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 A*320 (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)

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^{10}n
(Not illustrated)

^{10}n has not been observed in the interaction of 0.7 and 400 GeV protons with uranium: the cross section is $< 0.7 \pm 10^{-5}$ μb (1977TU02) at 0.7 GeV and < 0.5 μb (1977TU03) at 400 GeV. See also (1977DE08).

^{10}He
(Not illustrated)

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

^{10}Li
(Fig. 22)

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

^{10}Be
(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}Be(β^-)^{10}B $\qquad Q_{\rm m} = 0.5559$

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}Li(t, γ)^{10}Be $\qquad Q_{\rm m} = 17.251$

(b) ^{7}Li(t, n)^{9}Be $\qquad Q_{\rm m} = 10.4387 \qquad E_{\rm b} = 17.251$

(c) ^{7}Li(t, p)^{9}Li $\qquad Q_{\rm m} = -2.386$

(d) ^{7}Li(t, d)^{8}Li $\qquad Q_{\rm m} = -4.225$

(e) ^{7}Li(t, α)^{6}He $\qquad Q_{\rm m} = 9.838$

The yield of γ_0 and γ_1 has been studied for $E_{\rm t} = 0.5$ to 3.0 MeV (1973BL1B; unpublished): see (1974AJ01) and for $E_{\rm t} = 0.4$ to 1.1 MeV (1978SU02) [^{10}Be*(17.79) is said to be involved]. The neutron yield exhibits a weak structure at $E_{\rm t} = 0.24$ MeV and broad resonances at $E_{\rm t} \approx 0.77$ 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; $E_{\rm t} = 75$ to 400 keV) and (1966LA04). See also (1977SU1B). For total breakup into neutrons and α-particles see (1975JE04). See also (1975FO19; astrophys.). See also ^{6}He and ^{9}Li.

3. ^{7}Li(α, p)^{10}Be $\qquad Q_{\rm m} = -2.5635$

Table 10.1: Energy levels of ^{10}Be

E_x (MeV ± keV)	$J^\pi; T$	τ or $\Gamma_{c.m.}$	Deacy	Reactions
g.s.	$0^+; 1$	$\tau_{1/2} = (1.6 \pm 0.2) \times 10^6$ 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	$2^+; 1$	$\tau_m = 180 \pm 17$ fsec	γ	3, 4, 5, 12, 13, 15, 17, 18, 20, 22, 23, 25, 26, 27, 30, 31
5.9583 ± 0.3	$2^+; 1$	$\tau_m < 80$ 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	$0^+; 1$	$\tau_m = 1.1^{+0.4}_{-0.3}$ psec	π, γ	13, 27
6.2633 ± 5	$2^-; 1$		γ	13, 27
7.371 ± 1	$3^-; 1$	$\Gamma = 15.7 \pm 0.5$ 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	γ, n, t	2, 3, 4, 20
18.55		≈ 350	n, t	2, 3, 4
(24)				24

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

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

Angular distributions are reported for $E(^7\text{Li}) = 2.1$ to 5.75 MeV (1969CA1A; α_1, $\alpha_{2+3+4+5}$), 3.5 to 5.75 MeV (1969CA1A; α_0) and 30.3 MeV (1971GL07; α-groups to ^{10}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}Be*(18.8). See also (1973OG1A, 1978KA1H) and ^{14}C in (1976AJ04).

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

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. $\to$ g.s.	70	65	
5955.9 ± 0.5	5.96 [d] $\to$ g.s.	2	$\lesssim 2$	5958.3 ± 0.3
3443.3 ± 0.3	capt. $\to$ 3.37	15	11	
3367.4 ± 0.2 [c]	3.37 $\to$ g.s.	28	28	3368.0 ± 0.2
2589.9 ± 0.25	5.96 [d] $\to$ 3.37	17	21	
853.5 ± 0.3	capt. $\to$ 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}Be(n, n)^{9}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 ^{9}Be 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}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}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}Be(n, n)^{9}Be

E_{res} (MeV ± keV)	^{10}Be* (MeV)	$\Gamma_{c.m.}$ (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}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 $E_{\overline{n}} = 1.6$ to 4.8 MeV (1975HO01). See also (1974HE1E), (1975HO1F, 1975RO1G) and (1978BY1B; theor.).

7. (a) ^{9}Be(n, n′)^{9}Be* $E_b = 6.8118$
(b) ^{9}Be(n, 2n)^{8}Be $Q_m = -1.6652$
(c) ^{9}Be(n, 3n)^{7}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}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}Be(n, p)^{9}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}Be(n, d)^{8}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. ^{9}Be(n, t)^{7}Li $Q_m = -10.439$ $E_b = 6.8118$

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. ^{9}Be(n, α)^{6}He $Q_m = -0.600$ $E_b = 6.8118$]

The cross section for production of ^{6}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. ^{9}Be(p, π^+)^{10}Be $Q_m = -133.537$

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

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

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}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}Be*(0, 3.37, 5.96 [2^+], 7.37, 7.54)) and at $E_{\vec{d}} = 15$ MeV (1976DA15). In the latter experiment $S = 2.1$, 0.23 ($j_n = \frac{3}{2}$) and 0.12 ($j_n = \frac{1}{2}$), ≤ 1.0, 0.065 ($j_n = \frac{5}{2}$) and 0.132 ($j_n = \frac{1}{2}$), for ^{10}Be*(0, 3.37, 5.96, 6.26) (1976DA15). The angular distributions show $l_n = 1$ transfer for ^{10}Be*(0, 3.37, 5.958, 7.54), $l_n = 0$ transfer for ^{10}Be*(5.960, 6.26), $l = 2$ transfer for ^{10}Be*(7.37). ^{10}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}Be*(9.27, 9.4, 11.76) have $\Gamma_{c.m.} = 150 \pm 20$, 291 ± 20 and 121 ± 10 keV (1974AN27).

Table 10.4: Radiative transitions in ^{9}Be(d, p)^{10}Be [a]

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

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

[b] From (1966GR18): ^{9}Be(n, γ)^{10}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}Be*(5.96) and its population in ^{9}Be(n, γ)^{10}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}Be*(3.37) [it is the state fed in the ^{9}Be(n, γ) decay]; the higher state has $J^\pi = 1^-$ and goes mainly by a crossover to ^{10}Be$_{\rm g.s.}$. Angular correlations measured with the γ-ray detector located normal to the reaction plane ($\equiv$ angular distributions) lead to $l_{\rm n}$ values consistent with the assignments of 2^+ and 1^- for ^{10}Be*(5.9658, 5.9660) obtained from the character of the γ-decay (1969RO12). ^{10}Be*(6.18) decays primarily to ^{10}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}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}Be(t, d)^{10}Be $\qquad Q_{\rm m} = 0.5545$

See (1974AJ01).

15. ^{9}Be(^{7}Li, ^{6}Li)^{10}Be $\qquad Q_{\rm m} = -0.439$

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

16. ^{9}Be(^{18}O, ^{17}O)^{10}Be $\qquad Q_{\rm m} = -1.233$

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

17. (a) ^{10}Be(p, p)^{10}Be
(b) ^{10}Be(d, d)^{10}Be

Angular distributions of the p$_0$ and p$_1$ groups have been measured at $E_{\rm p} = 12.0$ to 16.0 MeV. The elastically scattered deuterons have been studied at $E_{\rm d} = 12.0$ and 15.0 MeV. B(E2) for the ^{10}Be*(3.4) $\xrightarrow{\gamma}$ ^{10}Be(0) transition is $23.8\ e^2 \cdot {\rm fm}^4$ (from a comparison of the angular distributions with DWBA predictions) (1970AU02).

18. ^{10}B(π^-, γ)^{10}Be $\qquad Q_{\rm m} = 139.011$

The total radiative capture branching ratio for stopped pions is $(2.27\pm0.22)\%$. The γ-spectrum is dominated by the transition to ^{10}Be*(6.0) [$J^\pi = 2^+$] (1975BA52).

19. ^{10}B(n, p)^{10}Be $\qquad Q_{\rm m} = 0.2265$

See (1974AJ01).

20. ^{10}B(p, pπ^+)^{10}Be $\qquad Q_{\rm m} = -140.123$

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

21. ^{10}B(t, ^{3}He)^{10}Be $\qquad Q_{\rm m} = -0.5373$

Not reported.

22. ^{10}B(^{7}Li, ^{7}Be)^{10}Be $\qquad Q_{\rm m} = -1.418$

See (1977KO27).

23. ^{11}B(γ, p)^{10}Be $\qquad Q_{\rm m} = -11.2287$

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

24. ^{11}B(n, d)^{10}Be $\qquad Q_{\rm m} = -9.0041$

The angular distribution of the d_0 group has been measured at $E_{\rm n} = 14.4$ MeV (1968MI10, 1971MI12).

25. ^{11}B(p, 2p)^{10}Be $\qquad Q_m = -11.2287$

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}B(d, ^{3}He)^{10}Be $\qquad Q_m = -5.7352$

Angular distributions have been measured at $E_d = 11.8$ and 22 MeV to ^{10}Be$_{g.s.}$ [see (1974AJ01)] and at 52 MeV to ^{10}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}Be*(9.6) (1975SC41).

27. ^{11}B(t, α)^{10}Be $\qquad Q_m = 8.585$

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

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

See (1974AN36).

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

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

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

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

31. ^{12}C(^{12}C, ^{14}O)^{10}Be $\qquad Q_m = -20.616$

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

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

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

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

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

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

See (1974AN36).

^{10}B

(Figs. 20 and 22)

GENERAL (See also (1974AJ01).):

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

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

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

Electromagnetic transitions: (1974BO29, 1974BO54, 1974BOZB, 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, 1976BAYR, 1976BO2C, 1976ED1A, 1976EN02, 1976GI01, 1976LI26, 1976RO14, 1976SH01, 1977AM1B, 1977BA2H, 1977BA51, 1977BA1Q, 1977BA2G, 1977BEZY, 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 ± keV)	$J^\pi; T$	τ_m or $\Gamma_{c.m.}$ (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 ± 5	$1^-; 0+1$	120 ± 5	γ, p, d, α	1, 14, 16, 18, 19
7.002 ± 6	$(1, 2)^+; (0)$	100 ± 10	p, d, α	3, 18, 19, 28, 30, 44, 50
7.430 ± 10	$2^{(-)}; 0+1$	100 ± 10	γ, p, d, α	1, 14, 18
7.467 ± 10	1^+	65 ± 10	p	16, 19, 44
7.477 ± 2	$2^-; 1$	74 ± 4	γ, p	14, 16, 19, 26, 44
7.5595 ± 0.9	$0^+; 1$	2.65 ± 0.18	γ, p	14, 16, 19, 44
(7.67 ± 30)	$(1^+; 0)$	250 ± 20	γ, p, d	14, 16, 18
7.817 ± 20	1^-	260 ± 30	p	16, 44
8.07	$(2^-; 0)$	800 ± 200	p, d	18
(8.7)	$(1^+, 2^+)$	(≈ 200)	p	18
8.889 ± 6	$3^-; 1$	84 ± 7	γ, n, p, α	15, 18, 26
8.893 ± 1	$2^+; 1$	40 ± 1	γ, p, α	14, 18, 24, 26
(9.7)	$(T = 1)$	(≈ 700)	n, p	15
10.84 ± 10	$(2^+, 3^+, 4^+)$	300 ± 100	γ, n, p	14, 15, 26
11.52 ± 35		500 ± 100	(γ)	26
12.56 ± 30	$(0^+, 1^+, 2^+)$	100 ± 30	γ, p	14
13.49 ± 5	$(0^+, 1^+, 2^+)$	300 ± 50	γ, p	14, 44
14.4 ± 100		800 ± 200	γ, p	3, 44
(18.2 ± 200)		(1500 ± 300)		44
18.43	$2^-; 1$	340	γ, ^{3}He	7
18.8	$2^+, 1^+$	< 600	γ, ^{3}He, α	7, 11
19.3	$2^-; 1$	190 ± 20	γ, n, ^{3}He, α	7, 8, 11
20.2	$1^-; 1$	350 ± 70	γ, n, t, ^{3}He, α	7, 8, 10, 11, 24
(21.1)			γ, ^{3}He	7
23.1		broad	γ, n	24

[a] See also Tables 10.6 and 10.9.

$$\mu = +1.80065 \pm 0.00001 \text{ nm (1978SHZM)};$$
$$Q = +84.72 \pm 0.56 \text{ mb (1978SHZM)}.$$

1. ^{6}Li(α, γ)^{10}B $\qquad Q_m = 4.4605$

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

Initial state	$J^\pi; T$	Γ_γ (total) (eV)	Branching ratios (%) to final states at: g.s. $3^+; 0$	0.72 $1^+; 0$	1.74 $0^+; 1$	2.15 $1^+; 0$	3.59 $2^+; 0$	4.77 $3^+; 0$	Γ_γ/Γ	Refs.
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					≤ 0.009	Table 10.7, (1966FO05, 1969YO01)
6.03	4^+	≤ 0.5	≈ 100	[d]					≤ 0.009	Table 10.7, (1969YO01)
6.13 [e]	3^-	≤ 21							≤ 0.009	(1969YO01)

[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 $^{6}Li(\alpha, \gamma)^{10}B$ [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)	$\lvert M \rvert^2$ [g]
500 ± 25	4.761	$3^+; 0$		0	0.5 ± 0.1			
				0.72	> 99		0.033 ± 0.006 [c]	
1085	5.112	$2^-; 0$	2 [b]	0	64 ± 7	0.059 ± 0.012 [d]		(1.5) [e]
								9×10^{-4} [k]
				0.72	31 ± 7	0.028 ± 0.008		(1.5) [e]
								6×10^{-4} [k]
				1.74	5 ± 5	0.005 ± 0.005		100 ± 100 [e]
1175 [i]	5.166	$2^+; 1$	< 0.5 [b]	0	5 ± 1	0.020 ± 0.004 [g]	0.076 ± 0.02 [g]	
				0.72	27 ± 2	0.11 ± 0.02 [g]	0.41 ± 0.11 [g]	
				1.74	< 0.5			
				2.15	61 ± 2	0.24 ± 0.03 [g]	0.91 ± 0.23 [g]	
				3.58	7 ± 3	0.03 ± 0.03 [g]	0.11 ± 0.05 [g]	
1210 ± 35	5.187	$1^+; 0$	340 ± 50	1.74	≈ 100		0.06 ± 0.03	
2435	5.922	2^+	10 ± 1	0	82 ± 5	0.31 ± 0.06		$0.27 \rightarrow 25$ [f,j]
				0.72	18 ± 5	0.07 ± 0.02		$0.1 \rightarrow 9$ [f,j]
				1.74		< 0.02		
2605	6.025	4^+	< 1.5 [b]	0	≈ 100	0.57 ± 0.08		20 [f]
								4×10^{-3} [h]
				0.72		< 0.02	1.2 [m]	
4019	6873 ± 5 [l]	$1^-; 0+1$	200 ± 10	0	6 ± 2			
				0.72	21 ± 4			
				1.74	59 ± 3			

Table 10.7: Levels of ^{10}B from ^{6}Li(α, γ)^{10}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}Be(d, n)^{10}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; $\Gamma_{\alpha}/\Gamma_{\text{p}} = 1.25 \pm 0.12$.

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

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

Table 10.8: ^{10}B levels from ^{6}Li(α, α)^{6}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}Li(α, n)^{9}B $\quad Q_m = -3.975 \quad E_b = 4.4605$

(b) ^{6}Li(α, p)^{9}Be $\quad Q_m = -2.1248$

(c) ^{6}Li(α, d)^{8}Be $\quad Q_m = -1.5654$

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 ^{9}B, ^{9}Be and ^{8}Be.

3. ^{6}Li(α, α)^{6}Li $\quad E_b = 4.4605$

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 $E(\overline{^{6}\mathrm{Li}}) = 21.3$ and 22.8 MeV (1976EG1A, 1976KA1E). See also ^{6}Li, (1974AJ01, 1974LO1B) and (1975CL01, 1975CL1C, 1975RE1C, 1977BA1N; theor.).

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

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}B(^{3}He, α)	(1968DO01)
	< 30 fsec [A]	^{9}Be(^{3}He, d)	(1966FI01, 1968FI09)
2.15 [b]	$2.1^{+0.8}_{-0.5}$ psec	^{11}B(^{3}He, α)	(1968DO01)
	$2.7^{+0.5}_{-0.4}$ psec	^{9}Be(d, n), ^{9}Be(^{3}He, d), ^{10}B(p, p$'$)	(1968FI09)
	2.0 ± 0.6 psec	^{9}Be(d, n)	(1969AL17)
	2.15 ± 0.45 psec	^{7}Li(α, n)	(1970GA01)
	2.30 ± 0.26 psec	mean	
3.59	115 ± 40 fsec [d]	^{9}Be(d, n)	(1966WA10)
	150 ± 15 fsec	^{9}Be(d, n), ^{10}B(p, p$'$)	(1968FI09)
	192^{+35}_{-29} fsec	^{9}Be(p, γ)	(1977KI1H)
	170 ± 70 fsec	^{11}B(^{3}He, α)	(1968DO01)
	153 ± 13 fsec	mean	
5.16 [c]	< 80 fsec	^{9}Be(d, n)	(1966WA10)

A = adopted.

[a] See also (1966LA04).

[b] See also (1966FI01).

[c] See also (1967PA01).

[d] Based on τ_m of ^{10}Be*(3.37) = 180 fsec.

Angular distributions of deuteron groups have been determined at $E(^6\mathrm{Li}) = 2.4$ to 9.0 MeV (d_0, d_1, 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}Li(^{7}Li, t)^{10}B $\qquad Q_m = 1.994$

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

Table 10.10: Resonances in ^{7}Li + ^{3}He [a]

$E_{\rm res}$ (MeV)	$\Gamma_{\rm c.m.}$ (keV)	$E_{\rm x}$ (MeV)	$J^{\pi}; T$	Γ_{γ} (eV) for transition to g.s.	0.72	3.59	4.77	Γ_{α} (keV)	$\Gamma_{\rm n}$	$\Gamma_{\rm p}$	$\Gamma_{\rm t}$
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 $\Gamma_{\rm c.m.} = 190 \pm 20$ and 350 ± 70 keV, respectively, from the n_0 yield.
[c] Assumes isotropy of angular distribution (1971LI20).
[d] (1975BO55).

6. ^{6}Li(^{9}Be, ^{5}He)^{10}B $\quad Q_{\rm m} = 1.99$

See (1974AJ01).

7. ^{7}Li(^{3}He, γ)^{10}B $\quad Q_{\rm m} = 17.788$

Capture γ-rays have been observed for $E(^{3}{\rm He}) = 0.8$ to 6.0 MeV. The γ_0 and γ_5 yields [to ^{10}B*(0, 4.77)] show resonances at $E(^{3}{\rm He}) = 1.1$ and 2.2 MeV [$E_{\rm res} = 0.92$ and 2.1 MeV: see (1971LI20)], the γ_1 and γ_4 yields [to ^{10}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}B*(18.4, 19.3)] appear to result from s-wave capture; the subsequent decay is to two 3^+ states [^{10}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}Li*(3.56) which has $J^{\pi} = 0^+$, $T = 1$: see reaction 11] (1965PA02, 1971LI20). The assignment for ^{10}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}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}Li(^{3}He, n)^{9}B $\quad Q_{\rm m} = 9.352 \quad E_{\rm b} = 17.788$

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

9. ^{7}Li(^{3}He, p)^{9}Be $\qquad Q_m = 11.2025 \qquad E_b = 17.788$

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}Li(^{3}He, d)^{8}Be $\qquad Q_m = 11.762 \qquad E_b = 17.788$

(b) ^{7}Li(^{3}He, t)^{7}Be $\qquad Q_m = -0.880$

(c) ^{7}Li(^{3}He, ^{3}He)^{7}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}Be and ^{7}Be. For reaction (c) see ^{7}Li.

11. ^{7}Li(^{3}He, α)^{6}Li $\qquad Q_m = 13.327 \qquad E_b = 17.788$

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}Li(^{3}He, γ)^{10}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}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}Li.

12. ^{7}Li(α, n)^{10}B $\qquad Q_m = -2.790$

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}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}B*(0, 0.72, (4.77), (6.42)): see (1974AJ01). The γ-decay of ^{10}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}Be(p, γ)^{10}B [a]

E_p (MeV ± keV)	E_x (MeV ± keV)	$\Gamma_{c.m.}$ (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	7.429	140 ± 30	$2^{(-)}; 0+1$ [b]	0.7	2.4	(1962EL06, 1964HO02, 1975AU02)
(0.98)	(7.47)		(2^+)			(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}Be(t, np)^{4}He^{4}He $\qquad Q_m = 10.510$

See (1975FO19; astrophsyics).

14. ^{9}Be(p, γ)^{10}B $\qquad Q_m = 6.5853$

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}B* $= 6.87$ MeV) is ascribed to s-wave protons because of its comparatively large proton width [see ^{9}Be(p, p)] and because of the isotropy of the γ-radiation. The strong transition to ^{10}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}B*(0.7, 2.1) indicates $T = 1$. The amplitudes for the $T = 0$ and $T = 1$ parts of the wave function for ^{10}B*(6.87) are 0.92 and 0.39, respectively (1972RE07). See also (1975AU02).

Table 10.12: Radiative transitions in ^{9}Be(p, γ)^{10}B

Initial state (MeV)	Γ_γ(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			0.35 ± 0.04	0.48 ± 0.04	0.11 ± 0.04						(1972RE07)
$E_p = 0.32$	4.8 [b]	< 0.05	0.20 ± 0.02	0.53 ± 0.02	0.13 ± 0.01	< 0.01	0.04 ± 0.01	0.03 ± 0.01	< 0.01	0.035 ± 0.01	(1975AU02)
			1.0	2.6	0.5				0.65		(1956CL69)
		< 0.7	6.4	15	4.5	≈ 1			< 2.9		(1959ME85)
$1^-;0+1$			0.039 ± 0.005	0.103 ± 0.008	0.032 ± 0.010					W.u.	(1972RE07)
7.43											
$E_p = 0.94$	[2.4]	< 2	1.3	[< 0.14]	0.62	0.5			[< 1]		(1964HO02)
$2^{(-)};0+1$			0.013		0.013	0.03				$\lvert M\rvert^2$E1	(1964HO02)
7.48		400	< 10	19	22	< 7			< 13		(1959ME85)
$E_p = 0.99$	[25.8]	25	0.3	[< 0.14]	0.49	0			[< 1]		(1964HO02)
$2^-;1$		0.19	0.003		0.10					$\lvert M\rvert^2$E1	(1964HO02)
7.56											
$E_p = 1.08$		< 3	100	< 8	< 8	< 4			23		(1959ME85)
	6.6		100	< 2	10				40		(1962ME1A)
	[8.5]	< 0.2	6.7	< 0.3	0.8	< 0.2			1.0		(1964HO02)
$0^+;1$			1.0		0.24				3.5	$\lvert M\rvert^2$M1	(1964HO02)
7.75 [a]	14.6	83									(1963FU11)
$E_p = 1.29$	[8.5]	6.6	0.9	< 0.08	0.3	0.3			0.4		(1964HO02)
$2^-;1$		0.044	0.008		0.006	0.013			0.08	$\lvert M\rvert^2$E1	(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}B* $= 7.56$ MeV) is formed by p-wave protons, $J^\pi = 0^+$ [see ^{9}Be(p, p), ^{9}Be(p, α)]. 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}B*(5.18) observed in the decay is 100 ± 10 keV (1975AU02).

The exciation 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}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}B*(0.7) (1953MA1A): unpublished Ph.D. Thesis). It appears from the width that this resonance corresponds to that observed in ^{9}Be(p, α), $J^\pi = 2^+$, $T = 1$ and not to the ^{9}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}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 $\approx 1.5\ \mu$b/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}B*(0.7) [$J^\pi_f = 1^+$] and therefore $J^\pi_i = 0^+$, 1^+, 2^+. The weak γ_2 yield (to ^{10}B*(1.74) [$J^\pi = 0^+$; $T = 1$]) seems to exhibit a braod peak centered near $E_x = 15$ MeV (maximum 90° differential cross section $\approx 0.5\ \mu$b/sr) and possibly some structure near $E_x = 20$ MeV. The γ_3 yield (to ^{10}B*(2.15) [$J^\pi = 1^+$]) increases to $\approx 0.4\ \mu$b/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}B*(12.9) appears to have positive parity. Angular distributions of γ_0, γ_1, γ_2 and γ_3 are also reported (1970FI1B); unpublished Ph.D. thesis).

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

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

15. (a) ^{9}Be(p, n)^{9}B $\quad Q_m = -1.850 \quad E_b = 6.5853$

(b) ^{9}Be(p, 2n)^{8}B $\quad Q_m = -20.428$

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

The $E_p = 2.56$ MeV resonance is considerably braoder than that observed at the same energy in ^{9}Be(p, α) and ^{9}Be(p, γ) 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}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 $E_{\overline{p}} = 2.4$ 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. (1976CRZV; abstract) report measuring an excitation function for $E_{\overline{p}} = 3.6$ 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 $E_{\overline{p}} = 3.9$ to 15.1 MeV by (1976LI08): negative values of $K_y^{y'}(0)$ are reported near $E_{\overline{p}} = 7$ MeV in a region where several states are known to exist in ^{10}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}B. The ^{8}B yield (reaction (b)) has been measured for $E_p = 22.0$ to 47.5 MeV (1974DA18). See also (1978BY1B, 1978DE37; theor.).

16. (a) ^{9}Be(p, p)^{9}Be $\quad E_b = 6.5853$

(b) ^{9}Be(p, pn)^{8}Be $\quad Q_m = -1.6652$

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}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}Be(p, p)^{9}Be

E_{res} (keV)	E_x (MeV)	$\Gamma_{c.m.}$ (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)		$(3^-; 1)$		(1969AN27, 1973MA59)
2560	8.89		$\geq 2; (1)$ [e]	large	(1956DE33, 1969AN27, 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 $\Gamma_{c.m.} = 130 \pm 10$ 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 exciation 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}Be*(7.37, 7.52) (1969AN27). 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 $E_{\overline{p}} = 32$ MeV (1976MOZF). The angular distributions of the depolarization parameter, D, have been studied at $E_{\overline{p}} = 17$ 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}Be(p, d)^{8}Be and ^{9}Be(p, α)^{6}Li

E_p (MeV)	E_x (MeV)	$\Gamma_{c.m.}$ (keV)	$J^\pi; T$	Γ_p/Γ	θ^2_p	θ^2_d	θ^2_α	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, 1965MO27)
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}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:

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

[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}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}Be.

17. (a) ^{9}Be(p, t)^{7}Be $\quad Q_m = -12.083 \quad E_b = 6.5853$

(b) ^{9}Be(p, ^{3}He)^{7}Li $\quad Q_m = -11.202$

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

18. (a) ^{9}Be(p, d)^{8}Be $\quad Q_{\rm m} = 0.5594 \quad E_{\rm b} = 6.5853$

(b) ^{9}Be(p, α)^{6}Li $\quad Q_{\rm m} = 2.125$

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

Measurements of exciation functions for deuterons and α-particles have been reported at a number of energies to $E_{\rm p} = 15$ 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; $\rm d_0$, α_0, α_1, α_2) and (1974WI21: 6.3 to 9.5 MeV; $\rm d_0$, α_0). Observed resonances are displayed in Table 10.14.

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

19. ^{9}Be(d, n)^{10}B $\quad Q_{\rm m} = 4.3607$

Neutron groups are observed corresponding to the ^{10}B states listed in Table 10.15. Thresholds for slow-neutron production corresponding to ^{10}B states with $4.7 < E_{\rm x} < 6.6$ MeV are displayed in Table 10.17 of (1974AJ01). Angular distributions have been measured from $E_{\rm d} = 0.5$ to 16 MeV [see (1959AJ76, 1966LA04, 1974AJ01)] and at 15.25 MeV (1975AZ02; n to ^{10}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 $\tau_{\rm m}$ are displayed in Table 10.9.

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

At $E_{\rm d} = 83.7$ MeV the relative neutron yield down to $E_{\rm n} = 4$ MeV is bell-shaped with a peak at about 34 MeV and a FWHM of ≈ 22 MeV (1976MA43). See also ^{11}B in (1980AJ01), (1973SR04, 1974KA34, 1975SR01, 1977BA2K, 1977LO10, 1977RI08, 1978LO1C) and (1975AU1C, 1976EA1A; applications).

20. ^{9}Be(^{3}He, d)^{10}B $\quad Q_{\rm m} = 1.0918$

Table 10.15: Levels of ^{10}B from ^{9}Be(d, n)^{10}B [a]

(1965BU10)			(1973PA14)		(1967FI01)	
^{10}B* (MeV ± keV)	l_p [d]	S_{rel} [e]	S_{rel} [k]	^{10}B* (MeV ± 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 ± 10	1	2.8
1.74 [b]	1	1.0 [f]	1.42	1.74 ± 10	1	1.4 [f]
2.15 [b]	1	0.41	0.41	2.15 ± 10	1	0.5
3.59 [b]	1	0.45	0.10	3.58 ± 10	(1)	0.3
4.77 [b]	(≥ 2)	0.43		4.77 ± 10	undetermined	0.07 if $l = 1$
						0.4 if $l = 2$
5.11 ± 20	0	1.3	0.14	5.11 ± 12	0	1.7 [i]
5.16 ± 20	1		0.43	5.17 ± 14	1	0.6
5.90 ± 80	(1)	1.3	0.49	5.93 ± 10	1	0.7
6.10 ± 80	(2)			6.03 ± 12		
				6.14 ± 10	(2)	0.3 [i,j]
6.35 ± 50	(0)	(0.86), 0.51				
6.50 ± 50	1			6.57 ± 10	(3)	
6.95 ± 30 [c]	0	1.8		6.89 ± 15	(1)	
				7.00 ± 12	(1)	
7.50 ± 50				7.48 ± 15		
7.60 ± 50				7.56 ± 25		
(7.85 ± 50)						
(8.07 ± 50)						
(8.12 ± 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}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}B*(0, 1.74) and find S_{rel}(ave.) $= 1.0$ and 1.36.

Table 10.16: The γ-rays observed in ^{9}Be(d, n)^{10}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}B: see Table 10.17. Angular distributions have been measured at $E_{\rm d} = 10$ to 25 MeV [see (1974AJ01)] and at $E(\overline{^{3}\rm He}) =$ 33.3 MeV (1976KA23) and lead to the $l_{\rm p}$ and spectroscopic factors shown in Table 10.17. For $\tau_{\rm m}$ see Table 10.9. See also (1973CL1D, 1977RI08) and ^{12}C in (1980AJ01).

21. ^{9}Be(α, t)^{10}B $\qquad Q_{\rm m} = -13.229$

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}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}C in (1976AJ04).

22. ^{9}Be(^{7}Li, ^{6}He)^{10}B $\qquad Q_{\rm m} = -3.390$

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

E_x (MeV ± keV)	J^π	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] $(2J+1)S_{rel}$.
[i] $E_d = 17$ MeV (1966SI02); see also (1973PA14). (1974KE06) have recalculated S_{rel} for ^{10}B*(0, 1.74) and find 1.0 and 1.58.
[j] (1976KA23): $E(\overline{^{3}\text{He}}) = 33.3$ MeV; the transferred j are $\frac{3}{2}$ and $\frac{1}{2}$ for ^{10}B*(0, 0.7).

At $E(^{7}\text{Li}) = 34$ MeV angular distributions have been obtained for the ^{6}He 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}B*(0, 0.74, 1.74, 2.15) (FRDWBA analysis) (1977KE09). See also (1974KE06).

23. ^{10}Be(β^-)^{10}B $\qquad Q_m = 0.5559$

See ^{10}Be.

24. (a) ^{10}B(γ, n)^{9}B $\quad Q_{\rm m} = -8.436$

(b) ^{10}B(γ, p)^{9}Be $\quad Q_{\rm m} = -6.5853$

(c) ^{10}B(γ, d)^{8}Be $\quad Q_{\rm m} = -6.0259$

(d) ^{10}B(γ, α)^{6}Li $\quad Q_{\rm m} = -4.4605$

Absolute measurements have been made of the ^{10}B(γ, 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 (γ, 2n) + (γ, 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 $E_{\rm x} = 20.1 \pm 0.1$ and 23.1 ± 0.1 MeV ($\sigma_{\rm max} \approx 5.5$ 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}B(γ, γ)^{10}B

See (1967LO1B).

26. (a) ^{10}B(e, e)^{10}B

(b) ^{10}B(e, ep)^{9}Be $\quad Q_{\rm m} = -6.5853$

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

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

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

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

E_x in ^{10}B (MeV)	$J^\pi; T$ [a]	Mult.	R (fm)	$\Gamma_{\gamma 0}$ (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 ± 0.07 [d,e]	(1976FA13)
				0.122 ± 0.020 [f]	(1966SP02)
7.477 ± 0.020	$2^+; 1$ [b]	M1		11.3 ± 2.0 [c]	(1976FA13)
			2.4 ± 0.4	10.1 ± 1.9 [d]	(1976FA13)
				11.0 ± 2.2	(1966SP02, 1969CH1A)
8.90	$2^+; 1$	E2		0.5 ± 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 ± 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] $\Gamma_{\gamma 0}$ 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}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}B + n into 2α + d + n has been studied at $E_n = 14.4$ MeV (1975AN1C). See also ^{11}B in (1975AJ02).

28. ^{10}B(p, p′)^{10}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)]; $B(\text{E2}\uparrow) = 26 \pm 5$ fm^4 and $\Gamma(\text{E2}\downarrow) = 0.14$ 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 ± 2.0, 1435.1,

2155.6 ± 2.0 and 2868.5 ± 2.0 keV (1969PA09: from decay of $E_x = 720.4 \pm 1.9$, 1742.3 ± 2.3, 2155.4 ± 1.9 and 3589.7 ± 2.2 keV). See also reaction 40. (1968MA18) report δ(E2/M1) $= -(0.23^{+0.06}_{-0.05})$ or $-(4.1^{+1.0}_{-0.7})$ 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}B(p, 2p)^{9}Be $\quad Q_m = -6.5863$
(b) ^{10}B(p, pn)^{9}B $\quad Q_m = -8.436$
(c) ^{10}B(p, pα)^{6}Li $\quad Q_m = -4.4605$

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 ± 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}B(d, d$'$)^{10}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}B*(1.74) (1974ST01) and the absence of the group to ^{10}B*(5.16) (1962AR02) is good evidence of theor $T = 1$ character. Angular distributions have been reported at $E_{\overline{d}} = 4$ 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 $E_{\overline{d}} = 15$ MeV (1974BU06; d_0). See also ^{12}C in (1980AJ01) and (1977IZ01; theor.).

31. ^{10}B(t, t)^{10}B

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

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

Angular distributions of elastically scattered ^{3}He 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}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 ^{3}He ions to ^{10}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}B(p, p′), ^{10}B(d, d′) and ^{10}B(^{3}He, ^{3}He′)

E_x (MeV ± keV)			$\Gamma_{c.m.}$ (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 [h], 3 [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}He, ^{3}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}B(α, α')^{10}B
(b) ^{10}B(α, 2α)^{6}Li $\qquad Q_{\rm m} = -4.4605$

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}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; α_0, α_1, α_3, α_4, α_5). ^{10}B*(1.74) is not observed. S_α for ^{10}B$_{\rm g.s.} = 0.29$ (1976WO11).

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

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

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

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

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

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

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

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

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

38. (a) ^{10}B(^{16}O, ^{16}O)^{10}B
(b) ^{10}B(^{18}O, ^{18}O)^{10}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}B(^{19}F, ^{19}F)^{10}B

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

40. ^{10}C(β^+)^{10}B $\qquad Q_{\text{m}} = 3.651$

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}B*(0.7, 1.7): see Table 10.20 for branching ratios and $\log ft$. The "corrected" ft value for the transition to ^{10}B*(1.7) is then 3108 ± 31 sec, based onE_{β^+}(max) $= 1910.22 \pm 0.59$ keV to ^{10}B*(0.7) [see ^{10}B(p, n)^{10}C] (1975HA45). The excitation energies of ^{10}B*(0.7, 1.7) are $E_{\text{x}} = 718.32 \pm 0.09$ and 1740.16 ± 0.17 keV [$E_\gamma = 718.29 \pm 0.09$ and 1021.78 ± 0.14 keV] (1969FR02). Based on the decay $^{10}\text{C}_{\text{g.s.}} \rightarrow {}^{10}$B*(1.7) and on other $0^+ \rightarrow 0^+$ decays, (1975HA45, 1977TO11) find an effective coupling constant $G'_{\text{V}} = (1.4128 \pm 0.0005) \times 10^{-49}$ erg $\cdot$ cm^3, in agreement with the CVC hypothesis. The Fierz interference constant $b_{\text{F}} \leq 0.006$ (1975HA45). See also (1975RA37), (1974AS07, 1974WI02, 1975KR14, 1977AZ02, 1977RI08, 1977SZ03, 1978SZ03; theor.) and this footnote † .

41. ^{11}B(γ, n)^{10}B $\qquad Q_{\text{m}} = -11.4552$

The intensities of the transitions to ^{10}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}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}B(p, d)^{10}B $\qquad Q_{\rm m} = -9.2306$

Angular distributions of deuteron groups have been measured at $E_{\rm p} = 17.7$ 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 $\Gamma_{\rm c.m.}$ of ^{10}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}B(d, t)^{10}B $\qquad Q_{\rm m} = -5.1979$

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

44. (a) ^{11}B(^{3}He, α)^{10}B $\qquad Q_{\rm m} = 9.1226$
(b) ^{11}B(^{3}He, 2α)^{6}Li $\qquad Q_{\rm m} = 4.662$

Reported levels are displayed in Table 10.21. Angular distributions have been measured at a number of energies between $E(^3{\rm He}) = 1.0$ 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}B(^{3}He, α)^{10}B

E_x [a] (MeV ± keV)	E_x (MeV ± keV)	$\Gamma_{c.m.}$ [b,c] (keV)	l [d]	S_{rel} [d]
0			1	1.0
0.718 ± 7			1	0.22
1.744 ± 7			1	0.73
2.157 ± 6			1	0.44
3.587 ± 6			1	0.09
4.777 ± 5			1	0.09
5.114 ± 5				
5.166 ± 5			1	1.81
5.923 ± 5				
6.028 ± 5				
6.131 ± 5				
6.573 ± 8	6.566 ± 10 [b]	30 ± 10		
	7.002 ± 10 [b]	95 ± 10		
7.475 ± 10				
7.567 ± 10				
	7.87 ± 40 [b]	240 ± 50		
	10.85 ± 100 [c]	300 ± 100		
	11.52 ± 35 [b,c]	500 ± 100 [c]		
	12.56 ± 30 [b,c]	100 ± 30		
	13.49 ± 50 [c]	300 ± 50		
	14.4 ± 100 [c]	800 ± 200		
	(18.2 ± 200) [c]	(1500 ± 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}B*(5.92, 6.03, 6.13, 6.56, 7.00). The results are consistent with $J^\pi = 2^+$ and 4^+ for ^{10}B*(5.92, 6.03) and require $J^\pi = 3^-$ for ^{10}B*(6.13). There is substantial interference between levels of opposite parity for the α-particles due to ^{10}B*(6.56, 7.00): the data are fitted by $J^\pi = 3^+$ for ^{10}B*(7.00) and (3, 4)$^-$ for ^{10}B*(6.56) [the ^{6}Li(α, α) results then require $J^\pi = 4^-$] (1971YO05). See, however, (1973SI27) in reaction 18.

45. ^{11}B(^{16}O, ^{17}O)^{10}B $\qquad Q_{\rm m} = -7.311$

See (1968OK06).

46. ^{12}C(γ, d)^{10}B $\qquad Q_{\rm m} = -25.1875$

See (1972SK08).

47. ^{12}C(n, t)^{10}B $\qquad Q_{\rm m} = -18.9302$

Not reported.

48. ^{12}C(π^-, 2n)^{10}B $\qquad Q_{\rm m} = 111.372$

See (1977BA51).

49. (a) ^{12}C(p, ^{3}He)^{10}B $\qquad Q_{\rm m} = -19.6940$
(b) ^{12}C(p, pd)^{10}B $\qquad Q_{\rm m} = -25.1875$

Angular distributions of ^{3}He ions have been measured at $E_{\rm p} = 39.8$ MeV (1973HO10; to ^{10}B*(0, 0.72, 1.74, 2.15, 3.59)), 51.9 MeV (1977YA10; to ^{10}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}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: $E_{\rm p} = 75$ MeV; spectroscopic factors). See also (1976HUZR) and (1974ZH01, 1975BA1H; theor.).

50. ^{12}C(d, α)^{10}B $\qquad Q_m = -1.3408$

Alpha groups have been observed to the known states of ^{10}B below $E_x = 7.1$ MeV: see Table 10.23 in (1974AJ01). Angular distributions have been measured for $E_d = 5.0$ to 29.1 MeV [see (1974AJ01)] and at 13.8 to 16.0 MeV (1974JO01; α_2), 14 and 15 MeV (1974JO01; α_0, α_1, α_3), at $E_{\vec{d}} = 20.7$ and 29 MeV (1977CO17; α_0, α_1, α_3, α_4, α_5), and at $E_d = 40$ MeV (1976VA07; α_0, α_1, α_3, α_4, α_5). Single particle S-values are 1.5, 0.5, 0.1, 0.1 and 0.3 for ^{10}B*(0, 0.72, 2.15, 3.59, 4.77) (1976VA07; ZRDWBA). A study of the $m_s = 0$ yield at $E_{\vec{d}} = 14.5$ MeV ($\theta = 0°$) leads to assignments of 3^+, 2^- and (3^+, 4^-) for ^{10}B*(4.77, 5.11, 6.56) (1975KU15).

The population of the isospin forbidden group to ^{10}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}C(α, ^{6}Li)^{10}B $\qquad Q_m = -23.714$

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

52. ^{12}C(^{10}B, 3α)^{10}B $\qquad Q_m = -7.2748$

See (1965SH1A).

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

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}B*(0, 0.72, 2.15, 3.59)) and 78.8 MeV (1977MO1H; to ^{10}B*(0, 0.72, 2.15)). See also ^{16}O in (1982AJ01).

54. ^{13}C(p, α)^{10}B $\qquad Q_m = -4.0626$

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

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

See (1974AN36).

56. (a) ^{14}N(γ, α)^{10}B $Q_m = -11.6132$
(b) ^{14}N(p, pα)^{10}B $Q_m = -11.6132$

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

57. ^{14}N(d, ^{6}Li)^{10}B $Q_m = -10.140$

See (1978OE1B).

58. ^{14}N(^{3}He, ^{7}Be)^{10}B $Q_m = -10.027$

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

59. ^{14}N(α, ^{8}Be)^{10}B $Q_m = -11.7051$

See (1974WO1C, 1976WO11).

60. ^{14}N(^{11}B, ^{10}B)^{15}N $Q_m = -0.6219$

See (1970GO1B).

61. ^{15}N(^{11}B, ^{16}N)^{10}B $Q_m = -8.964$

See (1974AJ01).

62. ^{16}O(p, ^{7}Be)^{10}B $Q_m = -25.270$

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, 1974BA89, 1974RI1A, 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}C(β^+)^{10}B $\qquad Q_m = 3.651$

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

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

See (1974CE06).

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

At $E_p = 185$ MeV the π^- spectrum shows groups corresponding to ^{10}C*(0, 3.36 ± 0.07, 5.28 ± 0.06, 6.63 ± 0.15). Angular distributions have been obtained for the π^- corresponding to these four states. The π^+/π^- intensity ratio is usually $>> 1$ for analog states in ^{10}Be and ^{10}C (1973DA09). The population of ^{10}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 ± keV)	J^π; T	τ or $\Gamma_{c.m.}$ (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}Be(^{3}He, 2n)^{10}C $\qquad Q_m = -5.566$

See (1974MO23).

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

$E_{thresh.} = 4880.6 \pm 0.6$ 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}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}C*(5.2 ± 0.3) at $E_p = 30$ and 50 MeV. The excitation of ^{10}C*(6.5 ± 0.3, 8.3 ± 0.3, 8.9 ± 0.3) is also reported (1970CL01). See also ^{11}C in (1980AJ01).

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

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}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}B(^{6}Li, ^{6}He)^{10}C $Q_{\rm m} = -7.158$

See (1974AJ01).

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

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

9. ^{12}C(π^{+}, d)^{10}C $Q_{\rm m} = 110.728$

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

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

Angular distributions have been reported at $E_{\rm p} = 30.0$ to 54.1 MeV [see (1974AJ01)] and at 51.9 MeV (1977YA10; t to ^{12}C*(0, 3.35, 5.28, 6.6)) and 80 MeV (1977AN1E; t to ^{12}C*(0, 3.35, 5.3)). $L = 0$, 2 and 2 for ^{10}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}Be]. At $E_{\rm p} = 51.9$ MeV ^{10}C*(0, 3.4) are strongly excited and states at $E_{\rm x} = 5.28$, 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}He) reaction to analog states in ^{10}Be (1977YA10).

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

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

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

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

[§] *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}C.

At $E(^{3}\text{He}) = 70.3$ MeV the angular distributions of the ^{6}He ions corresponding to the population of ^{10}C*(0, 3.35) have been measured. The group to ^{10}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}N(^{3}He, ^{7}Li)^{10}C $\qquad Q_{\text{m}} = -12.816$

See (1971DE37).

^{10}N, ^{10}O
(Not illustrated)

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

^{10}F, ^{10}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

1959ME85 W.E. Meyerhof, N.W. Tanner and C.M. 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. Wolfli, 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. Vatset, L.Y. Kolesnikov, S.G. Tonapetyan, K.K. Chernyavskii and A.I. Shpetnyi, Atomnaya Energ. 10 (1961) 577; Sov. J. At. Energy 10 (1962) 574; Correction At. Energy 123 (2018) 432

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, Atomnaya Energ. 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

1965MO27 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. Phys. 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. Isacsson 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 (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

1969AN27 G.B. Andreev, I.D. Lopatko, V.I. Borovlev, V.A. Lutsik, R.P. Slabospitskii and A.Y. Taranov, Yad. Fiz. 10 (1969) 902; Sov. J. Nucl. Phys. 10 (1970) 521

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

1970AU02 D.L. Auton, Nucl. Phys. A157 (1970) 305

1970BE1B R. Beurtey, P. Catillon and P. Schnabel, J. Phys. 31 (1970) C2-96

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)

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 (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

1972SK08 D.M. Skopik, Y.M. Shin, J.W. Horniachek and S.K. Kundu, Nucl. Phys. A197 (1972) 185

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 Dezho, Neitronnaya Fiz., Part III, 1973 (1974) 85

1973BL1B Blatt, Suffert, Degre and Schaeffer, Asilomar (1973) Paper 884

1973BO1C Bouten, Bouten and Depuydt. Recent Developments in Theor. Nucl. Phys., La Toussuire, 1973 (1973) S1-1

1973BR1C Bromley, in Munich, 2 (1973) 22

1973CL1D Clements, Rept. AERE-R-7600 (1973)

1973CO1B Colgate, Explosive Nucleosynthesis (1973) 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

1973SR04 M.L. Srivastava and J.P. Sah, Indian J. Pure Appl. Phys. 11 (1973) 361

1973SZ07 S. Szegedi, Acta Phys. Acad. Sci. Hung. 34 (1973) 215

1973TA30 K. Takahashi, M. Yamada and T. Kondoh, At. Data Nucl. Data Tables 12 (1973) 101

1973TI1A Tinsley, Explosive Nucleosynthesis (1973) 22

1973TR1B Truran, Cosmochemistry; Ed., Cameron (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

1974BA89 L.K. Batist, E.E. Berlovich, L.A. Vaishnene, V.G. Konev, K.A. Mezilev and Y.N. Novikov, Yad. Fiz. 20 (1974) 850; Sov. J. Nucl. Phys. 20 (1975) 453

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

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

1974BOZB M. Bouten and M.C. Bouten, Proc. Int. Conf. Nucl. Struct. Spectroscopy, Amsterdam, 1974, Vol. 1 (1974) 57

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. Spectroscopy, Amsterdam, 1974, Vol. 2 (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. 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. (London) 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 Nuclei, Vol. 1 (1974) 35

1974KO24 S.D. Kostyuchenkov, V.M. Lebedev, A.V. Spasskii and I.B. Teplov, Bull. Moscow Univ. Fiz. Astron. 15 (1974) 424

1974KO35 E. Kondaiah, J. Phys. (London) 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. C10 (1974) 2237

1974MI06 G.A. Miller, Nucl. Phys. A224 (1974) 269

1974MO23 C.E. Moss and C.S. Zaidins, Nucl. Phys. A235 (1974) 11

1974MU13 N.C. Mukhopadhyay and F. Cannata, Phys. Lett. B51 (1974) 225

1974NI1A N.N. Nikolaev and M.Zh. Shmatikov, Phys. Lett. B52 (1974) 293

1974RA09 G.M. Raisbeck and F. Yiou, Phys. Rev. C9 (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. A225 (1974) 109

1974SC1C Schwartz, Schrack and Heaton, NBS Monograph 138 (1974)

1974SC1D Schramm, Ann. Rev. 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. C9 (1974) 102

1974ST13 H. Stehle, H. Eichner, H.J. Helten, H. Klein, H. Kretzer, K. Prescher and W.W. Wohlfarth, Nucl. Phys. A228 (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

1974TH01 C. Thibault and R. Klapisch, Phys. Rev. C9 (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

1974VAZO N. Van Sen, H. Muller, J.C. Gondrand, A. Fiore and G. Perrin, Int. Conf. Nucl. Struct. Spectroscopy, Amsterdam, 1974 (1974) 180

1974WE11 D.R. Weaver and J. Walker, J. Phys. (London) D7 (1974) 1122

1974WI02 D.H. Wilkinson and B.E.F. Macefield, Nucl. Phys. A232 (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, Clustering Phenom. in Nucl., 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, Clustering Phenom. in Nucl., II, ORO-4856-26 (1975) 281

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. 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, 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)

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, Clustering Phenom. in Nucl., II, ORO-4856-26 (1975) 232

1975RO1G Rosen, 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, AIP Conf. Proc. 26 (1975) 541

1975TR1A Trimble, Rev. Mod. Phys. 47 (1975) 877

1975VE05 J.D. Vergadosk, 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 Zwieglinski, 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, Polarization, Zurich, 1975 (1976) 503

1976AS1B Aslanides, Meson-Nucl. Phys., 1976 (1976) 204

1976AU1B Audouze and Lequeux, Astron. Astrophys. 49 (1976) 133

1976AU1C Audouze, Meneguzzi and Reeves, Spallation Nucl. Reactions and Their Applications; Eds., Shen abd Merker (1976) 113

1976AU1D Auchampaugh, Plattard, Extermann and Ragan, Lowell Conf., CONF-760715-P2 (1976) 1389

1976BA1Q Baker et al., Polarization, Zurich, 1975 (1976) 628

1976BAYR A.D. Bacher, P.T. Debevec, G.T. Emery, M.A. Pickar, K. Gotow and D.A. Jenkins, Bull. Amer. Phys. Soc. 21 (1976) 983, CB5

1976BE1E Behrens and Lzybisz, Phys. Data 6-1; ZAED (1976)

1976BE1G Berlovich, Izv. Akad. Nauk SSSR Ser. Fiz. 40 (1976) 756

1976BE1H Berman, Preprint UCRL-78482 (1976)

1976BE1K Bertini, Spallation Nucl. Reactions and Their Applications; Eds., Shen and Merker (1976) 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., Lowell Conf., CONF-760715-P2 (1976) 1309

1976BL1B Blair, Baker and Sherif, Polarization, Zurich, 1975 (1976) 636

1976BO1E Boesgaard, Pub. Astron. Soc. Pac. 88 (1976) 353

1976BO2C Bornec et al., Meson-Nucl. Phys., 1976 (1976) 260

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)

1976CRZV K.R. Crosthwaite, H.W. Clark, T.R. Donoghue and J.F. Morgan, Bull. Amer. Phys. Soc. 21 (1976) 925, C1

1976DA15 S.E. Darden, G. Murillo and S. Sen, Nucl. Phys. A266 (1976) 29

1976DA1F Davis, Spallation Nucl. Reactions and Their Applications; Eds., Shen and Merker (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 (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, Lowell Conf., CONF-760715-P2 (1976)

1976ED1A Edge, Tompkins and Glenn, Nuovo Cim. A31 (1976) 641

1976EG1A Egelhof et al., Polarization, Zurich, 1975 (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., Atomic Masses and Fundamental Constants; Eds., Sanders and Wapstra (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. Austriaca 46 (1976) 9

1976GAYV D.I. Garber and R.R. Kinsey, BNL 325, 3rd Edition, 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

1976HUZR D.A. Hutcheon, A.N. James, P. Kitching, W.J. McDonald, C.A. Miller, G.A. Moss, W.C. Olsen, D.M. Sheppard, A.W. Stetz and J.G. Rogers, Bull. Amer. Phys. Soc. 21 (1976) 775, BA11

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, Polarization, Zurich, 1975 (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., Contrib. to Dubna Conf. on Slected 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., Polarization, Zurich, 1975 (1976) 499

1976LI1K Lingenfelter, Spallation Nucl. Reactions and Thier Applications; Eds., Shen and Merker (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

1976MOZF J.M. Moss, D.R. Brown and W.D. Cornelius, Bull. Amer. Phys. Soc. 21 (1976) 990, CF5

1976NA11 M.N. Namboodiri, E.T. Chulick and J.B. Natowitz, Nucl. Phys. A263 (1976) 491

1976NO1D Noble, Meson-Nucl. Phys., 1976 (1976) 221

1976NO1E Northcliffe, 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 and Their Applications; Eds., Shen and Merker (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. Shamai, 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, Polariation, Zurich, 1975 (1976) 189

1976SI1C Simpson, Bull. Amer. Phys. Soc. 21 (1976) 602

1976SI1D Silberberg, Tsao and Shapiro, Spallation Nucl. Reactions and Their Applications; Eds., Shen and Merker (1976) 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 Veeser and Arthur, 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, Polarization, Zurich, 1975 (1976) 377

1976WA1C Walter and Lisowski, Lowell Conf., CONF-760715-P2 (1976) 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) 844

1977AS1E Aslanides et al., 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, High Energy Phys. Nucl. Struct., Zurich, 1977 (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) 812

1977BA2K Bains and Galloway, Nucl. Instrum. Meth. Phys. Res. 143 (1977) 295

1977BA2L Barker and Nolen, in Tokyo (1977) 155

1977BA51 B. Bassalleck, W.-D. Klotz, F. Takeutchi, H. Ullrich and M. Furic, Phys. Rev. C16 (1977) 1526

1977BEZY R.D. Bent, P.T. Debevec, P.H. Pile and R.E. Pollock, Bull. Amer. Phys. Soc. 22 (1977) 81, HH10

1977BI1D Bizzeti, Nucl. Instrum. Meth. Phys. Res. 146 (1977) 285

1977BO1V Bouten, Flerackers and Bouten, in Tokyo (1977) 153

1977BO29 I.I. Bondouk and S. Saad, Atomkernergie 29 (1977) 270

1977BR1J Brajnik et al., Fiz. Suppl. 9 (1977) 48

1977BY1A Byrd, Lisowski, Tornow and Walter, Bull. Amer. Phys. Soc. 22 (1977) 587

1977CA1E Carter et al., Proc., Zurich-Sin (1977) 318

1977CI1A Ciric et al., Fiz. Suppl. 9 (1977) 39

1977CO17 J.D. Cossairt, W.S. Burns and R.A. Kenefick, Nucl. Phys. A287 (1977) 13

1977CO1G Colombo et al., in Tokyo (1977) 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, High Energy Phys. Nucl. Struct., Zurich, 1977 (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. Gusakow, 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, High Energy Phys. Nucl. Struct., Zurich, 1977 (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., 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) 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) 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 (!977) 207

1977SC1D Schramm and Wagoner, Ann. Rev. Nucl. Sci. 27 (1977) 37

1977SE1D Seya et al., in Tokyo (1977) 149

1977SH1D Shimoda et al., in Tokyo (1977) 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, High Energy Phys. Nucl. Struct., Zurich, 1977 (1977) 261

1977ST1J J. Stevenson, P.B. Price and K. Frankel, Phys. Rev. Lett. 38 (1977) 1125

1977SU1B Subotic et al., Fiz. Suppl. 9 (1977) 44

1977SZ03 L. Szybisz, J. Davidson and V. Silbergleit, Nucl. Phys. A282 (1977) 435

1977TE1A Terrien, in Tokyo (1977) 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

1977TU03 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) 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. Yad. (USSR) 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. Ottewell, 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., 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, Bull. Amer. Astron. Soc.; to be published

1978FA04 G. Faldt and I. Hulthage, J. Phys. (London) 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, 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

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., 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, Proc., Zurich-Sin (1977) 182

1978RO1D Rolfs and Trautvetter, Ann. Rev. Nucl. Part. Sci. 28 (1978) 115

1978SHZM V.S. Shirley and C.M. Lederer, Table of Isotopes, 7th Edition, Appendices (1978) 42

1978SU02 K.M. Subotic, B. Lalovic and B.Z. Stepancic, 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