R.L. Boudrie, J.J. Kraushaar, R.J. Peterson, R.A. Ristinen, C.L. Morris, J.E. Bolger, W.J. Braithwaite, C.F. Moore and L.E. Smith, Phys. Lett. B72 (1977) 176
- 1977ST1G Steiner, in High Energy Phys. Nucl. Struct., Zurich (Birkhauser Verlag, 1977) p. 261
- 1977ST1J J. Stevenson, P.B. Price and K. Frankel, Phys. Rev. Lett. 38 (1977) 1125
- 1977SU1B Subotic et al., Fizika (Yugoslavia) 9 Suppl. 1 (1977) 44; Phys. Abs. 13110 (1978)
- 1977SZ03 L. Szybisz, J. Davidson and V. Silbergleit, Nucl. Phys. A282 (1977) 435
- 1977TE1A Terrien, in Tokyo (1977), Contrib. Papers p. 843
- 1977TO02 C.W. Towsley, P.K. Bindal, K.-I. Kubo, K.G. Nair and K. Nagatani, Phys. Rev. C15 (1977) 281; Erratum Phys. Rev. C15 (1977) 1607
- 1977TO11 I.S. Towner, J.C. Hardy and M. Harvey, Nucl. Phys. A284 (1977) 269
- 1977TO1E Toyama, Proc. Int. Conf. Nucl. Struct., Tokyo (1977); J. Phys. Soc. Jpn. Suppl. 44 (1978) 450
- 1977TU02 A. Turkevich, J.R. Cadieux, J. Warren, T. Economou, J. La Rosa and H.R. Heydegger, Phys. Rev. Lett. 38 (1977) 1129
- 1977TU1B A. Turkevich, J.R. Cadieux, J. Warren, T. Economou and J. LaRosa, Phys. Lett. B72 (1977) 163
- 1977WA02 J. Warszawski and N. Auerbach, Nucl. Phys. A276 (1977) 402

- 1977WA05 C.N. Waddell, E.M. Diener, R.G. Allas, L.A. Beach, R.O. Bondelid, E.L. Petersen, A.G. Pieper, R.B. Theus, C.C. Chang and N.S. Chant, Nucl. Phys. A281 (1977) 418
- 1977WE03 R.B. Weisenmiller, N.A. Jelley, D. Ashery, K.H. Wilcox, G.J. Wozniak, M.S. Zisman and J. Cerny, Nucl. Phys. A280 (1977) 217
- 1977WE1B R.B. Weisenmiller, Thesis, Univ. of California, Berkeley (1976); LBL-5077 (1977)
- 1977WE1D Weller, Furst, Tombrello and Burnett, Astrophys. J. 214 (1977) L39
- 1977WE1F Webber, Lezniak, Kish and Simpson, Astrophys. Lett. 18 (1977) 125
- 1977WU1B Wu, Barnes, Overley and Switkowski, in Tokyo (1977), Contrib. Papers p. 661
- 1977YA10 M. Yasue, H. Yokomizo, S. Kubono, K. Koyama, S. Takeuchi and H. Ohnuma, J. Phys. Soc. Jpn. 42 (1977) 367
- 1977YA1B Yakovlev, Fiz. Elem. Chastits At. Yadra 8 (1977) 255
- 1977YE1A Yen, Caplan, Bergstrom and Ansaldo, Bull. Amer. Phys. Soc. 22 (1977) 591
- 1978AJ03 F. Ajzenberg-Selove, Nucl. Phys. A300 (1978) 1
- 1978AL25 H.W. Alberts and E. Friedland, Nucl. Phys. A307 (1978) 45
- 1978AM01 J.F. Amann, P.D. Barnes, K.G.R. Doss, S.A. Dytman, R.A. Eisenstein, J.D. Sherman and W.R. Wharton, Phys. Rev. Lett. 40 (1978) 758
- 1978AN07 I. Angeli and M. Csatlos, Atomki Kozlem. 20 (1978) 1
- 1978AT01 M. Atarashi, K. Hira and H. Narumi, Prog. Theor. Phys. 60 (1978) 209
- 1978AU07 E.G. Auld, A. Haynes, R.R. Johnson, G. Jones, T. Masterson, E.L. Mathie, D. Otewell, P. Walden and B. Tatischeff, Phys. Rev. Lett. 41 (1978) 462
- 1978AU1C Austin, Bull. Amer. Phys. Soc. 23 (1978) 609
- 1978AV1A Avishai, Z. Phys. A285 (1978) 333
- 1978BH01 R.S. Bhalerao and Y.R. Waghmare, Nucl. Phys. A298 (1978) 367
- 1978BI08 R. Billerey, C. Cerruti, A. Chevarier, N. Chevarier and A. Demeyer, Z. Phys. A285 (1978) 389
- 1978BO09 M.C. Bouten and M. Bouten, Nucl. Phys. A299 (1978) 141
- 1978BU1G Buffington, Bull. Amer. Phys. Soc. 23 (1978) 568
- 1978BY1B Byrd, Walter and Cotanch, Bull. Amer. Phys. Soc. 23 (1978) 526
- 1978CO15 P. Couvert, G. Bruge, R. Beurtey, A. Boudard, A. Chaumeaux, M. Garcon, D. Garreta, P.C. Gugelot, G.A. Moss, S. Platchkov et al., Phys. Rev. Lett. 41 (1978) 530.
- 1978DE15 P. Desgrolard, P.A.M. Guichon and J. Joseph, Nuovo Cim. A43 (1978) 475
- 1978DE1N Descroix et al., in Proc., Cluster, Winnipeg (1978) D4
- 1978DE37 A.S. Deineko, Y.G. Mashkarov and V.E. Storizhko, Izv. Akad. Nauk SSSR Ser. Fiz. 42 (1978) 144; Bull. Acad. Sci. USSR Phys. Ser. 42 (1978) 123

1978DU1E Duffey et al., Bull. Amer. Phys. Soc. 23 (1978) 558
 1978DW1A Dwek, Astrophys. J. 225 (1978) L149
 1978FA04 G. Faldt and I. Hulthage, J. Phys. G4 (1978) 363
 1978FA1D Fallica, Riggi, Spitaleri and Sutera, Lett. Nuovo Cim. 22 (1978) 547
 1978FR1D S. Frankel, W. Frati, G. Blanpied, G.W. Hoffmann, T. Kozlowski, C. Morris, H.A. Thiessen, O. Van Dyck, R. Ridge and C. Whitten, Phys. Rev. C18 (1978) 1375
 1978GE1C Gelbke et al., Phys. Rept. C42 (1978) 311
 1978GR1F Green and Korteling, in Proc., Cluster, Winnipeg (1978) 89
 1978GU1F Guichard, Reyss and Yokoyama, Nature 272 (1978) 155
 1978HE02 J.C. Herrera, J.J. Kolata, H.W. Kraner, C.L. Wang, R. Allen, D. Gockley, M.A. Hasan, A. Kanofsky and G. Lazo, Phys. Rev. Lett. 40 (1978) 158
 1978IZ02 T. Izumoto, Nucl. Phys. A301 (1978) 448
 1978KA1H Karadeniz, Rev. Fac. Sci. Univ. Istanbul C39 (1978) 108; Phys. Abs. 62573 (1978)
 1978KI08 H.R. Kissener, G.E. Dogotar, R.A. Eramzhyan and R.A. Sakaev, Nucl. Phys. A302 (1978) 523
 1978KN01 H.D. Knox, R.M. White and R.O. Lane, Nucl. Sci. Eng. 65 (1978) 65
 1978KO1H Kohno, Nagata and Tamagaki, Prog. Theor. Phys. 59 (1978) 1230
 1978KO1J Kolata, Malman, Grant and Rising, Bull. Amer. Phys. Soc. 23 (1978) 502
 1978LO1C Lone, Ferguson and Earle, Bull. Amer. Phys. Soc. 23 (1978) 500
 1978MA07 N. Marquardt, D. Sprengel, H.V. Buttlar and W. Hoppe, Z. Phys. A285 (1978) 89
 1978MC1F McMillan et al., Nucl. Instrum. Meth. Phys. Res. 149 (1978) 83
 1978ME1D Meyer, Nature 272 (1978) 675
 1978MU1C Muller, Bull. Amer. Phys. Soc. 23 (1978) 567
 1978NA05 K. Nakamura, S. Hiramatsu, T. Kamae, H. Muramatsu, N. Izutsu and Y. Watase, Nucl. Phys. A296 (1978) 431
 1978NA07 R. Nayak and L. Satpathy, Nucl. Phys. A304 (1978) 64
 1978OE1B Oelert et al., in Proc., Cluster, Winnipeg (1978) F15
 1978PE1D Peterson et al., Bull. Amer. Phys. Soc. 23 (1978) 48
 1978QA01 S.M. Qaim and R. Wolfle, Nucl. Phys. A295 (1978) 150
 1978RA1E Raisbeck, Yiou and Quechon, in Proc. Zurich-Sin (1977) 182
 1978RO1D Rolfs and Trautvetter, Ann. Rev. Nucl. & Part. Sci. 28 (1978) 115
 1978SH1E Shirley and Lederer, in Table of Isotopes, 7th Edition, John Wiley (1978)
 1978SU02 K.M. Subotic, B. Lalovic and B.Z. Stepantic, Nucl. Phys. A296 (1978) 141

- 1978SZ03 L. Szybisz, Z. Phys. A285 (1978) 223
- 1978WE1D Wessels et al., Nucl. Instrum. Meth. 141 (1977) 157
- 1978WE1E Westfall et al., Bull. Amer. Phys. Soc. 23 (1978) 576
- 1978WU1B Wu, Barnes, Overley and Switkowski, Bull. Amer. Phys. Soc. 23 (1978) 15
- 1978WU1C Wu, Overley, Barnes and Switkowski, LAP-164 (1978)
- 1978YO1C Yokoyama, Guichard, Reyss and Huu Van, Science 201 (1978) 1016
- 1978ZA1D Zalm, Van Hienen and Glaudemans, Z. Phys. A287 (1978) 255
- 1978ZE02 A.F. Zeller, G.T. Hickey, D.C. Weisser, D.F. Hebbard and B.A. Robson, Nucl. Phys. A301 (1978) 130
- 1979SP01 R.H. Spear, Z.E. Switkowski, D.L. Kennedy and J.C.P. Heggie, Nucl. Phys. A318 (1979) 21
- 1980AJ01 F. Ajzenberg-Selove and C.L. Busch, Nucl. Phys. A336 (1980) 1
- 1981AJ01 F. Ajzenberg-Selove, Nucl. Phys. A360 (1981) 1
- 1982AJ01 F. Ajzenberg-Selove, Nucl. Phys. A375 (1982) 1