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*490 (1988), 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. The introduction and introductory tables have been omitted from this manuscript. Reference key numbers have been changed to the NNDC/TUNL format.

(References closed June 1, 1988)

Table of Contents for $A = 10$

Below is a list of links for items found within the PDF document. The introductory Table 2 *is available on this website via the link.*

^{10}n

(Not illustrated)

^{10}n has not been observed: see (1979AJ01). See also (1986AB10; theor.).

^{10}He

(Not illustrated)

^{10}He has not been observed. It has been searched for in the spontaneous fission of ^{252}Cf (1982AL33), in the fragmentation of 0.79 GeV/A ^{11}Li ions (1987KO1Y) and in the fragmentation of a 30 MeV/A ^{18}O beam (1988ST06). The production rate in the latter experiment is $< 3 \times 10^{-5}$ of the measured production probability of ^{8}He (1988ST06). See also (1984AJ01). The calculated value of the atomic mass excess of ^{10}He is 48.92 ± 0.14 MeV: ^{10}He is then unstable with respect to breakup into ^{9}He + n and ^{8}He + 2n by 0.04 and 1.18 MeV, respectively (1988BRZZ). See also (1984BE1C), (1979AJ01, 1984AJ01, 1987FL1A, 1987HA1R, 1987PE1C, 1987SE05) and (1983ANZQ, 1983PO1A, 1984VA06, 1985PO10, 1985SA32, 1986SA30, 1987BL18, 1987SA15; theor.).

^{10}Li

(Fig. 4)

At $E(^9\mathrm{Be}) = 121$ MeV, ^{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 if the group observed ($\Gamma \approx 1.2 \pm 0.3$ MeV) corresponds to the ground state. ^{10}Li$_{\mathrm{g.s.}}$ would then be unbound with respect to breakup into ^{9}Li + n by 0.80 ± 0.25 MeV: see (1979AJ01). See also (1986GI10, 1987AB15), (1984AJ01, 1985AL1G, 1987PE1C) and (1982KA1D, 1983ANZQ, 1983FE07, 1984VA06, 1985PO10, 1986AB10, 1988POZS; theor.).

^{10}Be

(Figs. 1 and 4)

GENERAL: See also (1984AJ01).

Model calculations: (1983MI1E, 1983SH38, 1984NI12, 1984VA06, 1985KW02).

Special states: (1984NI12, 1984VA06, 1987AB1H, 1987BL18).

Electromagnetic transitions: (1984NI12).

Astrophysical questions: (1984BE1F, 1984EN1A, 1984NE1D, 1984SA1D, 1985WE1A, 1987EL1E, 1987GR1Q, 1987NA1M, 1987SO1E, 1988BE1B, 1988FE1A, 1988HA1M).

Complex reactions involving ^{10}Be: (1983EN04, 1983OL1A, 1983WI1A, 1984GR08, 1984HI1A, 1984ST1B, 1985JA18, 1985MA13, 1985PO11, 1985TA18, 1985TR1B, 1986AN1F, 1986AV1B, 1986BA69, 1986CS1A, 1986HA1B, 1986ME06, 1986PO06, 1986SA30, 1986SIZS, 1986SO10, 1986WE1E, 1987AR19, 1987BA38, 1987BA39, 1987CH26, 1987DE37, 1987FE1A, 1987GR11, 1987GU04, 1987JA06, 1987KI05, 1987NA01, 1987TAZU, 1987TR05, 1987VI02, 1987VI14, 1987WA09, 1987YA16, 1988BL09, 1988CA06, 1988KI05, 1988KR11, 1988RU01, 1988SA19).

Applications: (1983FA1B, 1983KU1C, 1983LI1A, 1983NE1A, 1983SH1G, 1983TU1A, 1984BE1F, 1984BE1H, 1984BO1E, 1984DO1B, 1984EL1B, 1984EL1C, 1984EN1A, 1984HE1B, 1984HE1C, 1984HO1E, 1984IM1A, 1984KL1A, 1984MA1K, 1984MI1D, 1984NE1C, 1984NE1E, 1984PO1C, 1984RA1D, 1984SE1B, 1984SE1D, 1984SH1L, 1984SO1A, 1984SO1B, 1984SP1B, 1984SU1B, 1984TU1A, 1984TU1C, 1984VA1D, 1985BE1D, 1985RA1A, 1985YI1A, 1986NI1A, 1986SU1H, 1986TE1A, 1987BE1X, 1987BR1Q, 1987BR1U, 1987DE1P, 1987EI1A, 1987EL1E, 1987GO1W, 1987GR1Q, 1987IN1A, 1987JA1G, 1987KU1L, 1987LA1G, 1987LA1I, 1987MO1F, 1987NA1M, 1987OE1A, 1987RA1N, 1987RE1H, 1987SE1D, 1987SE1E, 1987SH1N, 1987VA1S).

Muon and neutrino capture and reactions: (1984KO24).

Reactions involving pions and kaons (See also reactions 3, 10, 15 and 17.): (1982BE1D, 1984KA1C, 1985BE1K, 1985TU1B, 1986BE1P, 1986RA16).

Hypernuclei: (1982KA1D, 1982WA1A, 1983BA1D, 1983FE07, 1983MI1E, 1983PO1D, 1984BO1D, 1984BO1G, 1984CH1G, 1984DZ1A, 1984ER1A, 1984KO1F, 1984SH1J, 1985AH1A, 1985IK1A, 1986AN1R, 1986BA1W, 1986BO1E, 1986DA1B, 1986MA1C, 1986PO1H, 1986WA1J, 1986ZH1B, 1987BO1L, 1987BO1O, 1987MI38, 1987PO1H, 1987WU05, 1988GI1B).

Other topics: (1984PO11, 1985AN28, 1985WI1B).

Fig. 1: Energy levels of ^{10}Be. In these diagrams, energy values are plotted vertically in MeV, based on the ground state as zero. Uncertain levels or transitions are indicated by dashed lines; levels which are known to be particularly broad are cross-hatched. Values of total angular momentum J, parity, and isobaric spin T which appear to be reasonably well established are indicated on the levels; less certain assignments are enclosed in parentheses. For reactions in which ^{10}Be is the compound nucleus, some typical thin-target excitation functions are shown schematically, with the yield plotted horizontally and the bombarding energy vertically. Bombarding energies are indicated in laboratory coordinates and plotted to scale in cm coordinates. Excited states of the residual nuclei involved in these reactions have generally not been shown; where transitions to such excited states are known to occur, a brace is sometimes used to suggest reference to another diagram. For reactions in which the present nucleus occurs as a residual product, excitation functions have not been shown; a vertical arrow with a number indicating some bombarding energy, usually the highest, at which the reaction has been studied, is used instead. Further information on the levels illustrated, including a listing of the reactions in which each has been observed, is contained in the master table, entitled "Energy levels of ^{10}Be".

24

21.22 (2⁻;T=2)

γ_1 (90°) γ_0
α (90°) ⁹Li
n(0°)

5.62

18.55 1.74

17.79 0.77

17.2498 0.24

⁷Li + t

96 21.4743
⁸Li + d

19.636
⁹Li + p

30
14.782
⁷Li + ⁷Li − α

11.76

10.57 ≥1

σ_α 4.3

2.1
8.5861
¹¹B + t − α

8.4774
⁸Be + 2n

9.27 9.4 (4⁻) (2)⁺

2.85
2.73

7.371 7.542 2⁺ 3⁻

σ_t 0.82
0.63

7.4104
⁶He + α

6.8120

5.960 6.179 6.263 2⁻ 0⁺ ⁹Be + n

698 5.9583 1⁻ 2⁺

4.5874
⁹Be + d − p

π

3.3680 2⁺

¹⁰Be

J$^\pi$=0⁺;
T=1 β⁻ −0.5561
¹⁰B

7.88

14.8
0.2262
¹⁰B + n − p

50
−2.5642
⁷Li + α − p

1000
−11.2279
¹¹B + p − 2p

20
52 −3.8356
¹³C + n − α

−5.7344
¹¹B + d − ³He

800
−133.539
⁹Be + p − π⁺

5

Ground-state properties of ^{10}Be: (1983ANZQ, 1984FR13, 1984NI12, 1985AN28, 1985SA32, 1985TA18, 1986WI04, 1987BL18, 1987HA30, 1987LE33, 1987SA15, 1988JO1C).

The interaction nuclear radius of ^{10}Be is 2.46 ± 0.03 fm [(1985TA18), $E = 790$ MeV/A; see also for derived nuclear matter, charge and neutron matter r.m.s. radii].

B(E2)↑ for ^{10}Be*(3.37) $= (5.2 \pm 0.6) \times 10^{-3}$ $e^2 \cdot$ b^2 [$Q_0 = 0.229 \pm 0.013$ b] (1987RA01).

1. ^{10}Be$(\beta^-)^{10}$B $\qquad\qquad\qquad\qquad$ $Q_m = 0.5561$

The half-life of ^{10}Be is $(1.51 \pm 0.06) \times 10^6$ y (1987HO1P). Log $ft = 13.397 \pm 0.017$ (M.J. Martin, private communication). For the earlier work see (1974AJ01).

2. (a) ^{7}Li(t, γ)^{10}Be $\qquad\qquad$ $Q_m = 17.2498$
   (b) ^{7}Li(t, n)^{9}Be $\qquad\qquad$ $Q_m = 10.4378$ $\qquad\qquad\qquad$ $E_b = 17.2498$
   (c) ^{7}Li(t, p)^{9}Li $\qquad\qquad$ $Q_m = -2.386$
   (d) ^{7}Li(t, t)^{7}Li
   (e) ^{7}Li(t, α)^{6}He $\qquad\qquad$ $Q_m = 9.839$

The yield of γ_0 and γ_1 has been studied for $E_t = 0.4$ to 1.1 MeV [^{10}Be*(17.79) is said to be involved]: see (1984AJ01). The neutron yield exhibits a weak structure at $E_t = 0.24$ MeV and broad resonances at $E_t \approx 0.77$ MeV [$\Gamma = 160 \pm 50$ keV] and 1.74 MeV: see (1966LA04) [^{10}Be*(17.79, 18.47)]. The total cross section for reaction (c), the yield of neutrons (reaction (b) to ^{9}Be*(14.39)), and the yield of γ-rays from ^{7}Li*(0.48)(reaction (d)) all show a sharp anomaly at $E_t = 5.685$ MeV: $J^\pi = 2^-$; $T = 2$ is suggested for a state at $E_x = 21.22$ MeV. The total cross section for α_0 (reaction (e)) and the all-neutrons yield do not show this structure: see (1983AB1A), (1984AJ01) and (1985DE19; theor.). An additional anomaly in the proton yield is also reported at $E_t = 8.5$ MeV [^{10}Be*(23.2)][see (1987AB15)]. Differential cross sections and S-factors are reported by (1983CE1A) for $E_t = 70$ to 110 keV for ^{6}He*(0, 1.80). The zero-energy S-factor for ^{6}He*(1.80) is 14 ± 2.5 MeV· b. The relevance to an Li-seeded tritium plasma is discussed by (1983CE1A). See also (1987AB09), (1985CA41; astrophys.) and (1986AB10; theor.).

3. ^{7}Li(^{3}He, π^+)^{10}Be $\qquad\qquad\qquad$ $Q_m = -122.337$

Cross sections have been measured to ^{10}Be*(3.37, 6.2[u], 7.4[u] [u=unresolved]) at $E(^3$He) = 235 MeV. The ground-state group is not seen: its intensity at $\theta_{lab} = 20°$ is ≤ 0.1 that to ^{10}Be*(3.37) (1984BI08).

Table 10.1: Energy levels of ^{10}Be [a]

E_{x} (MeV $\pm$ keV)	$J^{\pi}; T$	τ or $\Gamma_{\mathrm{c.m.}}$ (keV)	Decay	Reactions
g.s.	$0^+; 1$	$\tau_{1/2} = (1.51 \pm 0.06) \times 10^6$ y	β^-	1, 2, 4, 5, 6, 10, 11, 12, 13, 14, 15, 17, 18, 19, 20, 21, 22, 23, 24, 26
3.36803 ± 0.03	$2^+; 1$	$\tau_{\mathrm{m}} = 180 \pm 17$ fsec	γ	2, 3, 4, 5, 6, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 26
5.95839 ± 0.05	$2^+; 1$	$\tau_{\mathrm{m}} < 80$ fsec	γ	4, 6, 11, 12, 16, 18, 19, 22, 24
5.9599 ± 0.6	$1^-; 1$		γ	4, 11, 12, 18, 19, 22, 24
6.1793 ± 0.7	$0^+; 1$	$\tau_{\mathrm{m}} = 1.1^{+0.4}_{-0.3}$ psec	π, γ	11, 19
6.2633 ± 5	$2^-; 1$		γ	11, 12
7.371 ± 1	$3^-; 1$	$\Gamma = 15.7 \pm 0.5$ keV	n	5, 7, 11, 12
7.542 ± 1	$2^+; 1$	6.3 ± 0.8	n	4, 5, 7, 11, 12, 24
9.27	$(4^-); 1$	150 ± 20	n	5, 7, 11, 12
9.4	$(2)^+; 1$	291 ± 20	n	5, 7, 11, 12, 18, 24
10.57 ± 30	$\geq 1; 1$		n	4, 5, 7, 11
11.76 ± 20		121 ± 10		4, 5, 11, 12, 24
17.79		110 ± 35	γ, n, t	2, 4, 5
18.55		≈ 350	n, t	2, 4, 5
(21.22)	$(2^-; 2)$	sharp	n, p, t	2
(24)				25

[a] See also Table 10.4.

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

E_γ (keV) [b]	Transition	E_x (keV) [b]
6809.585 (33)	capt.$\rightarrow$g.s.	6812.038 (29)
5955.9 (5) [a]	5.96 [c] $\rightarrow$g.s.	5958.387 (51)
3443.374 (30)	capt.$\rightarrow$ 3.37	
3367.415 (30)	3.37 $\rightarrow$g.s.	3368.029 (29)
2589.999 (60)	5.96 [c] $\rightarrow$ 3.37	
853.605 (60)	capt.$\rightarrow$ 5.96 [c]	

[a] See also Tables 10.2 in (1974AJ01, 1979AJ01).
[b] (1983KE11). 12 eV has been added in quadrature to the uncertainties. I am very grateful to T.J. Kennett for his comments. Some of the work displayed in Table 10.2 of (1984AJ01) is not shown here because it has not been published. However, those particular transitions are shown in Fig. 1 since it is clear that they have been observed although the lack of published uncertainties make their inclusion in this table inadvisable.
[c] This is the 2^+ member of the doublet at $E_x = 5.96$ MeV.

4. ^{7}Li(α, p)^{10}Be $\qquad\qquad Q_m = -2.5642$

See (1987BI1C) and (1979AJ01).

5. ^{7}Li(^{7}Li, α)^{10}Be $\qquad\qquad Q_m = 14.782$

See (1974AJ01).

6. ^{9}Be(n, γ)^{10}Be $\qquad\qquad Q_m = 6.8120$

The thermal capture cross section is 8.49 ± 0.34 mb (1986CO14). Reported γ-ray transitions are displayed in Table 10.2 (1983KE11). Partial cross sections involving ^{10}Be*(0, 3.37, 5.96) are listed in (1987LY01). See also (1984SH1P, 1984SH1R) and (1985MU03, 1986MU1B, 1986RA1B, 1987LY01, 1988MU05; theor.).

Table 10.3: Resonances in ^{9}Be(n, n)^{9}Be [a]

E_{res} (MeV $\pm$ keV)	^{10}Be* (MeV)	$\Gamma_{\text{c.m.}}$ (keV)	J^π	l	θ^2 (%) [b]
0.6220 ± 0.8	7.371	15.7 ± 0.5	3^-	2	7.5
0.8118 ± 0.7	7.542	6.3 ± 0.8	2^+	1	0.28
2.73	9.27	≈ 100	(4^-)	(2)	
(2.85)	9.4	≈ 400	(2^+)	(1)	
4.3	10.7		≥ 1		

[a] For references see Table 10.3 in (1979AJ01).
[b] $R = 5.6$ fm.

7. (a) ^{9}Be(n, n)^{9}Be $\hspace{6cm} E_{\text{b}} = 6.8120$

   (b) ^{9}Be(n, 2n)^{8}Be $\hspace{3cm} Q_{\text{m}} = -1.6654$

The scattering amplitude (bound) $a = 7.778 \pm 0.003$ fm, $\sigma_{\text{free}} = 6.151 \pm 0.005$ b (1981MUZQ). The difference in the spin-dependent scattering lengths, $b^+ - b^-$ is $+0.24 \pm 0.07$ (1987GL06). See also (1987LY01). Total cross section measurements have been reported for $E_{\text{n}} = 2 \times 10^{-3}$ eV to 2.6 GeV/c [see (1979AJ01, 1984AJ01)] and at 24 keV (1983AI01), 7 to 15 MeV (1983DA22; also reaction cross sections) and 10.96, 13.89 and 16.89 MeV (1985TE01; for n$_0$ and n$_2$).

Observed resonances are displayed in Table 10.3. Analysis of polarization and differential cross section data leads to the 3^-, 2^+ assignments for ^{10}Be*(7.37, 7.55). Below $E_{\text{n}} = 0.5$ 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. The structure at $E_{\text{n}} = 2.73$ 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 $E_{\text{n}} = 2.73$ MeV with a probable assignment of $J^\pi = 4^-$. The 4^- assignment results from a study of the polarization of the n$_0$ group at $E_{\text{n}} = 2.60$ 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). A weak dip at $E_{\text{n}} \approx 4.3$ MeV is ascribed to a level with $J \geq 1$. See (1974AJ01) for references. The analyzing power has been measured for $E_{\text{n}} = 1.6$ to 15 MeV [see (1984AJ01)] and at $E_{\bar{\text{n}}} = 9$ to 17 MeV (1984BY03; n$_0$, n$_2$).

The non-elastic and the (n, 2n) cross sections rise rapidly to ≈ 0.6 b (≈ 0.5 b for (n, 2n)) at $E_{\text{n}} \approx 3.5$ MeV and then stay approximately constant to $E_{\text{n}} = 15$ MeV: see (1979AJ01, 1984AJ01). For total γ-ray production cross sections for $E_{\text{n}} = 2$ to 25 MeV, see (1986GO1L). See also (1983GO1H, 1984SH1P, 1984SH1R, 1986MU07), (1985PE06; applications) and (1986DU1G, 1987HAZS; theor.).

8. (a) ^{9}Be(n, p)^{9}Li $\hspace{3cm} Q_{\text{m}} = -12.824 \hspace{3cm} E_{\text{b}} = 6.8120$

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(b) ^{9}Be(n, d)^{8}Li $Q_m = -14.662$

(c) ^{9}Be(n, t)^{7}Li $Q_m = -10.438$

Cross sections have been measured at $E_n = 14.1$–14.9 MeV for reaction (a), 16.3 to 18.7 MeV for (b) and 13.3 to 15.0 (t$_1$) and 22.5 MeV (reaction (c)): see (1979AJ01). A recent measurement (reaction (c)) has been reported at $E_n = 14.6$ MeV (1987ZA01). See (1983BO1C) and (1984SH1P, 1984SH1R, 1985BO1D).

9. ^{9}Be(n, α)^{6}He $Q_m = -0.598$ $E_b = 6.8120$
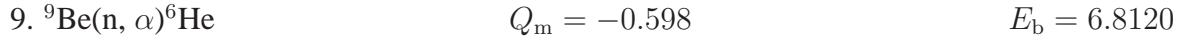
The cross section for production of ^{6}He shows a smooth rise to a broad maximum of 104 ± 7 mb at 3.0 MeV, followed by a gradual decrease to 70 mb at 4.4 MeV. From $E_n = 3.9$ to 8.6 MeV, the cross section decreases smoothly from 100 mb to 32 mb. Excitation functions have been measured for α_0 and α_1 for $E_n = 12.2$ to 18.0 MeV: see (1979AJ01) for references. See also (1983SH1J) and (1984SH1P, 1984SH1R).

10. ^{9}Be(p, π^+)^{10}Be $Q_m = -133.539$

Angular distributions have been studied at $E_p = 185$ to 800 MeV [see (1984AJ01)] and at $E_{\vec{p}} = 650$ MeV (1986HO23; to ^{10}Be*(0, 3.37)). States at $E_x = 6.07 \pm 0.13, 7.39 \pm 0.13, 9.31 \pm 0.24,$ 11.76 MeV have also been populated. A_y measurements involving ^{10}Be*(0, 3.37) are reported at $E_{\vec{p}} = 200$ to 250 MeV [see (1984AJ01)] and at 650 MeV (1986HO23).

11. ^{9}Be(d, p)^{10}Be $Q_m = 4.5874$

Angular distributions of proton groups have been studied at many energies in the range $E_d = 0.15$ to 17.3 MeV and at 698 MeV [see (1979AJ01, 1984AJ01)], as well as at $E_{\vec{d}} = 2.0$ to 2.8 MeV (1984DE46, 1984AN16; p$_0$, p$_1$; also VAP) and $E_d = 12.5$ MeV (1987VA13; p$_0$, p$_1$). At $E_d = 15$ MeV $S = 2.1, 0.23$ ($j_n = \frac{3}{2}$) and 0.12 ($j_n = \frac{1}{2}$), $\leq 1.0, 0.065$ ($j_n = \frac{5}{2}$) and 0.132 ($j_n = \frac{1}{2}$), for ^{10}Be*(0, 3.37, 5.96, 6.26). 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), $l_n = 2$ 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. ^{10}Be*(9.27, 9.4, 11.76) have $\Gamma_{c.m.} = 150 \pm 20, 291 \pm 20$ and 121 ± 10 keV. See (1979AJ01) for references.

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 directly in the ^{9}Be(n, γ) decay]; the higher state has $J^\pi = 1^-$ and goes mainly by a crossover to

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

E_{x} (keV)	Transition	ΔJ^π	Mtpl.	Branch (%)	τ_{m} (psec)	Γ_γ (meV)
3368.0 ± 0.2	$3.37 \to$ g.s.	$2^+ \to 0^+$	E2	100	0.189 ± 0.020	3.48 ± 0.37
					0.160 ± 0.030	4.11 ± 0.78
5958.3 ± 0.3	$5.96 \to 3.37$	$2^+ \to 2^+$	M1	> 90	< 0.08	
	$5.96 \to$ g.s.	$2^+ \to 0^+$	E2	< 10		
5959.9 ± 0.6	$5.96 \to$ 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	$6.18 \to 5.96$	$0^+ \to 1^-$	E1	24 ± 2	$1.1^{+0.4}_{-0.3}$	0.14 ± 0.05
	$6.18 \to 3.37$	$0^+ \to 2^+$	E2	76 ± 2		0.46 ± 0.28
	$6.18 \to$ g.s.	$0^+ \to 0^+$	E0			
		1^-	M1	$\left.\rule{0pt}{40pt}\right\}$ ≤ 1		
6263.3 ± 5	$6.26 \to 5.96$	$2^- \to$				
		2^+	E1			
	$6.26 \to 3.37$	$2^- \to 2^+$	E1	99^{+1}_{-2}		
	$6.26 \to$ g.s.	$2^- \to 0^+$	M2	1 ± 1		

[a] See Table 10.4 in (1979AJ01) for references. However, note that there are several typographical errors in the ^{10}Be*(6.18) decay.

^{10}Be(g.s.). Angular correlations measured with the γ-ray detector located normal to the reaction plane ($\equiv$ angular distributions) lead to l_{n} values consistent with the assignments of 2^+ and 1^- for ^{10}Be*(5.9584, 5.9599) obtained from the character of the γ-decay. ^{10}Be*(6.18) decays primarily to ^{10}Be*(3.37): $E_\gamma = 219.4 \pm 0.3$ keV for the $6.18 \to 5.96$ transition. See Table 10.4 for a listing of the information on radiative transitions obtained in this reaction and lifetime measurements. For (p, γ) correlations through ^{10}Be*(3.37) see (1987VA13) and references in (1974AJ01). For polarization measurements see ^{11}B in (1990AJ01).

12. ^{9}Be(α, ^{3}He)^{10}Be $\qquad\qquad Q_{\mathrm{m}} = -13.7658$

Angular distributions have been studied at $E_\alpha = 65$ MeV to ^{10}Be*(0, 3.37, 5.96, 6.26, 7.37, 7.54, 9.33, 11.88). DWBA analyses of these lead to spectroscopic factors which are in poor agreement with those reported in other reactions: see (1984AJ01).

13. (a) ^{9}Be(^{7}Li, ^{6}Li)^{10}Be $\qquad\qquad Q_{\mathrm{m}} = -0.438$

(b) ^{9}Be(^{9}Be, ^{8}Be)^{10}Be $\qquad\qquad Q_m = 5.1466$

Angular distributions have been measured at $E(^7\text{Li}) = 34$ MeV (reaction (a)) to ^{10}Be*(0, 3.4): $S = 2.07$ and 0.42 (p$_{1/2}$), 0.38 (p$_{3/2}$). See (1979AJ01). At $E(^9\text{Be}) = 20$ MeV an angular distribution involving ^{8}Be$_{\text{g.s.}} + {}^{10}$Be$_{\text{g.s.}}$ has been measured: transitions to excited states of ^{10}Be are very weak (1985JA09).

14. (a) ^{10}Be(p, p)^{10}Be
    (b) ^{10}Be(d, d)^{10}Be
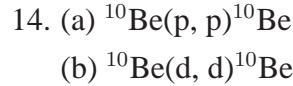
Angular distributions of the p$_0$ and p$_1$ groups have been measured at $E_p = 12.0$ to 16.0 MeV. The elastically scattered deuterons have been studied at $E_d = 12.0$ and 15.0 MeV: see (1974AJ01).

15. (a) ^{10}B(γ, π^+)^{10}Be $\qquad\qquad Q_m = -140.125$
    (b) ^{10}B(e, $e'\pi^+$)^{10}Be $\qquad\qquad Q_m = -140.125$
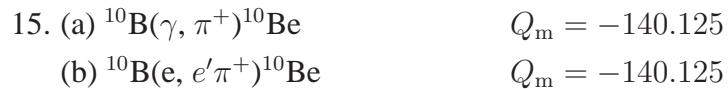
Differential cross sections have been measured to ^{10}Be*(0, 3.37) at $E_\gamma = 230$ to 340 MeV [see (1984AJ01)] and at $E_e = 185$ MeV (1986YA07) and 200 MeV (1984BLZY). See also (1984AJ01).

16. ^{10}B(μ^-, ν)^{10}Be $\qquad\qquad Q_m = 105.1031$

Partial capture rates leading to the 2^+ states ^{10}Be*(3.37, 5.96) have been reported: see (1984AJ01).

17. ^{10}B(π^-, γ)^{10}Be $\qquad\qquad Q_m = 139.012$

The photon spectrum from stopped pions is dominated by peaks corresponding to ^{10}Be*(0, 3.4, 6.0, 7.5, 9.4), and branching ratios have been obtained. Those to ^{10}Be*(0, 3.4) are $(2.02 \pm 0.17)\%$ and $(4.65 \pm 0.30)\%$, respectively [absolute branching ratio per stopped pion] (1986PE05). See (1979AJ01) for the earlier work.

18. (a)^{10}B(n, p)^{10}Be $\qquad\qquad Q_m = 0.2262$
    (b) ^{10}B(d, 2p)^{10}Be $\qquad\qquad Q_m = -1.9983$

Angular distributions [reaction (b)] are reported at $E_d = 55$ MeV to ^{10}Be*(0, 3.37, 5.96, 9.4): see (1984AJ01). See also (1987KW01; theor.). For reaction (a) see (1974AJ01) and (1987LA16) in ^{11}B (1990AJ01).

19. ^{11}Li(β^-)^{11}Be$\rightarrow$^{10}Be + n $Q_m = 20.22$
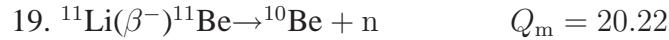
^{11}Li populates several states of ^{10}Be, via delayed neutron emission. Gamma rays have been observed for the transitions $6.18 \rightarrow 5.96$, $6.18 \rightarrow 3.37$, 5.96 (unres.)$\rightarrow 3.37$ and $3.37\rightarrow$ g.s. with $I_\gamma = (0.95 \pm 0.35)$, (1.65 ± 0.70), (3.5 ± 1.0) and $(21 \pm 6)\%$, respectively: see Table 11.2 in (1985AJ01).

20. ^{11}B(γ, p)^{10}Be $Q_m = -11.2279$

See (1984AL22) and ^{11}B in (1990AJ01). See also (1979AJ01).

21. ^{11}B(p, 2p)^{10}Be $Q_m = -11.2279$

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 (1974AJ01). See also (1985BE30, 1985DO16; prelim.).

22. ^{11}B(d, ^{3}He)^{10}Be $Q_m = -5.7343$

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): see (1979AJ01).

23. ^{11}B(^{11}B, ^{12}C)^{10}Be $Q_m = 4.7293$

See (1985PO02).
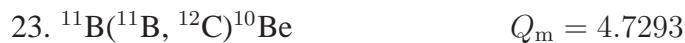
24. ^{12}C(^{6}Li, ^{8}B)^{10}Be $Q_m = -21.442$

At $E(^6\text{Li}) = 80$ MeV, $^{10}\text{Be}^*(0, 3.37, 5.96, 7.54, (9.4), 11.8)$ are populated and the angular distribution to $^{10}\text{Be}_{\text{g.s.}}$ has been measured: see (1979AJ01). See also (1982AL08, 1983AL20, 1985AL1G).

25. $^{13}\text{C}(\text{p, d2p})^{10}\text{Be}$ $\qquad\qquad\qquad Q_{\text{m}} = -29.9069$

See (1987GIZZ) and ^{12}C in (1990AJ01).

26. $^{14}\text{C}(^{14}\text{C}, {}^{18}\text{O})^{10}\text{Be}$ $\qquad\qquad\qquad Q_{\text{m}} = -5.785$

See (1985KO04).

<p style="text-align:center">^{10}**B**</p>
<p style="text-align:center">(Figs. 2 and 4)</p>

GENERAL: See also (1984AJ01).

Shell and deformed models: (1983VA31, 1984VA06, 1984ZW1A, 1987KI1C, 1988OR1C, 1988WO04).

Cluster and α-particle models: (1983SH38, 1984NI12, 1985KW02).

Special states: (1983BI1C, 1983FE07, 1983VA31, 1984NI12, 1984VA06, 1984ZW1A, 1985GO1A, 1985HA18, 1985HA1J, 1986BA1X, 1986XU02, 1987AB1H, 1987BA2J, 1987KI1C, 1988KW02).

Electromagnetic transitions and giant resonances: (1983GM1A, 1984NI12, 1985GO1A, 1987BA2J, 1987KI1C).

Astrophysical questions: (1982AU1A, 1982CA1A, 1984TR1C, 1985CA41, 1985WA1K, 1987AR1C, 1987AU1A, 1987RO25, 1988KR1G, 1988RE1B).

Complex reactions involving ^{10}B: (1983EN04, 1983GU1A, 1983NA08, 1983OL1A, 1984GR08, 1984HI1A, 1984HO23, 1984RE14, 1984TE1A, 1985KAZQ, 1985LI1B, 1985MO08, 1985WI18, 1986AV1A, 1986CA30, 1986HA1B, 1986MA19, 1986ME06, 1986MO13, 1986SA30, 1986SH1F, 1986UT01, 1986XU02, 1986XU1B, 1987AK1A, 1987AR19, 1987BA38, 1987BA39, 1987BU07, 1987DE37, 1987FE1A, 1987GE1B, 1987HE1H, 1987HI05, 1987JA06, 1987KO15, 1987LY04, 1987MU03, 1987NA01, 1987PO23, 1987RO10, 1987ST01, 1987TR05, 1987WA09, 1987YA16, 1988BL09, 1988CA06, 1988KI05, 1988KR11, 1988RU01, 1988SA19, 1988SI01, 1988TS03).

Applications: (1983AM1A, 1983KU1C, 1985KO47, 1986EN1A, 1986WE1E).

Muon and neutrino capture and reactions: (1983GM1A, 1985MI1D, 1987KU23, 1987SU06).

Pion and kaon capture and reactions (See also reactions 23 and 48.): (1982BE1D, 1983AN1F, 1983BA71, 1983FE07, 1983GE12, 1983GE13, 1983GE1C, 1983GM1A, 1983MA40, 1983ZIZZ, 1984BA1U, 1984CO1D, 1984ER1B, 1984KA1C, 1984MA1F, 1985IM1A, 1985RO17, 1985TU1B, 1985ZI04, 1986BE1P, 1986GA1F, 1986GA1H, 1986MA1C, 1986PE05, 1986RA16, 1986RO03, 1988AB05, 1987LE1E, 1987NA04, 1987SI18, 1988GIZU, 1988GIZT, 1988RIZZ).

Hypernuclei: (1982KA1D, 1983FE07, 1983SH38, 1983SH1E, 1984BO1H, 1984CH1H, 1984ER1A, 1984MA1F, 1984MI1C, 1984MI1E, 1984SH1J, 1984ZH1B, 1985AH1A, 1985DEZY, 1985GU1J, 1986AN1R, 1986CH1P, 1986DA1B, 1986GA1H, 1986MA1C, 1986MA1W, 1987BO1L, 1987MI38, 1987PO1H).

Other topics: (1983BI1C, 1985AN28, 1986IS04, 1986YA1F, 1987BA2J, 1988AJ1B, 1988KW02, 1988OR1C).

Ground-state properties of ^{10}B: (1983ANZQ, 1983VA31, 1984BR25, 1984MIZM, 1984NI12, 1984VA06, 1985AN28, 1985GO1A, 1985HA18, 1985ZI05, 1986DO1E, 1986GL1A, 1986RO03, 1987KI1C, 1987LE33, 1988VA03, 1988WO04).
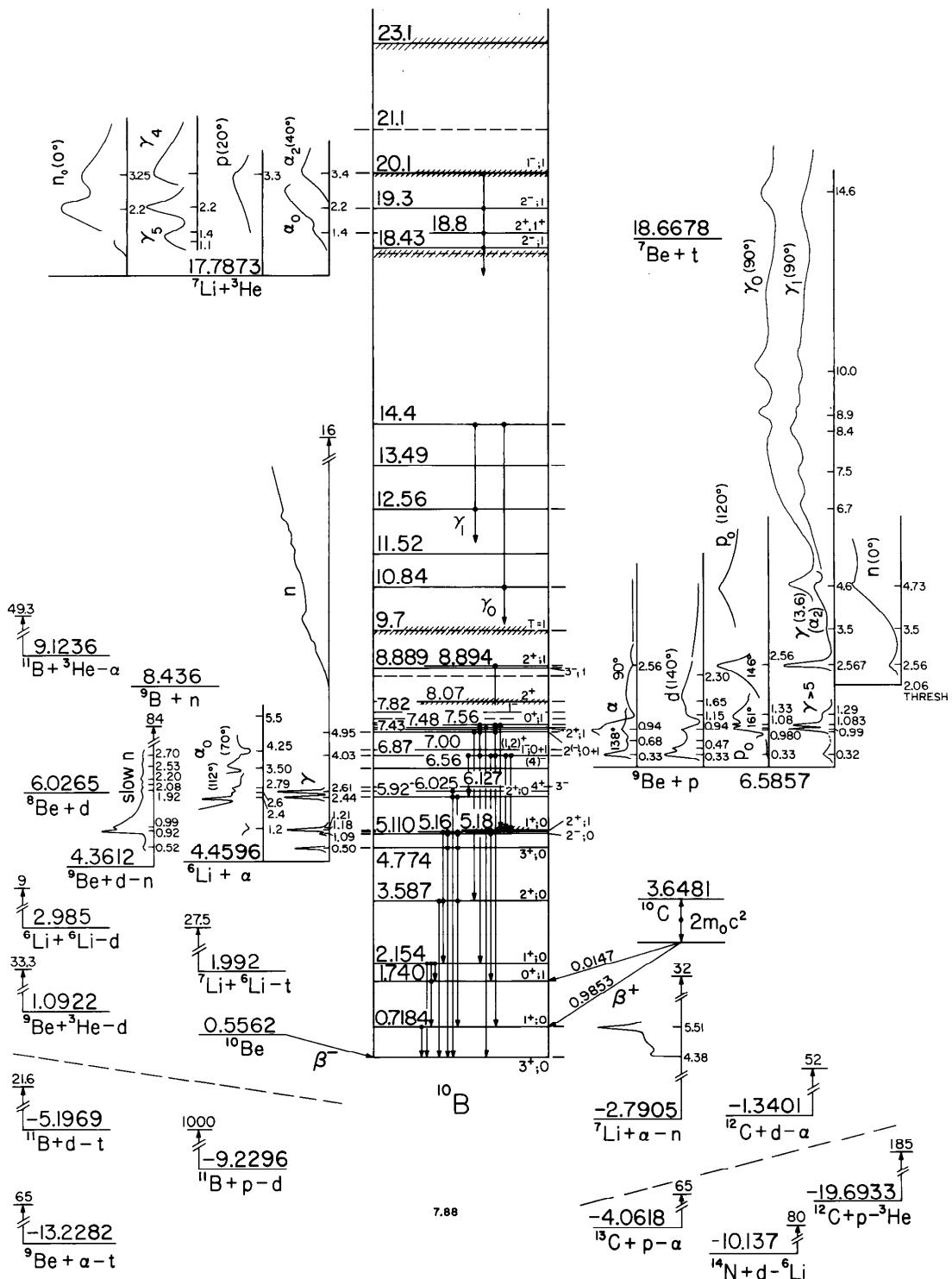
Fig. 2: Energy levels of ^{10}B. For notation see Fig. 1.

Table 10.5: Energy levels of ^{10}B [a]

E_x (MeV $\pm$ keV)	$J^\pi; T$	τ_m or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
g.s.	$3^+; 0$	stable		1, 4, 5, 10, 11, 16, 17, 18, 19, 20, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 42, 43, 44, 45, 49, 50, 51, 52, 53, 54, 56, 57
0.71835 ± 0.04	$1^+; 0$	$\tau_m = 1.020 \pm 0.005$ nsec $g = +0.63 \pm 0.12$	γ	1, 4, 5, 10, 11, 16, 17, 18, 19, 21, 24, 25, 26, 28, 29, 34, 40, 42, 43, 44, 45, 48, 49, 50, 51, 53, 56
1.74015 ± 0.17	$0^+; 1$	7 ± 3 fsec	γ	1, 4, 10, 11, 16, 17, 18, 19, 23, 24, 25, 28, 40, 41, 42, 43, 44, 45, 49, 50, 54
2.1543 ± 0.5	$1^+; 0$	2.13 ± 0.20 psec	γ	1, 4, 11, 16, 17, 18, 19, 24, 25, 26, 28, 29, 34, 42, 43, 44, 45, 48, 49, 50, 51, 52, 53
3.5871 ± 0.5	$2^+; 0$	153 ± 12 fsec	γ	1, 4, 5, 11, 16, 17, 18, 24, 25, 26, 28, 29, 41, 42, 44, 49, 50, 51, 53, 56
4.7740 ± 0.5	$3^+; 0$	$\Gamma = 8.4 \pm 1.8$ eV	γ, α	1, 4, 5, 16, 17, 18, 24, 25, 26, 29, 44, 49, 50, 51, 56
5.1103 ± 0.6	$2^-; 0$	0.98 ± 0.07 keV	γ, α	1, 11, 16, 17, 25, 29, 44, 50
5.1639 ± 0.6	$2^+; 1$	$\tau_m < 6$ fsec	γ, α	1, 11, 16, 17, 23, 25, 26, 41, 44, 49
5.180 ± 10	$1^+; 0$	$\Gamma = 110 \pm 10$	γ, α	1, 3, 11, 16, 17, 26, 29, 44
5.9195 ± 0.6	$2^+; 0$	6 ± 1	γ, α	1, 3, 11, 16, 17, 18, 25, 26, 28, 29, 44, 49, 50, 51

E_{x} (MeV $\pm$ keV)	J^π; T	τ_{m} or $\Gamma_{\text{c.m.}}$ (keV)	Decay	Reactions
6.0250 ± 0.6	4^+	0.05 ± 0.03	γ, α	1, 3, 16, 17, 18, 23, 24, 25, 26, 28, 29, 42, 44, 50, 51, 54, 56
6.1272 ± 0.7	3^-	2.36 ± 0.03	α	3, 16, 17, 18, 25, 26, 28, 42, 44, 50
6.560 ± 1.9	$(4)^-$	25.1 ± 1.1	α	3, 16, 17, 18, 25, 26, 28, 29, 42, 44, 49, 50
6.873 ± 5	$1^-; 0+1$	120 ± 5	$\gamma,$ p, d, α	1, 11, 13, 15, 16
7.002 ± 6	$(1,2)^+; (0)$	100 ± 10	p, d, α	3, 15, 16, 18, 25, 26, 28, 44, 50, 56
7.430 ± 10	$2^{(-)}; 0+1$	100 ± 10	$\gamma,$ p, d, α	1, 11, 15
7.467 ± 10	1^+	65 ± 10	p	13, 44
7.478 ± 2	$2^+; 1$	74 ± 4	$\gamma,$ p	11, 13, 23, 44
7.5599 ± 0.6	$0^+; 1$	2.65 ± 0.18	$\gamma,$ p	11, 13, 16, 44
(7.67 ± 30)	$(1^+; 0)$	250 ± 20	p, d	13, 15
7.819 ± 20	1^-	260 ± 30	p	13, 16, 18, 44
8.07	2^+	800 ± 200	$\gamma,$ p, d	15, 16, 23
(8.7)	$(1^+, 2^+)$	(≈ 200)	p	13, 15, 56
8.889 ± 6	$3^-; 1$	84 ± 7	$\gamma,$ n, p, α	12, 13, 15, 18, 23, 49
8.894 ± 2	$2^+; 1$	40 ± 1	$\gamma,$ p, α	11, 13, 15, 18, 23, 49
(9.7)	$(T=1)$	(≈ 700)	n, p, α	12, 15
10.84 ± 10	$(2^+, 3^+, 4^+)$	300 ± 100	$\gamma,$ n, p	11, 12, 13, 23, 44
11.52 ± 35		500 ± 100	(γ)	23, 42, 44
12.56 ± 30	$(0^+, 1^+, 2^+)$	100 ± 30	$\gamma,$ p	11, 23, 44
13.49 ± 5	$(0^+, 1^+, 2^+)$	300 ± 50	$\gamma,$ p	11, 23, 44
14.4 ± 100		800 ± 200	$\gamma,$ p, α	3, 11, 42, 44
(18.2 ± 200)		(1500 ± 300)		44
18.43	$2^-; 1$	340	$\gamma,\,^3$He	5, 7
18.80	$2^+, 1^+$	< 600	$\gamma,\,^3$He, α	5, 9
19.29	$2^-; 1$	190 ± 20	$\gamma,$ n, p, ^{3}He, α	5, 6, 7, 9
20.1 ± 100	$1^-; 1$	broad	$\gamma,$ n, p, t, ^{3}He, α	5, 6, 7, 8, 9, 22
(21.1)			$\gamma,\,^3$He	5

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

E_{x} (MeV $\pm$ keV)	$J^{\pi}; T$	τ_{m} or $\Gamma_{\mathrm{c.m.}}$ (keV)	Decay	Reactions
23.1 ± 100		broad	γ, n	22

[a] See also Tables 10.6, 10.7 and 10.11.

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

Mass of ^{10}*B*: (1988WA18) have re-evaluated the evidence on the mass of ^{10}B: the mass excess is 12050.99 ± 0.27 keV. This readjustment includes the value obtained by (1984EL05): $12937.32 \pm 0.57 \ \mu$u [mass spectrometer]. I am indebted to A.H. Wapstra for his comments.

Isotopic abundance: $(19.9 \pm 0.2)\%$ (1984DE53).

$$^{10}\text{B*}(0.72): \mu = +0.63 \pm 0.12 \text{ nm: see (1978LEZA)}.$$
$$B(\text{E2})\!\downarrow = 4.18 \pm 0.02 \ e^2 \cdot \text{fm}^4 \text{ (1983VE03)}.$$

1. ^{6}Li$(\alpha, \gamma)^{10}$B $\qquad\qquad\qquad Q_{\mathrm{m}} = 4.4596$

Observed resonances are displayed in Table 10.8. For a discussion of isovector parity mixing between ^{10}B*(5.16, 5.11) [2^{+}; $T = 1$ and 2^{-}; $T = 0$] see (1984NA07). For a preliminary report involving a target of laser-polarized ^{6}Li atoms see (1987MU13). See also (1984YA1A, 1985CA41; astrophys.).

2. (a) ^{6}Li$(\alpha, \mathrm{n})^{9}$B $\qquad\qquad Q_{\mathrm{m}} = -3.977 \qquad\qquad\qquad E_{\mathrm{b}} = 4.4596$
   (b) ^{6}Li$(\alpha, \mathrm{p})^{9}$Be $\qquad\qquad Q_{\mathrm{m}} = -2.1261$
   (c) ^{6}Li$(\alpha, \mathrm{d})^{8}$Be $\qquad\qquad Q_{\mathrm{m}} = -1.5669$

The excitation functions for neutrons [from threshold to $E_{\alpha} = 15.5$ MeV] and for deuterons [$E_{\alpha} = 9.5$ to 25 MeV; d_0, d_1 over most of range] do not show resonance structure: see (1974AJ01, 1979AJ01). See also (1985GU1J; theor.).

3. (a) ^{6}Li$(\alpha, \alpha)^{6}$Li $\qquad\qquad\qquad\qquad\qquad\qquad\qquad E_{\mathrm{b}} = 4.4596$
   (b) ^{6}Li$(\alpha, 2\alpha)^{2}$H $\qquad\qquad Q_{\mathrm{m}} = -1.4750$

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

Initial state	$J^\pi; T$	Γ_γ (total) (eV)	Branching ratios (%) to final states at:					Γ_γ/Γ
			g.s. $3^+; 0$	0.72 $1^+; 0$	1.74 $0^+; 1$	2.15 $1^+; 0$	3.59 $2^+; 0$	
0.72	$1^+; 0$	6.5×10^{-7}	100					
1.74	$0^+; 1$	0.09 ± 0.04 [b]	< 0.2	100				
2.15	$1^+; 0$	$(3.1 \pm 0.3) \times 10^{-4}$	21.1 ± 1.6	27.3 ± 0.9	51.6 ± 1.6			
3.59	$2^+; 0$	$(4.31 \pm 0.34) \times 10^{-3}$	19 ± 3	67 ± 3	< 0.3	14 ± 2		
4.77	$3^+; 0$	0.020 ± 0.004	0.5 ± 0.1	> 99				$(2.3 \pm 0.3) \times 10^{-3}$
5.11	$2^-; 0$		64 ± 7	31 ± 7	5 ± 5			
5.16	$2^+; 1$	1.5 ± 0.1 [c]	4.4 ± 0.4	22.4 ± 0.6	0.7 ± 0.2	64.8 ± 0.9	7.7 ± 0.3	0.87 ± 0.04
5.18	$1^+; 0$	0.06 ± 0.03			≈ 100			
5.92	$2^+; 0$	0.15 ± 0.04	82 ± 5	18 ± 5				≤ 0.009
6.03	4^+	0.11 ± 0.02	≈ 100	[d]				≤ 0.009
6.13 [e]	3^-	≤ 21						≤ 0.009

[a] For references see Table 10.6 in (1979AJ01).

[b] From Table 10.7.

[c] See also Table 10.8 here. Branching ratios and Γ_γ/Γ from (1979KE08). The mixing ratios $\delta = 0.12 \pm 0.05, 0.03 \pm 0.03, 0.02 \pm 0.03$ and 0.00 ± 0.02 for the transitions to ^{10}B*(0, 0.72, 2.15, 3.59), respectively (1979KE08).

[d] Other branches $< 3\%$.

[e] For γ-decay of higher ^{10}B states see Tables 10.8, 10.10 and 10.11. See also Table 10.15.

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 10.9. Elastic scattering and VAP measurements are reported for $E(^6\vec{Li}) = 15.1$ to 22.7 MeV [see (1984AJ01)] and at $E(^6\vec{Li}) = 19.8$ MeV (1986CAZT; also TAP; prelim.). Small anomalies have been reported in reaction (b) corresponding to ^{10}B*(8.67, 9.65, 10.32, 11.65): see (1984AJ01). See, however, Table 10.5. See also ^{6}Li, (1987BU27), (1986ST1E; applications) and (1986GA1F, 1986YA15, 1988LE06: theor.).

4. ^{6}Li(^{6}Li, d)^{10}B $\qquad\qquad\qquad Q_m = 2.985$

Angular distributions of deuteron groups have been determined at $E(^6$Li$) = 2.4$ to 9.0 MeV (d_0, d_1, d_3) and 7.35 and 9.0 MeV (d_4, d_5). The d_2 group is also observed but its intensity is weak: see (1974AJ01) and ^{12}C in (1980AJ01).

5. ^{7}Li(^{3}He, γ)^{10}B $\qquad\qquad\qquad Q_m = 17.7873$

Table 10.7: Lifetime of ^{10}B states

^{10}B* (MeV)	τ_m	Reactions	Refs.
0.72	1.020 ± 0.005 nsec	^{10}B(p, p′)	(1983VE03) [a]
1.74	7 ± 3 fsec	^{6}Li(α, γ)	(1979KE08)
2.15	2.30 ± 0.26 psec	mean	(1979AJ01) [b]
	1.9 ± 0.3 psec	^{6}Li(α, γ)	(1979KE08)
	2.13 ± 0.20 psec	mean	all values
3.59	153 ± 13 fsec	mean	(1979AJ01)
	150 ± 30 fsec	^{6}Li(α, γ)	(1979KE08)
	153 ± 12 fsec	mean	all values
5.16	< 6 fsec	^{6}Li(α, γ)	(1979KE08)

[a] See also Table 10.20 of (1966LA04).
[b] Table 10.9 in (1979AJ01).

Table 10.8: Levels of ^{10}B from ^{6}Li$(\alpha, \gamma)^{10}$B [a]

$E_{\rm res}$ (keV)	$E_{\rm x}$ (MeV $\pm$ keV)	J^π; T	$\Gamma_{\rm lab}$ (keV)	Decay to $E_{\rm t}$	Branch (%)	$\omega\gamma$ (eV)	Γ_γ (eV)
500 ± 25	4.760	3^+; 0	$(1.4 \pm 0.3) \times 10^{-2}$	0	0.5 ± 0.1		
				0.72	> 99	$(4.1 \pm 0.4) \times 10^{-2}$ [c]	0.018 ± 0.002 [c]
1085	5.112	2^-; 0	1.63 ± 0.11 [b]	0	64 ± 7	0.059 ± 0.012 [d]	
				0.72	31 ± 7	0.028 ± 0.008	
				1.74	5 ± 5	0.005 ± 0.005	
1175 [e]	5.166	2^+; 1	$(2.8 \pm 0.3) \times 10^{-3}$	0	4.4 ± 0.4	0.018 ± 0.002	0.068 ± 0.007
				0.72	22.4 ± 0.6	0.090 ± 0.008	0.33 ± 0.03
				1.74	0.7 ± 0.2	$(2.8 \pm 0.8) \times 10^{-3}$	0.010 ± 0.003
				2.15	64.8 ± 0.9	0.259 ± 0.024	0.942 ± 0.090
				3.59	7.7 ± 0.3	0.031 ± 0.004	0.114 ± 0.015
1210 ± 35	5.186	1^+; 0	340 ± 50	1.74	≈ 100		0.06 ± 0.03
2435	5.922	2^+	10 ± 1	0	82 ± 5	0.19 ± 0.04	0.13 ± 0.03
				0.72	18 ± 5	0.04 ± 0.01	0.02 ± 0.01
				1.74		< 0.02	
2605 [f]	6.024	4^+	0.08 ± 0.05	0	≈ 100	0.34 ± 0.05	0.11 ± 0.02
				0.72		< 0.02	
4019 [g]	6.873 ± 5	1^-; $0 + 1$	200 ± 10	0	6 ± 2		
				0.72	21 ± 4		
				1.74	59 ± 3		
				2.15	14 ± 4		
4964 [h]	7.440 ± 20	$2^{(-)}$; $0 + 1$	150 ± 15	[h]			

$^{\mathrm{a}}$ For earlier references see Table 10.7 in (1979AJ01).

$^{\mathrm{b}}$ $\Gamma_\alpha = \Gamma_{\mathrm{c.m.}} = 0.98 \pm 0.07$ keV (1984NA07).

$^{\mathrm{c}}$ (1985NE05). $\Gamma_\gamma/\Gamma = (2.3 \pm 0.3) \times 10^{-3}$; $\Gamma_\alpha = 8.4 \pm 1.8$ eV (E. K. Warburton and D. E. Alburger, private communication).

$^{\mathrm{d}}$ Absolute error only.

$^{\mathrm{e}}$ Branching ratios of (1979KE08); $\omega\gamma_{\mathrm{c.m.}} = 0.40 \pm 0.04$ eV (1979SP01). Therefore $\Gamma_\alpha\Gamma_\gamma/\Gamma_{\mathrm{tot}} = 0.24 \pm 0.02$ eV and since $\Gamma_\gamma/\Gamma_{\mathrm{tot}} = 0.87 \pm 0.04$, $\Gamma_\alpha = 0.28 \pm 0.03$ eV (1984NA07).

$^{\mathrm{f}}$ Values of $\omega\gamma$ (1966FO05) have been multiplied by 0.6 to convert them to the c.m. system.

$^{\mathrm{g}}$ Branching ratios calculated from $0°$ relative intensities; $\Gamma_\alpha/\Gamma_{\mathrm{p}} = 1.25 \pm 0.12$.

$^{\mathrm{h}}$ At $0°$ the branches to ^{10}B*(0, 0.72) are equally strong ((50 ± 12)%).

Table 10.9: ^{10}B levels from ^{6}Li$(\alpha, \alpha)^6$Li ^{a}

E_α (MeV $\pm$ keV)	E_x (MeV)	Γ_lab (keV)	$J^\pi; T$
1.210 ± 30	5.19	175	$1^+; 0$
2.440 ^{b}	5.92	≈ 30	$2^+; 0$
2.6060 ± 1.5	6.024	0.09 ± 0.04	4^+
2.7855 ± 1.5 ^{c}	6.132	3.93 ± 0.05	3^-
3.4985 ± 1.6 ^{d}	6.560	41.8 ± 1.9	$4^-, 2^-$
4.250 ± 15 ^{d}	7.011	183 ± 25	$(2)^+; (0)$
16.000	14.1	broad	

^{a} For references see Tables 10.8 in (1979AJ01) and 10.9 in (1984AJ01).
^{b} $\Gamma_\alpha = 9.7 \pm 0.1$ keV.
^{c} $\Gamma_\alpha = 2.45 \pm 0.12$ keV and $\Gamma_\mathrm{d} = 0.08 \pm 0.05$ keV.
^{d} There is evidence of broad structure near these states.

Capture γ-rays have been observed for $E(^3$He$) = 0.8$ to 6.0 MeV. The γ_0 and γ_5 yields [to ^{10}B*(0, 4.77)] show resonances at $E(^3$He$) = 1.1$ and 2.2 MeV [$E_\mathrm{res} = 0.92$ and 2.1 MeV], 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 in (1979AJ01). 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_2 to ^{6}Li*(3.56) which has $J^\pi = 0^+, T = 1$: see reaction 9]. 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. See (1974AJ01) for references.

6. ^{7}Li$(^3$He, n$)^9$B $\qquad\qquad Q_\mathrm{m} = 9.351 \qquad\qquad E_\mathrm{b} = 17.7873$

The excitation curve is smooth up to $E(^3$He$) = 1.8$ MeV and the n$_0$ yield shows resonance behavior at $E(^3$He$) = 2.2$ and 3.25 MeV, $\Gamma_\mathrm{lab} = 270 \pm 30$ and 500 ± 100 keV. No other resonances are observed up to $E(^3$He$) = 5.5$ MeV. See Table 10.10 in (1979AJ01), (1986AB10; theor.) and (1974AJ01).

7. ^{7}Li$(^3$He, p$)^9$Be $\qquad\qquad Q_\mathrm{m} = 11.2016 \qquad\qquad E_\mathrm{b} = 17.7873$

Table 10.10: Resonances in ^{9}Be(p, γ)^{10}B [a]

E_p (MeV $\pm$ keV)	E_x (MeV $\pm$ keV)	$\Gamma_{\text{c.m.}}$ (keV)	J^π; T	Γ_p/Γ	Γ_γ (eV)
0.319	6.873 $\pm$ 5	120 $\pm$ 5	1^-; 0 + 1	0.30	4.8
0.938 $\pm$ 10	7.430	140 $\pm$ 30	$2^{(-)}$; 0 + 1	0.7	2.4
(0.98)	(7.47)		(2^+)		
0.992 $\pm$ 2	7.478	72 $\pm$ 4	2^-; 1 [c]	≈ 0.65	25.8
1.0832 $\pm$ 0.4	7.5599	2.65 $\pm$ 0.18	0^+; 1	1.0	8.5
1.29	7.75	210 $\pm$ 60	2^-; (1)	≈ 0.65	8.5
2.567 $\pm$ 2	8.894	36 $\pm$ 2	2^+; 1		
4.72 [b]	10.83	≈ 500	$2^+, 3^+, 4^+$		
6.7 [b]	12.6	< 200	$0^+, 1^+, 2^+$		
(7.0) [b]	(12.9)	(≈ 100)	($\pi = +$)		
7.5 [b]	13.3	≈ 300	$0^+, 1^+, 2^+$		
8.4 [b]	14.1	≈ 250	$0^+, 1^+, 2^+$		
8.9 [b]	14.6	≈ 150	$2^+, 3^+, 4^+$		
10.0 [b]	15.6	≈ 400	$2^+, 3^+, 4^+$		
14.6 [b]	19.7	≈ 500	$2^-, 3^-, 4^-$		

[a] For references and for additional comments see Table 10.11 in (1979AJ01). See Table 10.11 for decay schemes.

[b] Unpublished Ph.D. thesis.

[c] See (1974AJ01). This state is assigned $J^\pi = 2^+$ on the basis of the (e, e$'$) work (see Table 10.15). I am indebted to Dr. D. Kurath for his comments.

The yield of protons has been measured for $E(^3\text{He}) = 0.60$ to 4.8 MeV: there is some indication of weak maxima at 1.1, 2.3 and 3.3 MeV. Measurements of A_y for the ground-state group at $E(^3\vec{\text{He}}) = 14$ MeV (1983LE17, 1983RO22) and 33 MeV (1983LE17) and of the polarization at $E(^3\text{He}) = 14$ MeV (1984ME11, 1984TR03) have been reported. $P = A$ in this and in the inverse reaction [see reaction 4 in ^{12}C (1985AJ01) for some additional comments]. For earlier references see (1984AJ01). See also (1986AB10; theor.).

8. (a) ^{7}Li(^{3}He, d)^{8}Be $Q_m = 11.7606$ $E_b = 17.7873$

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

  (c) ^{7}Li(^{3}He, ^{3}He)^{7}Li

Table 10.11: Radiative transitions in ^{9}Be(p, γ)^{10}B [a]

Initial state (MeV)	$J^\pi; T$	Γ_γ (tot) (eV)	Relative intensities to final states								
			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 $2^+; 0$
6.87 $E_\mathrm{p} = 0.32$	$1^-; 0+1$	4.8	< 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
7.43 $E_\mathrm{p} = 0.94$	$2^{(-)}; 0+1$	[2.4]	< 2	1.3	$[< 0.14]$	0.62	0.5			$[< 1]$	
7.48 $E_\mathrm{p} = 0.99$	$2^+; 1$	[25.8]	25	0.3	$[< 0.14]$	0.49	0			$[< 1]$	
7.56 $E_\mathrm{p} = 1.08$	$0^+; 1$	[8.5]	< 0.2	6.7	< 0.3	0.8	< 0.2			1.0	
7.75 [b] $E_\mathrm{p} = 1.29$	$(2^-; 1)$	[8.5]	6.6	0.9	< 0.08	0.3	0.3			0.4	

[a] For references and other values see Table 10.12 in (1979AJ01).
[b] See, however, Table 10.12.

Yields of deuterons have been measured for $E(^3\text{He}) = 1.0$ to 2.5 MeV (d_0) and yields of tritons are reported for 2.0 to 4.2 MeV (t_0): a broad peak is reported at $E(^3\text{He}) \approx 3.5$ MeV in the t_0 yield. See (1979AJ01) for references. Polarization measurements are reported at $E(^3\vec{\text{He}}) = 33.3$ MeV for the deuteron groups to $^8\text{Be}^*$(16.63, 17.64, 18.15) and for the triton and ^3He groups to $^7\text{Be}^*$(0, 0.43) and $^7\text{Li}^*$(0, 0.48, 4.63): see (1984AJ01).

9. $^7\text{Li}(^3\text{He}, \alpha)^6\text{Li}$ $\qquad\qquad Q_m = 13.328$ $\qquad\qquad E_b = 17.7873$
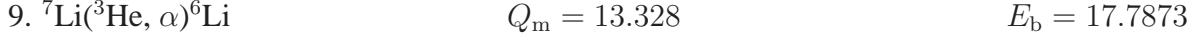
Excitation functions have been measured for $E(^3\text{He}) = 1.3$ to 18.0 MeV: see (1974AJ01). The α_0 group (at $8°$) shows a broad maximum at ≈ 2 MeV, a minimum at 3 MeV, followed by a steep rise which flattens off between $E(^3\text{He}) = 4.5$ and 5.5 MeV. Integrated α_0 and α_1 yields rise monotonically to 4 MeV and then tend to decrease. Angular distributions give evidence of the resonances at $E(^3\text{He}) = 1.4$ and 2.1 MeV seen in $^7\text{Li}(^3\text{He}, \gamma)^{10}\text{B}$: $J^\pi = 2^+$ or 1^-, $T = (1)$ for both [see, however, reaction 5]: Γ_α is small. The α_2 yield [to $^6\text{Li}^*$(3.56), $J^\pi = 0^+$, $T = 1$] shows some structure at $E(^3\text{He}) = 1.4$ MeV and a broad maximum at ≈ 3.3 MeV: see Table 10.10 in (1979AJ01). Polarization measurements are reported at $E(^3\vec{\text{He}}) = 33.3$ MeV to $^6\text{Li}^*$(0, 2.19, 3.56): see (1984AJ01). See also (1983AN1D, 1984PA1E).

10. $^7\text{Li}(\alpha, \text{n})^{10}\text{B}$ $\qquad\qquad Q_m = -2.7905$

Angular distributions are reported at $E_\alpha = 28$ and 32 MeV for the n_0, n_1 and n_2 groups (1985GUZQ; prelim.). See (1979AJ01, 1984AJ01) for the earlier work.

11. $^9\text{Be}(\text{p}, \gamma)^{10}\text{B}$ $\qquad\qquad Q_m = 6.5857$
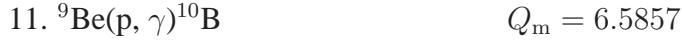
Parameters of observed resonances are listed in Tables 10.10 and 10.11. Table 10.6 summarizes the γ-transitions from this and other reactions. For references to the discussion below, see (1974AJ01, 1979AJ01, 1984AJ01).

The $E_p = 0.32$ MeV resonance ($^{10}\text{B}^* = 6.87$ MeV) is ascribed to s-wave protons because of its comparatively large proton width [see $^9\text{Be}(\text{p}, \text{p})$] and because of the isotropy of the γ-radiation. The strong transition to $^{10}\text{B}^*$(1.74) requires E1 and hence $J^\pi = 1^-$, $T = 0$. $T = 0$ is also indicated by the large deuteron width. On the other hand, the strength of E1 transitions to $^{10}\text{B}^*$(0.7, 2.1) indicates $T = 1$. The amplitudes for the $T = 0$ and $T = 1$ parts of the wave function for $^{10}\text{B}^*$(6.87) are 0.92 and 0.39, respectively. For the $5.16 \to 1.74$ decay see Table 10.6. The proton capture data near $E_p = 1$ MeV appears to require at least five resonant states, at $E_p = 938$, (980), 992, 1083 and 1290 keV. The narrow $E_p = 1083$ keV level ($^{10}\text{B}^* = 7.56$ MeV) is formed by p-wave protons, $J^\pi = 0^+$ [see $^9\text{Be}(\text{p}, \text{p})$, $^9\text{Be}(\text{p}, \alpha)$]. The isotropy of the γ-rays supports this

assignment. The strong M1 transitions to $J^\pi = 1^+$, $T = 0$ levels at 0.72, 2.15 and 5.18 MeV (Table 10.11) indicate $T = 1$. The width of ^{10}B*(5.18) observed in the decay is 100 ± 10 keV.

The excitation function for ground-state radiation shows resonance at $E_p = 992$ ($\Gamma = 80$ keV) and 1290 keV ($\Gamma = 230$ keV). Elastic scattering studies indicate s-wave formation and $J^\pi = 2^-$ for both. For the lower level ($E_x = 7.48$ MeV) the intensity of the g.s. capture radiation, $\Gamma_\gamma = 25$ eV 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 or with some contribution from a nearby p-wave resonance; possibly a $J^\pi = 2^+$ level at $E_p = 980$ keV.

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

Transitions to ^{10}B*(0.7) [γ_1] show resonance at $E_p = 992$, 1290 and 938 keV, $\Gamma = 155$ keV. 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.

A resonance for capture radiation at $E_p = 2.567 \pm 0.003$ ($E_x = 8.895$ MeV) has a width of 40 ± 2 keV and decays mainly via ^{10}B*(0.7) (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. A further resonance is reported at $E_p = 4.72 \pm 0.01$ MeV, $\Gamma \approx 0.5$ MeV.

In the range $E_p = 4$ to 18 MeV, the γ_0 yield at 90° shows [unpublished Ph.D. thesis] the resonance at $E_p = 4.7$ MeV ($E_x = 10.7$ MeV) and fluctuations suggest states at $E_x \approx 14.6$, 15.6 and 19.7 MeV. ^{10}B*(19.7) possibly 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 ≈ 1.5 μb/sr. The average yield 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) [$J_f^\pi = 1^+$] and therefore $J_i^\pi = 0^+$, 1^+, 2^+. The weak γ_2 yield (to ^{10}B*(1.74) [J^π; $T = 0^+$; 1]) seems to exhibit a broad peak centered near $E_x = 15$ MeV (maximum 90° differential cross section ≈ 0.5 μb/sr) and possibly some structure near $E_x = 20$ MeV. The γ_3 yield (to ^{10}B*(2.15) [$J^\pi = 1^+$]) increases to ≈ 0.4 μb/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 [in an unpublished Ph.D. thesis].

The magnetic moment of ^{10}B*(0.72) has been studied via γ-γ correlations from ^{10}B*(7.56): $g = +0.63 \pm 0.12$. See also (1985KI1B, 1985NE1C; applications), (1984YA1A; astrophysics) and (1983GO28, 1986NA15; theor.).

12. ^{9}Be(p, n)^{9}B $\qquad\qquad Q_m = -1.851 \qquad\qquad E_b = 6.5857$

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*(8.890,

10.83, 9.7): see Table 10.13 in (1974AJ01). Cross section measurements for the (p, n) and (p, n_0) reactions have been obtained by (1983BY01; $E_p = 8.15$ to 15.68 MeV) [see also for a review of earlier work]. They indicate possible structure in ^{10}B near 13–14 MeV (1983BY01).

The $E_p = 2.56$ MeV resonance is considerably broader 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. 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): see (1974AJ01).

The analyzing power for n_0 has been measured for $E_p = 2.7$ to 17 MeV (1980MA33, 1983BY02, 1986MU07) as has the polarization in the range $E_p = 2.7$ to 10 MeV (1983BY02). See (1983BY02, 1986MU07) for discussions of the $\sigma(\theta)$, $A_y(\theta)$ and $P(\theta)$ measurements. Polarization measurements have also been reported at $E_{\tilde{p}} = 3.9$ to 15.1 MeV and 800 MeV: [see (1984AJ01)] and at 53.5, 53.9 and 71.0 MeV (1988HE08) [$K_y^{y'}$, $K_z^{z'}$]. See also ^{9}B, (1985TE1C), (1985CA41; astrophys.), (1986AL1J; applications) and (1988ZVZZ; theor.).

13. (a) ^{9}Be(p, p)^{9}Be $\hspace{6cm} E_b = 6.5857$

(b) ^{9}Be(p, pn)^{8}Be $\hspace{2cm} Q_m = -1.6654$

(c) ^{9}Be(p, pα)^{5}He $\hspace{2cm} Q_m = -2.47$

The elastic scattering has been studied for $E_p = 0.2$ to 9.5 MeV [see (1974AJ01, 1979AJ01, 1984AJ01)] and at $E_p = 2.0$ to 3.8 MeV (1983AL10). 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 ^{3}S$_1$, ^{5}S$_2$, ^{5}P$_1$ and ^{5}P$_2$ 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 10.12. Pronounced minima at $E_p = 2.48$ and 2.55 MeV 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). A strong anomaly is observed at $E_p = 6.7$ MeV: see Table 10.12.

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, 1979AJ01)] as well as at $E_{\tilde{p}} = 780$ MeV and at 1 GeV [see (1984AJ01)]. Recently, A_y measurements have been reported at $E_{\tilde{p}} = 200$ MeV (1985GLZZ; p_0; prelim.) and 220 MeV (1985RO15; p_0, p_2). For inclusive proton scattering at $E_{\tilde{p}} = 303$ MeV see (1987MO04). See also (1985SE15). For reaction (b) see (1984WA21, 1986MEZZ, 1988BO47). Reaction (c) at $E_{\tilde{p}} = 150.5$ MeV has been studied by (1985WA13; A_y). For other high energy studies see (1984AJ01). See also ^{9}Be, (1982BA78, 1985RO1C, 1985TR1A, 1986KO1R), (1984ZU01, 1985SA1G, 1986BA88, 1986MU07) and (1983KA37, 1984SH1K, 1985DY03, 1986HA1K; theor.).

14. (a) ^{9}Be(p, t)^{7}Be $\hspace{2cm} Q_m = -12.082$ $\hspace{3cm} E_b = 6.5857$

(b) ^{9}Be(p, ^{3}He)^{7}Li $\hspace{2cm} Q_m = -11.016$

Table 10.12: Resonances in ^{9}Be(p, p)^{9}Be [a]

$E_{\rm res}$ (keV)	$E_{\rm x}$ (MeV)	$\Gamma_{\rm c.m.}$ (keV)	J^π	$\Gamma_{\rm p}/\Gamma$
330	6.88	145	1^-	0.30
980 ± 10	7.467	65 ± 10	1^+	1.0
980 ± 10	7.467	80 ± 8	2^{-} [d]	0.90 ± 0.05
1084 ± 2	7.561	2.7	0^+	1.0
(1200 ± 30)	(7.67)	250 ± 20	(1^+)	0.30 ± 0.10
1370 ± 20	7.818	265 ± 30	1^-	0.90 ± 0.05
(2070 ± 10)	(8.4)	70 ± 10	$(1^-, 2^-)$	0.43
(2300)	(8.65)	≈ 300	$(1^+, 2^+)$	
(2480)	(8.82)		$(3^-; 1)$	
2560	8.89		$\geq 2; (1)$ [c]	large
(4600)	(10.7)			
(5100)	(11.2)			
6700 [b]	12.6	broad		

[a] For references and for a listing of other reported resonances see Table 10.13 in (1979AJ01). Nine anomalies in the p_0 yield are reported by (1983AL10) at $E_{\rm p} = 2.07, 2.30, 2.44, 2.55, 2.56, 2.60, 3.80, 4.20$ and 4.72 MeV.
[b] Weak resonance near $E_{\rm p} = 6.5$ MeV in p_0.
[c] Resonance shape shows $l_{\rm p} = 2$ formation with a large $\Gamma_{\rm p}/\Gamma$: the contribution from the 2^+ state appears small.
[d] See, however, Table 10.15 and footnote [a] in Table 10.13 of (1979AJ01).

Polarization measurements (reaction (b)) are reported at $E_{\bar{\rm p}} = 23.06$ MeV: see (1984AJ01). For a study at $E_{\rm p} = 190$ and 300 MeV see (1987GR11). See also (1985SE15).

15. (a) ^{9}Be(p, d)^{8}Be $Q_{\rm m} = 0.5592$ $E_{\rm b} = 6.5857$
   (b) ^{9}Be(p, α)^{6}Li $Q_{\rm m} = 2.126$

Knowledge of the cross sections of these two reactions at low energies is of importance for power generation and astrophysical considerations. Absolute cross sections for the d_0 and α_0 groups have been measured for $E_{\rm p} = 28$ to 697 keV with ± 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 $\sigma_{d_0} = 470 \pm 30$ mb. The data (including angular

Table 10.13: Resonances in ^{9}Be(p, d)^{8}Be and ^{9}Be(p, α)^{6}Li [a]

E_{p} (MeV)	E_{x} (MeV)	$\Gamma_{\mathrm{c.m.}}$ (keV)	$J^\pi; T$	$\Gamma_{\mathrm{p}}/\Gamma$
0.34	6.89		$1^-; 0$	0.30
0.46	7.00		$1^+(2^+, 3^+)$ [d]	
(0.69)	(7.20)			
0.94	7.43	140	$(2^-; 0)$	0.7
1.15	7.62	225 ± 50	$(1^+; 0)$	≈ 0.4
1.65	8.07	800 ± 200	$(2^-; 0)$	≈ 0.07
(2.3)	(8.7)	(≈ 220)		
2.56 [b]	8.89	36 ± 2	$2^+; 1$	
3.5 [c]	9.7		$T = 1$	
4.49 [c]	10.62		$T = 1$	

[a] For references and for a listing of other reported resonances and additional information see Table 10.14 in (1979AJ01).
[b] (1977KI04) have analyzed the ($\alpha_2\gamma$) and p$_0$ yields with an R-matrix formalism and find the following parameters

$$\left. \begin{array}{ll} 2.566 \pm 0.001 & 2^+ \\ 2.561^{+10}_{-2} & 3^- \end{array} \right\} \quad \Gamma_{\mathrm{c.m.}} = \left\{ \begin{array}{l} 40 \pm 1 \text{ keV,} \\ 100 \pm 20 \text{ keV.} \end{array} \right.$$

[c] Resonance for α_2 to ^{6}Li*(3.56), $J^\pi = 0^+$, $T = 1$.
[d] See, however, Table 10.8.

distributions), analyzed by an R-matrix compound nucleus model, were fitted by assuming three states at E_{p}(c.m.) $= -20$ keV ($J^\pi = 2^+$; 3^+ possible) [$E_{\mathrm{x}} = 6.57$ MeV] [see, however, Table 10.8], 310 keV (1^-) and 410 keV (1^+; 2^+ or 3^+ possible): see (1979AJ01). See also (1988ABZW).

Measurements of excitation functions for deuterons and α-particles have been reported at a number of energies to $E_{\mathrm{p}} = 15$ MeV: see (1974AJ01, 1979AJ01). Observed resonances are displayed in Table 10.13.

Polarization measurements have been made in the range $E_{\mathrm{p}} = 0.30$ to 15 MeV and at 185 MeV [see (1974AJ01, 1979AJ01)] and at $E_{\bar{\mathrm{p}}} = 60$ MeV (1987KA25; A_y; inclusive deuteron spectra). For a fragmentation study at $E_{\mathrm{p}} = 190$ and 300 MeV see (1987GR11). See also (1983AN1D, 1984BA1L, 1985SE15, 1986ER1B), (1984YA1A, 1985CA41; astrophysics), (1984PA1E) and (1982BR1A; theor.).

16. ^{9}Be(d, n)^{10}B $\qquad\qquad Q_{\mathrm{m}} = 4.3612$

Neutron groups are observed corresponding to the ^{10}B states listed in Table 10.14. Angular distributions have been measured for $E_d = 0.5$ to 16 MeV [see (1974AJ01, 1979AJ01)], at 8 MeV (1986BA40; $n_0 \to n_5$, n_{6+7+8}; also at 4 MeV to the latter) and at 18 MeV (1987KAZL; n_0, n_1). Observed γ-transitions are listed in Table 10.16 of (1979AJ01). See Tables 10.6 and 10.7 here for the parameters of radiative transitions and for τ_m.

From all the various experiments the following picture emerges: the first five states of ^{10}B have even parity [from l_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$_{g.s.}$ [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)].

See also ^{11}B in (1985AJ01), (1983TA17, 1985SM08) and (1986OV1A; applications).

17. ^{9}Be(^{3}He, d)^{10}B $Q_m = 1.0922$

Deuteron groups have been observed to a number of states of ^{10}B: see Table 10.14. Angular distributions have been reported at $E(^3$He$) = 10$ to 33.3 MeV [see (1974AJ01, 1979AJ01, 1984AJ01)]. Spectroscopic factors obtained in the (d, n) and (^{3}He, d) reactions are not in good agreement: see the discussions in (1974KE06, 1980BL02). See also (1986AV01; theor.).

18. ^{9}Be(α, t)^{10}B $Q_m = -13.2282$

Angular distributions have been studied at $E_\alpha = 27$, 28.3 and 43 MeV [see (1979AJ01)], at 30.2 MeV (1984VA07; t_0, t_1, t_3, t_4) and at 65 MeV (1980HA33). In the latter experiment DWBA analyses have been made of the distributions to ^{10}B*(0, 0.72, 1.74, 2.15, 3.59, 5.2, 5.92, 6.13, 6.56, 7.00, 7.5, 7.82, 8.9) and spectroscopic factors were derived. The distributions to ^{10}B*(4.77, 6.03) could not be fitted by either DWBA or coupled channel analyses. In general coupled-channels calculations give a better fit to the 65 MeV data than does DWBA (1980HA33; see also for a comparison with the (d, n) and (^{3}He, d) results).

19. ^{9}Be(^{7}Li, ^{6}He)^{10}B $Q_m = -3.389$

At $E(^7$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): see (1979AJ01). See also (1988AL1G).

20. ^{10}Be(β^-)^{10}B $Q_m = 0.5561$

Table 10.14: Levels of ^{10}B from ^{9}Be(d, n) and ^{9}Be(^{3}He, d) [a]

E_x (MeV) [a]	^{9}Be(d, n) [b]		^{9}Be(^{3}He, d) [c]		$J^\pi; T$ [a]
	l_p	S_{rel}	l_p	$(2J+1)C^2S$	
0	1	1.0	1	3.30	$3^+; 0$
0.72	1	1.97	1	2.76	$1^+; 0$
1.74	1	1.36	1	1.20	$0^+; 1$
2.15	1	0.41	1	0.82	$1^+; 0$
3.59	1	0.10	1	0.29	$2^+; 0$
4.77	(≥ 2)		$1 + (3)$ [e]	0.10	$3^+; 0$
				≤ 0.82	
5.11	0	0.14	$0 + 2$	0.34, 0.14	$2^-; 0$
5.16 $\left.\begin{array}{c}\\\\\end{array}\right\}$	1	0.43	1	0.86	$2^+; 1$
5.18					$1^+; 0$
5.92	1	0.49	1	2.05	$2^+; 0$
6.03			(3) [e]	≤ 0.20	4^+
6.13	(2)		(2) [f]	3.04	3^-
6.56	(3)		(2) [f]	2.01	$(4)^-$
6.89 ± 15	(1)				$1^-; 0+1$
7.00 ± 15	(1)				$(1, 2)^+; (0)$
7.48 ± 15	[d]				[g]
7.56 ± 25	[d]				$0^+; 1$
(7.85 ± 50)	[d]				1^-
(8.07 ± 50)	[d]				$(2^-; 0)$
(8.12 ± 50)	[d]				

[a] Values without uncertainties are from Table 10.5; others are from Table 10.15 in (1979AJ01). See that table for additional information and for references. See also (1984AJ01).

[b] S_{rel} from experiment at $E_d = 12.0 - 16.0$ MeV.

[c] $E(^{3}$He$) = 18$ MeV; DWBA analysis; values shown are those obtained with one of the two optical-model potentials used in the analysis. For earlier (^{3}He, d) results see Table 10.17 in (1979AJ01).

[d] State observed in (d, n) reaction; l_p not determined.

[e] Angular distribution poorly fitted by DWBA.

[f] See (1980BL02) for a discussion of these two states, including a comparison with the (d, n) data: $l_p = 2$ is slightly preferred to $l_p = 1$ on the basis of the observed strengths. Neither $l_p = 2$ nor 1 gives a good DWBA fit.

[g] Group shown corresponds to unresolved states in ^{10}B.

See ^{10}Be.

21. ^{10}Be(p, n)^{10}B $\qquad\qquad\qquad\qquad$ $Q_m = -0.2261$

The yield of the n$_1$ group has been studied for $E_p = 0.9$ to 2.0 MeV: see ^{11}B in (1990AJ01) (1986TE1A).

22. (a) ^{10}B(γ, n)^{9}B $\qquad\qquad\qquad\qquad$ $Q_m = -8.436$
$\quad$ (b) ^{10}B(γ, p)^{9}Be $\qquad\qquad\qquad\qquad$ $Q_m = -6.5857$
$\quad$ (c) ^{10}B(γ, pn)^{8}Be $\qquad\qquad\qquad\quad$ $Q_m = -8.2511$
$\quad$ (d) ^{10}B(γ, π^+)^{10}Be $\qquad\qquad\qquad$ $Q_m = -140.125$

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 (60 NZ/A MeV·mb). The (γ, 2n) + (γ, 2np) cross section is zero, within statistics, for $E_\gamma = 16$ to 35 MeV: see (1979AJ01) and (1988DI02). The giant resonance is broad with the major structure contained in two peaks at $E_x = 20.1 \pm 0.1$ and 23.1 ± 0.1 MeV ($\sigma_{max} \approx 5.5$ mb for each of the two maxima): see (1979AJ01). (1987AH02) [and H. H. Thies, private communication] [using bs] report two broad [$\Gamma \approx 2$ MeV] maxima at 20.2 and 23.0 MeV [± 0.05 MeV] ($\sigma = 5.0$ and 6.0 mb, respectively; $\pm 10\%$) and a minor structure at $E_x = 17.0$ MeV. For reactions (b) and (c) see (1988SU14). For reaction (d) see ^{10}Be. See also (1974AJ01) and (1983GO28, 1985GO1A, 1987KI1C; theor.).

23. (a) ^{10}B(e, e)^{10}B
$\quad$ (b) ^{10}B(e, en)^{9}B $\qquad\qquad\qquad\qquad$ $Q_m = -8.436$
$\quad$ (c) ^{10}B(e, ep)^{9}Be $\qquad\qquad\qquad\qquad$ $Q_m = -6.5857$
$\quad$ (d) ^{10}B(e, eπ^+)^{10}Be $\qquad\qquad\qquad$ $Q_m = -140.125$

$$\langle r^2 \rangle^{1/2} = 2.49 \pm 0.09 \text{ fm (1986DO1E; prelim.).}$$

Inelastic electron groups are displayed in Table 10.15. (1986FRZZ; prelim.) have measured the form factors for ^{10}B*(0, 1.74, 5.16). For reactions (b) and (c) see (1984AJ01). For reaction (d) see ^{10}Be. See also (1984DO20, 1986PE05, 1987DE43, 1987HI1F) and (1986HA1M; theor.).

24. ^{10}B(n, n)^{10}B
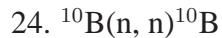
Table 10.15: Radiative widths for ^{10}Be(e, e′) [a]

E_x in ^{10}B (MeV)	J^π; T	Mult.	$\Gamma_{\gamma 0}$ (eV)
1.74	0^+; 1	M3	$(1.05 \pm 0.25) \times 10^{-7}$
5.16 ± 0.04 [b]	2^+; 1	M1	0.05 ± 0.05
		M3	$(1.1 \pm 0.1) \times 10^{-6}$
6.03	4^+	C2	0.106 ± 0.005
		C4	$(3.3 \pm 0.8) \times 10^{-7}$
7.48	2^+; 1	M1	11.75 ± 0.75
8.07	2^+ [c]	C2	0.19 ± 0.02
8.9	2^+; 1	M1	0.3 ± 0.1
		M3	$(1.0 \pm 0.1) \times 10^{-5}$
	3^-; 1	M2	$(1.2 \pm 0.1) \times 10^{-3}$
10.79		M1 or C2	
11.56		(M1)	11.4 ± 2.3 [c]
12.6			
13.3			

[a] See Table 10.16 in (1984AJ01) for references. See also Table 10.18 in (1979AJ01).

[b] Assumed to correspond to 2^+ state at 5.16 MeV. $\Gamma_{\gamma 0} = (3.5 \pm 0.3) \times 10^{-4}$ eV for M2 if the transition were to the 2^- state at 5.11 MeV: see also footnote [g] in Table 10.18 (1979AJ01).

[c] $\Gamma \approx 760$ keV.

Angular distributions have been studied for $E_n = 1.5$ to 14.1 MeV [see (1974AJ01, 1979AJ01)] and at 3.02 to 12.01 MeV (1986SAZR, 1987SAZX; prelim; $n_1 \to n_5$), 8 to 14 MeV (1983DA22; n_0) and 9.96 to 16.94 MeV (1986MU08; prelim.; n_0). See also ^{11}B in (1985AJ01, 1990AJ01), (1984TU02) and (1983KO1F; theor.).

25. (a) ^{10}B(p, p)^{10}B

   (b) ^{10}B(p, 2p)^{9}Be $Q_m = -6.5857$

Angular distributions have been measured for a number of energies between $E_p = 3.0$ and 800 MeV [see (1974AJ01, 1979AJ01, 1984AJ01)] and at 10 to 17 MeV (1986MU08; p_0; prelim.). Table 10.16 displays the states observed in this reaction. The γ-ray results are shown in Table 10.6. See also (1979AJ01). For τ_m see Table 10.7 (1983VE03).

Table 10.16: ^{10}B levels from ^{10}B(p, p), ^{10}B(d, d) and ^{10}B(^{3}He, ^{3}He) [a]

E_x (MeV $\pm$ keV) [b]	$\Gamma_{\text{c.m.}}$ (keV)	L	β_L [b, c]
0 [d]			
0.7183 ± 0.4 [d, e, f]		2	0.67 ± 0.05
$\equiv 1.7402$ [f, g]		(3)	
2.1541 ± 0.5 [d]		2	0.49 ± 0.04
3.5870 ± 0.5 [d]		2	0.45 ± 0.04
4.7740 ± 0.5 [h]			
5.1103 ± 0.6		3	0.45 ± 0.04
5.1639 ± 0.6			
5.18 ± 10 [h, i]	110 ± 10		
5.9195 ± 0.6 [d]	< 5		0.28 ± 0.03
6.0250 ± 0.6 [d]	< 5	2	0.95 ± 0.04
6.1272 ± 0.7 [d]	< 5	3	0.58 ± 0.03
6.55 ± 10 [d]	25 ± 5	3	0.46 ± 0.04 [j]
7.00 ± 10 [d]	95 ± 10		
7.48 ± 10	90 ± 15		

[a] For references and a more complete presentation see Table 10.19 in (1979AJ01).

[b] From (p, p).

[c] See results obtained from (^{3}He, ^{3}He) in Table 10.19 of (1979AJ01).

[d] Also observed in (d, d) and (^{3}He, ^{3}He).

[e] $E_x = 718.35 \pm 0.04$ (from E_γ).

[f] $E_x = 718.5 \pm 0.2$ and 1740.0 ± 0.6 keV (from E_γ).

[g] Also observed in (^{3}He, ^{3}He).

[h] Also observed in (d, d).

[i] Not reported in (p, p) at $E_p = 10$ MeV.

[j] If $J^\pi = 4^-$; $\beta_L = 0.59 \pm 0.03$ if $J^\pi = 2^-$.

Axions may cause e^+e^- pairs in competition with γ-ray emission in an isoscalar M1 transition: a search for axions was undertaken in the case of the $3.59 \rightarrow$ g.s. $[2^+ \rightarrow 3^+]$ transition. It was negative (1986DE25). A beam dump experiment and other attempts to observe axions are discussed in (1987HA1O). For reaction (b) at $E_p = 1$ GeV see (1985BE30, 1985DO16; prelim.) and (1974AJ01). See also (1988KRZY), (1985KI1B, 1988KOZL; applied) and ^{11}C in (1985AJ01, 1990AJ01).

26. ^{10}B(d, d)^{10}B
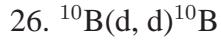
Angular distributions have been reported at $E_d = 4$ to 28 MeV: see (1974AJ01, 1979AJ01). Observed deuteron groups are displayed in Table 10.16. The very low intensity of the group to ^{10}B*(1.74) and the absence of the group to ^{10}B*(5.16) is good evidence of their $T = 1$ character: see (1974AJ01).

27. ^{10}B(t, t)^{10}B
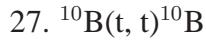
Angular distributions of elastically scattered tritons have been measured at $E_t = 1.5$ to 3.3 MeV: see (1974AJ01).

28. ^{10}B(^{3}He, ^{3}He)^{10}B

Angular distributions have been measured at $E(^3$He$) = 4$ to 46.1 MeV [see (1974AJ01, 1979AJ01, 1984AJ01)] and at 2.10 and 2.98 MeV (1987BA34; elastic). $L = 2$ gives a good fit of 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 of (1979AJ01). See also Table 10.16 here, ^{13}N in (1986AJ01) and (1987RA36; theor.).

29. (a) ^{10}B(α, α)^{10}B
(b) ^{10}B(α, 2α)^{6}Li $Q_m = -4.4596$

Angular distributions have been measured for $E_\alpha = 5$ to 56 MeV [see (1974AJ01, 1979AJ01, 1984AJ01)] and at 91.8 MeV (1985JA12; α_0). Reaction (b) has been studied at $E_\alpha = 24$ and 700 MeV: see (1979AJ01, 1984AJ01). See also (1983GO27, 1985SH1D; theor.).

30. (a) ^{10}B(^{6}Li, ^{6}Li)^{10}B
(b) ^{10}B(^{7}Li, ^{7}Li)^{10}B
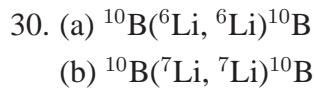
Elastic-scattering angular distributions have been studied at $E(^6\text{Li}) = 5.8$ and 30 MeV and at $E(^7\text{Li}) = 24$ MeV: see (1979AJ01).

31. $^{10}\text{B}(^9\text{Be}, {}^9\text{Be})^{10}\text{B}$

Elastic angular distributions have been measured at $E(^{10}\text{B}) = 20.1$ and 30.0 MeV (1983SR01). For yield and cross section measurements see (1983SR01, 1986CU02). See also (1984IN03, 1986RO12; theor.).

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

Elastic angular distributions (reaction (a)) have been studied at $E(^{10}\text{B}) = 8$, 13 and 21 MeV. For yields and reaction (b) see (1979AJ01). See also (1985BE1A, 1985CU1A) and (1984HA43, 1986RO12; theor.).

33. (a) $^{10}\text{B}(^{12}\text{C}, {}^{12}\text{C})^{10}\text{B}$
    (b) $^{10}\text{B}(^{13}\text{C}, {}^{13}\text{C})^{10}\text{B}$

Elastic angular distributions have been measured at $E(^{10}\text{B}) = 18$ and 100 MeV for reaction (a) [see (1979AJ01)] and at 18–46 MeV [see (1984AJ01)] and 42.5, 62.3 and 80.9 MeV for reaction (b) (1985MA10). For yield, cross section and fusion experiments see (1983DA20, 1983MA53, 1985MA10, 1988MA07) and (1984AJ01). See also (1984DEZX, 1984HAZK, 1987SAZW), (1982BA1D, 1985BA1T; astrophysics), (1983BI13, 1983DU13, 1984FR1A, 1984HA53, 1985BE1A, 1985CU1A, 1986MA19) and (1983HA1E, 1984HA43, 1984IN03, 1984MAZT, 1985KO1J, 1986RO12; theor.).

34. $^{10}\text{B}(^{14}\text{N}, {}^{14}\text{N})^{10}\text{B}$

Angular distributions have been reported at $E(^{10}\text{B}) = 100$ MeV and $E(^{14}\text{N}) = 73.9$ and 93.6 MeV: see (1979AJ01, 1984AJ01). For fusion cross section studies see (1979AJ01, 1984AJ01) and (1983DE26). See also (1983BI13, 1983DA10, 1984FR1A, 1984HA53, 1985BE1A, 1985CU1A) and (1983GO13, 1984HA43, 1984IN03, 1985KO1J, 1986RO12; theor.).

35. (a) $^{10}\text{B}(^{16}\text{O}, {}^{16}\text{O})^{10}\text{B}$
    (b) $^{10}\text{B}(^{17}\text{O}, {}^{17}\text{O})^{10}\text{B}$
    (c) $^{10}\text{B}(^{18}\text{O}, {}^{18}\text{O})^{10}\text{B}$

Elastic angular distributions (reaction (a)) have been studied at $E(^{16}\text{O}) = 15.0$ to 32.5 MeV and at $E(^{10}\text{B}) = 33.7$ to 100 MeV: see (1979AJ01, 1984AJ01). The elastic scattering for reaction (c) has been studied at $E(^{18}\text{O}) = 20$, 24 and 30.5 MeV: see (1974AJ01). For yield and fusion cross section measurements see (1984AJ01) and (1984GO05). See also (1983BI13, 1984FR1A, 1984HA53) and (1983GO13, 1985HU04; theor.).

36. (a) $^{10}\text{B}(^{19}\text{F}, {}^{19}\text{F})^{10}\text{B}$
     (b) $^{10}\text{B}(^{20}\text{Ne}, {}^{20}\text{Ne})^{10}\text{B}$

The elastic scattering has been investigated for $E(^{19}\text{F}) = 20$ and 24 MeV for reaction (a) and $E(^{10}\text{B}) = 65.9$ MeV for reaction (b): see (1974AJ01, 1984AJ01).

37. (a) $^{10}\text{B}(^{24}\text{Mg}, {}^{24}\text{Mg})^{10}\text{B}$
     (b) $^{10}\text{B}(^{25}\text{Mg}, {}^{25}\text{Mg})^{10}\text{B}$

The elastic scattering for both reactions has been studied at $E(^{10}\text{B}) = 87.4$ MeV: see (1984AJ01). The elastic scattering for reaction (b) has been measured at $E(^{10}\text{B}) = 34$ MeV by (1985WI18).

38. (a) $^{10}\text{B}(^{27}\text{Al}, {}^{27}\text{Al})^{10}\text{B}$
     (b) $^{10}\text{B}(^{28}\text{Si}, {}^{28}\text{Si})^{10}\text{B}$
     (c) $^{10}\text{B}(^{30}\text{Si}, {}^{30}\text{Si})^{10}\text{B}$

The elastic scattering for all three reactions has been studied at $E(^{10}\text{B}) = 41.6$ and ≈ 50 MeV [and also at 33.7 MeV for reaction (b)]: see (1984AJ01). See also (1984TE1A).

39. (a) $^{10}\text{B}(^{39}\text{K}, {}^{39}\text{K})^{10}\text{B}$
     (b) $^{10}\text{B}(^{40}\text{Ca}, {}^{40}\text{Ca})^{10}\text{B}$

The elastic scattering has been studied at $E(^{10}\text{B}) = 44$ MeV for reaction (a) (1985WI18) and at 46.6 MeV for reaction (b): see (1984AJ01).

40. $^{10}\text{C}(\beta^+)^{10}\text{B}$ $Q_m = 3.6481$

The half-life of ^{10}C is 19.255 ± 0.53 sec [see (1974AJ01, 1979AJ01)]: the decay is to ^{10}B*(0.72, 1.74) with branching ratios of $(98.53 \pm 0.02)\%$ and $(1.465 \pm 0.014)\%$ and $\log ft = 3.047$ for the transition to ^{10}B*(0.72) and 3.492 ± 0.005 for that to the analog state, ^{10}B*(1.74): see Table 10.20 in (1979AJ01). The excitation energies of the two states are 718.32 ± 0.09 and 1740.16 ± 0.17 keV [$E_\gamma = 718.29 \pm 0.09$ and 1021.78 ± 0.14 keV]. See (1979AJ01) for a further discussion of the decay. See also (1988GI02, 1988KRZY).

41. ^{11}B$(\gamma, n)^{10}$B $Q_m = -11.4542$

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: see ^{11}B in (1980AJ01). See also ^{11}B in (1985AJ01, 1990AJ01) and (1984AL22).

42. (a) ^{11}B$(p, d)^{10}$B $Q_m = -9.2296$
    (b) ^{11}B$(p, pn)^{10}$B $Q_m = -11.4542$

Angular distributions of deuteron groups have been measured at several energies in the range $E_p = 17.7$ to 154.8 MeV [see (1979AJ01)] and at 18.6 MeV (1985BE13; d_0, d_1). The population of the first five states of ^{10}B and of ^{10}B*(5.2, 6.0, 6.56, 7.5, 11.4 ± 0.2, 14.1 ± 0.2) is reported. For reaction (b) see (1985BE30, 1985DO16; 1 GeV; prelim.). See also (1988GUZW) and (1988BE1I; theor.).

43. ^{11}B$(d, t)^{10}$B $Q_m = -5.1969$

Angular distributions have been measured at $E_d = 11.8$ MeV ($t_0 \rightarrow t_3$; $l = 1$) [see (1974AJ01)] and at 18 MeV (1987GUZZ, 1988GUZW; prelim.).

44. (a) ^{11}B$(^3$He, $\alpha)^{10}$B $Q_m = 9.1236$
    (b) ^{11}B$(^3$He, $2\alpha)^6$Li $Q_m = 4.6640$

Reported levels are displayed in Table 10.17. Angular distributions have been measured at a number of energies between $E(^3$He$) = 1.0$ and 33 MeV [see (1974AJ01)] and at 23.4 MeV (1987VA1I; α_0, α_1; prelim.). For the decay of observed states see Table 10.6.

The α-α 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

40

Table 10.17: ^{10}B levels from ^{11}B(^{3}He, α)^{10}B [a]

E_{x} (MeV $\pm$ keV)	$\Gamma_{\mathrm{c.m.}}$ (keV)	l	S_{rel}
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			
6.570 ± 7	30 ± 10		
7.002 ± 10	95 ± 10		
7.475 ± 10			
7.567 ± 10			
7.87 ± 40	240 ± 50		
10.85 ± 100	300 ± 100		
11.52 ± 35	500 ± 100		
12.56 ± 30	100 ± 30		
13.49 ± 50	300 ± 50		
14.4 ± 100	800 ± 200		
(18.2 ± 200)	(1500 ± 300)		

[a] See Table 10.21 in (1979AJ01) for references.

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 $J^\pi = 4^-$]. See, however, reaction 15, and see (1974AJ01) for the references. See also (1988GOZB; theor.).

45. ^{11}B(^{7}Li, ^{8}Li)^{10}B $\qquad\qquad Q_m = -9.421$

Angular distributions have been measured at $E(^7$Li$) = 34$ MeV involving ^{10}B*(0, 0.72, 1.74, 2.15) and ^{8}Li$_{g.s.}$ (as well as ^{8}Li*(0.98) in the case of the ^{10}B$_{g.s.}$ transition) (1987CO16).

46. (a) ^{12}C(γ, d)^{10}B $\qquad\qquad Q_m = -25.1868$
    (b) ^{12}C(γ, pn)^{10}B $\qquad\qquad Q_m = -27.4114$

For reaction (a) see (1986SH1M) and ^{12}C in (1990AJ01). For reaction (b) see ^{12}C in (1985AJ01). See also (1984DO17) and (1984CH1A, 1986GU1G; theor.).

47. ^{12}C(n, t)^{10}B $\qquad\qquad Q_m = -18.9295$

See (1985FR07, 1987FR16; $E_n = 319$ to 545 MeV). See also (1986DO12).

48. ^{12}C($\pi^\pm$, $\pi^\pm$d)^{10}B $\qquad\qquad Q_m = -25.1868$

At $E_{\pi^+} = 180$ MeV and $E_{\pi^-} = 220$ MeV, ^{10}B*(0.72, 2.15) are populated: see (1984AJ01). At $E_{\pi^+} = 150$ MeV momentum distributions of pions to unresolved states of ^{10}B are reported by (1987HU13).

49. (a) ^{12}C(p, ^{3}He)^{10}B $\qquad\qquad Q_m = -19.6933$
    (b) ^{12}C(p, pd)^{10}B $\qquad\qquad Q_m = -25.1868$

Angular distributions of ^{3}He ions have been measured for $E_p = 39.8$, 51.9 and 185 MeV: see (1979AJ01). ^{10}B*(0, 0.72, 1.74, 2.15, 3.59, 4.77, 5.16, 5.92, 6.56, 7.50, 8.90) are populated. For reaction (b) see (1985DE17; $E_p = 58$ MeV; ^{10}B*(0.72, 1.74)) and (1984AJ01). See also (1986VDZY) and (1986GO28, 1986ZH03, 1987GA08, 1987KW01; theor.).

50. ^{12}C(d, α)^{10}B $Q_m = -1.3401$

Alpha groups have been observed to most of 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 40 MeV: see (1979AJ01). 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). A study of the $m_s = 0$ yield at $E_d = 14.5$ MeV ($\theta = 0°$) leads to assignments of 3^+, 2^- and (3^+, 4^-) for ^{10}B*(4.77, 5.11, 6.56). 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 (1986AJ01). See also (1984LOZZ).

51. ^{12}C(α, ^{6}Li)^{10}B $Q_m = -23.7118$

Angular distributions have been reported at $E_\alpha = 42$ and 46 MeV: see (1979AJ01). At $E_\alpha = 65$ MeV, an investigation of the ^{6}Li breakup shows that ^{10}B*(0, 0.72, 2.16, 3.57, 4.77, 5.2, 5.9, 6.0) are involved: see (1984AJ01). See also (1987GA20).

52. ^{12}C(^{7}Li, ^{9}Be)^{10}B $Q_m = -8.492$

At $E(^7$Li$) = 78$ MeV angular distributions have been measured to ^{10}B*(0, 2.15) (1986GLZV; prelim.).

53. (a) ^{12}C(^{12}C, ^{14}N)^{10}B $Q_m = -14.9144$
    (b) ^{12}C(^{14}N, ^{16}O)^{10}B $Q_m = -4.4505$

Angular distributions (reaction (a)) involving ^{10}B*(0, 0.7) have been studied at $E(^{12}$C$) = 49.0$ to 75.5 and 93.8 MeV. Angular distributions (reaction (b)) involving ^{10}B*(0, 0.72, 2.15, 3.59) have been measured at $E(^{14}$N$) = 53$ MeV and 78.8 MeV (not to ^{10}B*(3.59)): see (1979AJ01, 1984AJ01) for references. See also (1986AR04, 1986CR1A, 1986MOZV).

54. ^{13}C(p, α)^{10}B $Q_m = -4.0618$

Angular distributions have been measured at $E_p = 5.8$ to 18 MeV and 43.7 and 50.5 MeV: see (1979AJ01). See also ^{14}N in (1986AJ01) and (1985MAZG; theor.).

55. ^{14}N(p, pα)^{10}B $Q_m = -11.6125$

See (1986VDZY; $E_\mathrm{p} = 50$ MeV; prelim.). See also (1986GO28; theor.).

56. $^{14}\mathrm{N}(\mathrm{d},\,^6\mathrm{Li})^{10}\mathrm{B}$ $\qquad\qquad Q_\mathrm{m} = -10.137$

At $E_\mathrm{d} = 80$ MeV angular distributions are reported to $^{10}\mathrm{B}^*(0, 0.72, 2.15, 3.59, 4.8, 6.04, 7.05, 8.68)$: see (1984AJ01).

57. $^{16}\mathrm{O}(^9\mathrm{Be},\,^{15}\mathrm{N})^{10}\mathrm{B}$ $\qquad\qquad Q_\mathrm{m} = -5.542$

See (1985WI18).

<div align="center">

^{10}C

(Figs. 3 and 4)

</div>

GENERAL: See also (1984AJ01).

Model calculations: (1984SA37, 1987BL18).

Special states: (1986AB10).

Astrophysical questions: (1987RA1D).

Complex reactions involving ^{10}C: (1983FR1A, 1983OL1A, 1986HA1B, 1987AR19, 1987BEYI, 1987RI03, 1987SN01, 1987TAZU, 1988BEYJ, 1988CA06, 1988KI05, 1988SA19).

Reactions involving pions and other mesons (See also reactions 2 and 4.): (1985LI1E, 1987SI18).

Other topics: (1982KA1D, 1985AN28, 1986YA1F).

Ground-state properties of ^{10}C: (1983ANZQ, 1985AN28, 1987BL18, 1987SA15).

Mass of ^{10}C: The threshold energy for the ^{10}B(p, n)^{10}C reaction is 4876.90 ± 0.37 keV: then $Q_0 = -4430.17 \pm 0.34$ keV (1984BA12). Using the (1988WA18) masses for ^{10}B, p and n, the atomic mass excess of ^{10}C is then 15698.8 ± 0.5 keV. This value does not include a contribution from unpublished work on ^{12}C(p, t)^{10}C quoted in (1984AJ01). However, we adopt the (1988WA18) value: 15699.1 ± 0.3 keV.

$$B(E2)\uparrow \text{ for } ^{10}\text{C*}(3.35) = (6.2 \pm 1.0) \times 10^{-3} \ e^2 \cdot \text{b}^2,$$

$$[Q_0 = 0.25 \pm 0.02 \text{ b}] \ (1987\text{RA}01).$$

1. ^{10}C$(\beta^+)^{10}$B $\qquad\qquad\qquad\qquad Q_m = 3.6481$

^{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: see (1974AJ01). See also reaction 40 in ^{10}B and (1986CA1L).

2. ^{7}Li$(^3$He, $\pi^-)^{10}$C $\qquad\qquad\qquad\qquad Q_m = -125.429$

At $E(^3$He$) = 235$ MeV ^{10}C*(3.35) is populated (1984BI08). π^- production in this reaction has also been studied by (1984BR22) At $E(^3$He$) = 910$ MeV.

6.58

5.100
^{6}Be+α

3.8207
^{8}Be+2p

5.22 5.38

4.006
^{9}B+p

3.354   2$^+$

slow n

1000

4.835

2m$_0$c^2 ^{10}C   0$^+$;1

β$^+$

−3.6481
^{10}B

217

−3.6667
^{10}B+^{3}He−t

−4.4305
^{10}B+p−n

155

−23.3600
^{12}C+p−t

7.88

30

−7.155
^{10}B+^{6}Li−^{6}He

613

−136.631
^{9}Be+p−π$^-$

70

−15.235
^{13}C+^{3}He−^{6}He
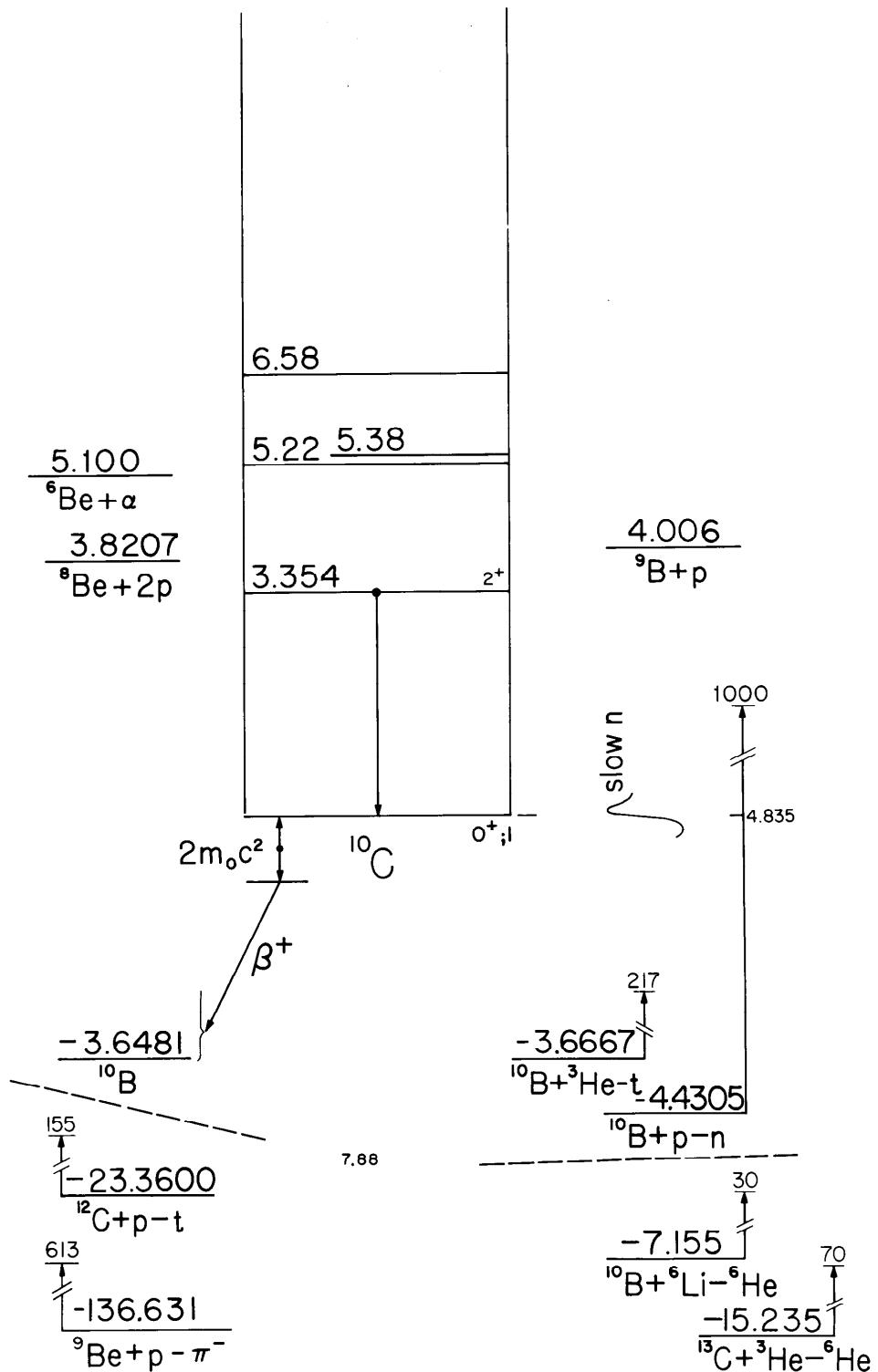
Fig. 3: Energy levels of ^{10}C. For notation see Fig. 1.

Table 10.18: Energy levels of ^{10}C

E_x (MeV $\pm$ 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, 4, 5, 6, 7, 8
3.3536 ± 0.7	2^+	$\tau_m = 155 \pm 25$ fsec	γ	2, 4, 5, 6, 7, 8
5.22 ± 40	a	$\Gamma = 225 \pm 45$ keV		4, 5, 6, 7
5.38 ± 70	a	300 ± 60		4, 5, 6, 7
6.580 ± 20	(2^+)	200 ± 40		4, 6, 7

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

3. ^{7}Li(^{7}Li, 4n)^{10}C $\qquad\qquad Q_m = -18.171$

Tetraneutron (n^4) production has been studied in this and in other reactions involving ^{10}C at $E(^7\text{Li}) = 82$ MeV (1987ALZG; prelim.): it is not observed.

4. ^{9}Be(p, π^-)^{10}C $\qquad\qquad Q_m = -136.631$

Angular distributions of π^- groups have been measured at $E_p = 185$ MeV (to ^{10}C*(0, 3.35, 5.28, 6.63)), at 200 MeV (g.s.), at 800 MeV (to ^{10}C*(0, 3.35, 5.3, 6.6)) [see (1984AJ01)] and at $E_{\bar{p}} = 650$ MeV (1986HO23; ^{10}C*(0, 3.35); also A_y). A_y measurements have also been reported at $E_{\bar{p}} = 200$ to 250 MeV: see (1984AJ01).

5. ^{10}B(p, n)^{10}C $\qquad\qquad Q_m = -4.4305$

$$Q_0 = -4430.17 \pm 0.34 \text{ keV (1984BA12)}$$

The E_x of ^{10}C*(3.35) $= 3352.7 \pm 1.5$ keV, $\tau_m = 155 \pm 25$ fsec, $\Gamma_\gamma = 4.25 \pm 0.69$ meV. Angular distributions have been measured for the n_0 and n_1 groups and for the neutrons to ^{10}C*(5.2 $\pm$ 0.3) at $E_p = 30$ and 50 MeV [see (1974AJ01, 1979AJ01)] and for the n_0 and n_1 groups at $E_p = 14.0$, 14.3 and 14.6 MeV (1985SC08) and 15.8 and 18.6 MeV (1985GU1C; prelim.). See also (1984BA1R, 1988KA2E).

6. ^{10}B(^{3}He, t)^{10}C $\qquad\qquad Q_m = -3.6667$

Angular distributions have been measured at $E(^3\text{He}) = 14$ MeV and 217 MeV: see (1979AJ01). The latter [to $^{10}\text{C}^*(0, 3.35, 5.6)$] have been compared with microscopic calculations using a central+tensor interaction [$J^\pi = 0^+$, 2^+, 2^+]. Structures have been reported at $E_\text{x} = 5.22 \pm 0.04$ [$\Gamma = 225 \pm 45$ keV], 5.38 ± 0.07 [300 ± 60 keV] and 6.580 ± 0.020 MeV [190 ± 35 keV].

7. $^{12}\text{C}(\text{p, t})^{10}\text{C}$ $\qquad\qquad\qquad\qquad Q_\text{m} = -23.3600$

Angular distributions have been reported at $E_\text{p} = 30.0$ to 54.1 MeV and at 80 MeV [see (1974AJ01, 1979AJ01, 1984AJ01)]. $L = 0$, 2 and 2 to $^{10}\text{C}^*(0, 3.35, 5.28)$ thus leading to 0^+, 2^+ and 2^+ for these states [but note that the "5.28 MeV" state is certainly unresolved]: see reaction 6 and Table 10.18. $^{10}\text{C}^*(6.6)$ is also populated. Two measurements of the excitation energy of $^{10}\text{C}^*(3.4)$ are 3353.5 ± 1.0 keV, 3354.3 ± 1.1 keV: see (1984AJ01) [based on Q_m]. See also (1987KW01; theor.).

8. $^{13}\text{C}(^3\text{He}, {}^6\text{He})^{10}\text{C}$ $\qquad\qquad\qquad\qquad Q_\text{m} = -15.235$

At $E(^3\text{He}) = 70.3$ MeV the angular distributions of the ^6He ions corresponding to the population of $^{10}\text{C}^*(0, 3.35)$ have been measured. The group to $^{10}\text{C}^*(3.35)$ is much more intense than the ground-state group: see (1979AJ01).

^{10}N, ^{10}O, ^{10}F, ^{10}Ne
(Not illustrated)
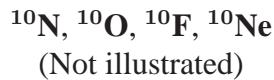
Not observed: see (1979AJ01). (1985WA02) suggest 39.7 ± 0.4 MeV for the atomic mass excess of ^{10}N. See also (1982KA1D, 1983ANZQ, 1987BL18, 1987SA15; theor.).
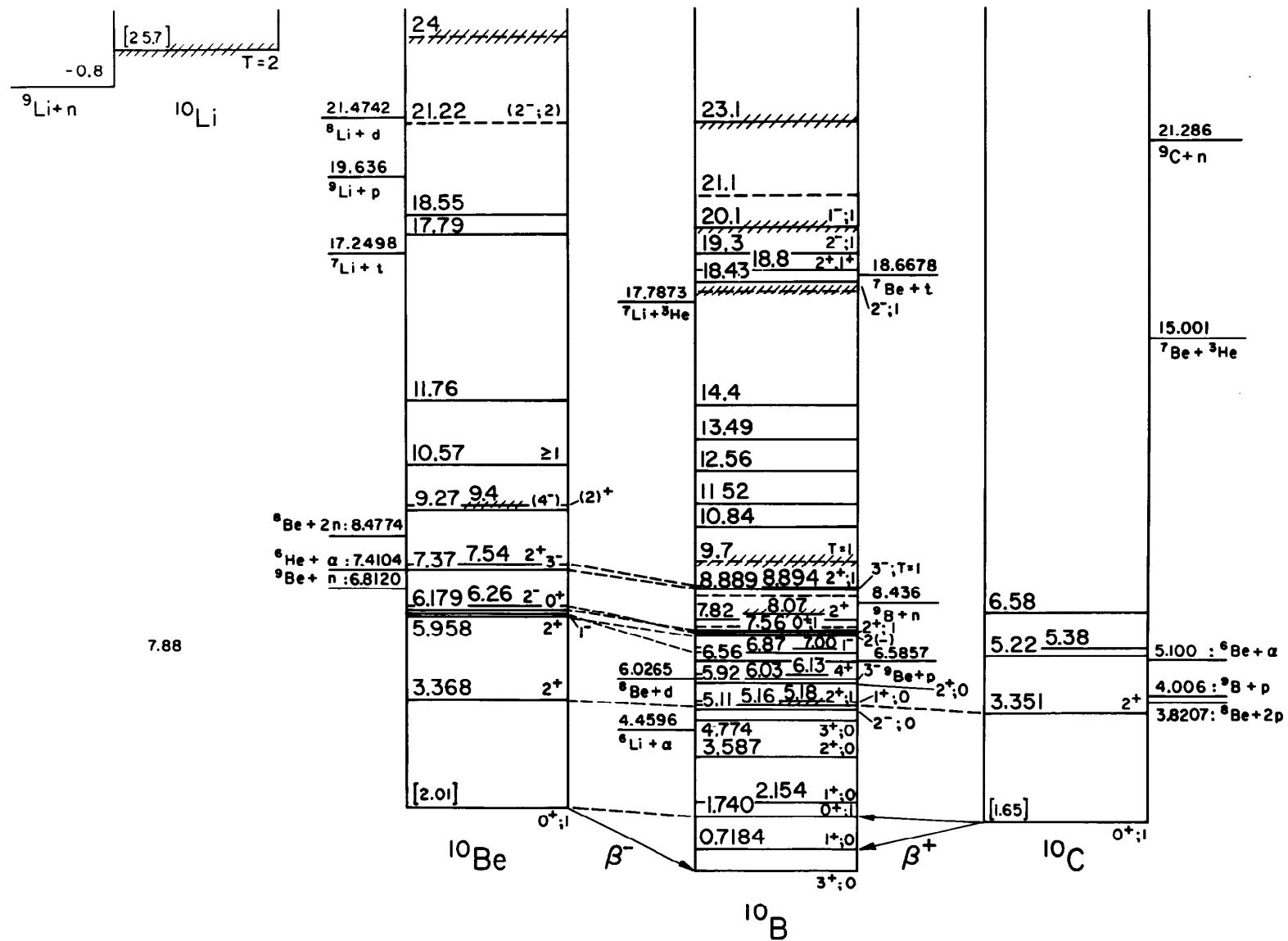
Fig. 4: Isobar diagram, $A = 10$. The diagrams for individual isobars have been shifted vertically to eliminate the neutron-proton mass difference and the Coulomb energy, taken as $E_C = 0.60Z(Z-1)/A^{1/3}$. Energies in square brackets represent the (approximate) nuclear energy,

$E_N = M(Z, A) - ZM(H) - NM(n) - E_C$, minus the corresponding quantity for ^{10}B: here M represents the atomic mass excess in MeV. Levels which are presumed to be isospin multiplets are connected by dashed lines.

References

(Closed 1 June 1988)

1966FO05   P.D. Forsyth, H.T. Tu and W.F. Hornyak, Nucl. Phys. 82 (1966) 33

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

1966WA10   E.K. Warburton, J.W. Olness, K.W. Jones, C. Chasman, R.A. Ristinen and D.H. Wilkinson, Phys. Rev. 148 (1966) 1072

1974AJ01   F. Ajzenberg-Selove and T. Lauritsen, Nucl. Phys. A227 (1974) 1

1974KE06   K.W. Kemper, S. Cotanch, G.E. Moore, A.W. Obst, R.J. Puigh and R.L. White, Nucl. Phys. A222 (1974) 173

1977KI04   A. Kiss, E. Koltay, G. Szabo and L. Vegh, Nucl. Phys. A282 (1977) 44

1978LEZA   C.M. Lederer, V.S. Shirley, E. Browne, J.M. Dairiki, R.E. Doebler, A.A. Shihab-Eldin, L.J. Jardine, J.K. Tuli and A.B. Buyrn, Table of Isotopes 7th Ed. (1978)

1979AJ01   F. Ajzenberg-Selove, Nucl. Phys. A320 (1979) 1

1979KE08   J. Keinonen and A. Anttila, Nucl. Phys. A330 (1979) 397

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

1980BL02   L. Bland and H.T. Fortune, Phys. Rev. C21 (1980) 11

1980HA33   M.N. Harakeh, J. Van Popta, A. Saha and R.H. Siemssen, Nucl. Phys. A344 (1980) 15

1980MA33   G. Mack, R.C. Byrd, P.W. Lisowski and R.L. Walter, Nucl. Phys. A345 (1980) 241

1981MUZQ   S.F. Mughabghab, M. Divadeenam and N.E. Holden, Neutron Cross Sections Part A, Z=1-60 (1981)

1982AL08   D.V. Aleksandrov, Yu.A. Glukhov, A.S. Demyanova, V.I. Dukhanov, I.B. Mazurov, B.G. Novatsky, A.A. Ogloblin, S.B. Sakuta and D.N. Stepanov, Yad. Fiz. 35 (1982) 277; Sov. J. Nucl. Phys. 35 (1982) 158

1982AL33   D.V. Aleksandrov, Yu.A. Glukhov, A.S. Demyanova, V.I. Dukhanov, I.B. Mazurov, B.G. Novatsky, A.A. Ogloblin, S.B. Sakuta and D.N. Stepanov, Yad. Fiz. 36 (1982) 1351; Sov. J. Nucl. Phys. 36 (1982) 783

1982AU1A   Audouze and Reeves, Essays in Nucl. Astrophys. (1982) 355

1982BA1D   C.A. Barnes, Essays in Nucl. Astrophys. (1982) 193

1982BA78   V.N. Baturin, V.V. Vikhrov, M.M. Makarov, V.V. Nelyubin, A.A. Naberezhnov, V.V. Sulimov and L.N. Uvarov, Pisma Zh. Eksp. Teor. Fiz. 36 (1982) 370; JETP Lett. 36 (1982) 448

1982BE1D   A.M. Bernstein, Proc. Int. School of Intermediate Energy Nucl. Phys., Verona, Italy, July 1981; Eds., R. Bergere, S. Costa and C. Schaerf (1982) 125

1982BR1A   Braun and Vechernin, Sov. J. Nucl. Phys. 36 (1982) 357

1982CA1A   Cameron, Essays in Nucl. Astrophys. (1982) 23

1982KA1D   K. Kar and J.C. Parikh, Pramana 19 (1982) 555

1982WA1A   W.W. Wang, Y.S. Zhang and R.L. Wang, Kexue Tongbao 27 (1982) 711

1983AB1A   Abramovitch et al., in Moscow (1983) 362

1983AI01   O. Aizawa, T. Matsumoto and H. Kadotani, J. Nucl. Sci. Tech. 20 (1983) 354

1983AL10   M. Allab, A. Boucenna and M. Haddad, J. Phys. (Paris) 44 (1983) 579

1983AL20   D.V. Aleksandrov, E.A. Ganza, Yu.A. Glukhov, V.I. Dukhanov, I.B. Mazurov, B.G. Novatsky, A.A. Ogloblin, D.N. Stepanov, V.V. Paramonov and A.G. Trunov, Yad. Fiz. 37 (1983) 797; Sov. J. Nucl. Phys. 37 (1983) 474

1983AM1A   G. Amsel and J.A. Davies, Nucl. Instrum. Meth. Phys. Res. 218 (1983) 177

1983AN1D   Antolkovic et al., in Florence (1983) 438

1983AN1F   L. Antonuk, G. Blanpied, D. Bovet, E. Bovet, Y. de Coulon, J.P. Egger, F. Goetz, P. Gretillat, C. Lunke, C. Perrin et al., Sin Newsl. 15 (1983) 40

1983ANZQ   Y. Ando, M. Uno and M. Yamada, JAERI-M-83-025 (1983)

1983BA1D   H. Bando, Prog. Theor. Phys. 69 (1983) 1731

1983BA71   C.J. Batty, Nucl. Phys. A411 (1983) 399

1983BI13   J.R. Birkelund and J.R. Juizenga, Ann. Rev. Nucl. Part. Sci. 33 (1983) 265

1983BI1C   P.G. Bizzeti, Riv. Nuovo Cim. 6 (1983) 1

1983BO1C   Z.T. Body, F. Cserpak, J. Csikai, S. Sudar and K. Mihaly, Proc. Int. Conf. on Nucl. Data for Sci. and Tech., Antwerp, Belgium, 6-10 Sept. 1982 (1983) 368

1983BY01   R.C. Byrd, C.E. Floyd, P.P. Guss, K. Murphy and R.L. Walter, Nucl. Phys. A399 (1983) 94

1983BY02   R.C. Byrd, P.W. Lisowski, W. Tornow and R.L. Walter, Nucl. Phys. A404 (1983) 29

1983CE1A   Cereda, de Leo, Micheletti and Pignanelli, in Florence (1983) 234

1983DA10   B. Dasmahapatra, B. Cujec and F. Lahlou, Can. J. Phys. 61 (1983) 657

1983DA20   B. Dasmahapatra, B. Cujec and F. Lahlou, Nucl. Phys. A408 (1983) 192

1983DA22   J.H. Dave and C.R. Gould, Phys. Rev. C28 (1983) 2212

1983DE26 P.A. De Young, J.J. Kolata, L.J. Satkowiak and M.A. Xapsos, Phys. Rev. C28 (1983) 692

1983DU13 G.G. Dussel, A.O. Gattone and E.E. Maqueda, Phys. Rev. Lett. 51 (1983) 2366

1983EN04 Y.M. Engel and R.D. Levine, Phys. Rev. C28 (1983) 2321

1983FA1B Farwell et al., in Florence (1983) 752

1983FE07 V.N. Fetisov, L. Majling, J. Zofka and R.A. Eramzhyan, Z. Phys. A314 (1983) 239

1983FR1A W.A. Friedman and W.G. Lynch, Phys. Rev. C28 (1983) 950

1983GE12 P.M. Gensini, Lett. Nuovo Cim. 38 (1983) 469

1983GE13 P.M. Gensini, Lett. Nuovo Cim. 38 (1983) 620

1983GE1C P.M. Gensini, Nuovo Cim A78 (1983) 471

1983GM1A M. Gmitro, H.R. Kissener, P. Truol and R.A. Eramzhyan, Fiz. Elem. Chastits At. Yadra 14 (1983) 773; Sov. J. Part. Nucl. 14 (1983) 323

1983GO13 J. Gomez del Campo and G.R. Satchler, Phys. Rev. C28 (1983) 952

1983GO1H C.R. Gould, J. Dave and R.L. Walter, Proc. Int. Conf. on Nucl. Data for Sci. and Tech., Antwerp, Belgium, 6-10 Sept. 1982 (1983) 766

1983GO27 V.G. Gonchar and V.V. Tokarevsky, Izv. Akad. Nauk. SSSR Ser. Fiz. 47 (1983) 2156; Bull. Acad. Sci. USSR Phys. Ser. 47 (1983) 69

1983GO28 A.N. Goltsov and N.G. Goncharova, Yad. Fiz. 38 (1983) 1410; Sov. J. Nucl. Phys. 38 (1983) 857

1983GU1A C. Guet, Nucl. Phys. A400 (1983) 191

1983HA1E Haider and Malik, in Florence (1983) 548

1983KA37 S.G. Kadmenskyii and Yu.L. Ratis, Izv. Akad. Nauk. SSSR Ser. Fiz. 47 (1983) 2254; Bull. Acad. Sci. USSR Phys. Ser. 47 (1983) 162

1983KE11 T.J. Kennett, W.V. Prestwich, R.J. Tervo and J.S. Tsai, Nucl. Instrum. Meth. Phys. Res. 215 (1983) 159

1983KO1F S. Komoda and T. Sekiya, Atomkernenerg. Kerntech. 42 (1983) 101

1983KU1C Kutschera, Radiocarbon 25 (1983) 677

1983LE17 P.M. Lewis, O. Karban, J.M. Barnwell, J.D. Brown, P.V. Drumm, J.M. Nelson and S. Roman, Nucl. Phys. A404 (1983) 205

1983LI1A Litherland, Proc. Int. Conf. on Nucl. Phys., Florence, Aug.-Sept. 1983; Eds., P. Blasi and R.A. Riccii; Vol.2 (1983) 697

1983MA40 S. Maleki, Nucl. Phys. A403 (1983) 607

1983MA53 J.F. Mateja, J. Garman and A.D. Frawley, Phys. Rev. C28 (1983) 1579

1983MI1E K. Miyahara, K. Ikeda and H. Bando, Prog. Theor. Phys. 69 (1983) 1717

1983NA08   M.N. Namboodiri, R.K. Choudhury, J.B. Natowitz, K. Hagel, L. Adler, P.L. Gonthier, H. Simon, S. Kniffen, R. Patton, E. Tomasi et al., Phys. Rev. C28 (1983) 460

1983NE1A   Nelson et al., Radiocarbon 25 (1983) 693

1983OL1A   D.L. Olson, B.L. Berman, D.E. Greiner, H.H. Heckman, P.J. Lindstrom and H.J. Crawford, Phys. Rev. C28 (1983) 1602

1983PO1A   Poenaru, Ivascu and Sandulescu, in Florence (1983) 662

1983PO1D   Povh, Proc. Int. Conf. on Nucl. Phys., Florence, Aug.-Sept. 1983; Eds., P. Blasi and R.A. Ricci; Vol. 2 (1983) 455

1983RO22   S. Roman, O. Karban, M. Barnwell, J.D. Brown, P.V. Drumm, P.M. Lewis and J.M. Nelson, Phys. Rev. C28 (1983) 2515

1983SH1E   Y.-J. Shi and F. Zhuang, Phys. Energ. Fortis Phys. Nucl. 7 (1983) 605

1983SH1G   Sharma et al., Proc. Indian Acad. Sci. 92 (1983) 1

1983SH1J   K. Shibata and S. Shirato, J. Phys. Soc. Jpn. 52 (1983) 3748

1983SH38   Y.-J. Shi, Phys. Rev. C28 (1983) 2452

1983SR01   J. Sromicki, M. Hugi, J. Lang, R. Muller, E. Ungricht, L. Jarczyk, B. Kamys, A. Magiera, Z. Rudy, A. Strzalkowski et al., Nucl. Phys. A406 (1983) 390

1983TA17   F. Tancu, M.T. Magda, S. Dima, M. Macovei, E. Ivanov, R. Dumitrescu and C. Stan-Sion, Rev. Roum. Phys. 28 (1983) 857

1983TU1A   Tuniz et al., in Florence (1983) 751

1983VA31   A.G.M. van Hees and P.W.M. Glaudemans, Z. Phys. A314 (1983) 323

1983VE03   W.J. Vermeer, R.K. Bhalla and A.R. Poletti, Phys. Rev. C28 (1983) 432

1983WI1A   Wilczynski, Proc. Int. Conf. on Nucl. Phys., Florence, Aug.-Sept. 1983; Eds., P. Blasi and R.A. Ricci; Vol. 2 (1983) 305

1983ZIZZ   K.O.H. Ziock, J. Boswell, J. Hurd, R.C. Minehart, Y. Tzeng and H.J. Ziock, Bull. Amer. Phys. Soc. 28 (1983) 671, BG4

1984AJ01   F. Ajzenberg-Selove, Nucl. Phys. A413 (1984) 1

1984AL22   A.S. Alimov, V.I. Mokeev, E.S. Omarov and I.M. Piskarev, Yad. Fiz. 40 (1984) 301; Sov. J. Nucl. Phys. 40 (1984) 190

1984AN16   Yu.P. Antufyev, A.S. Deineko, I.I. Zalyubovsky, V.D. Sarana, V.E. Storizhko, A.I. Tutubalin, C. Hategan and N.A. Schliakhov, Yad. Fiz. 40 (1984) 53; Sov. J. Nucl. Phys. 40 (1984) 35

1984BA12   P.H. Barker and R.E. White, Phys. Rev. C29 (1984) 1530

1984BA1L   Yu.D. Bayukov, V.B. Gavrilov, N.A. Goryainov, Yu.G. Grishuk, O.B. Gushchin, P.V. Degtyarenko, N.L. Kornienko, G.A. Leksin, V.B. Fedorov, B.B. Shvartsman et al., Yad. Fiz. 39 (1984) 1482; Sov. J. Nucl. Phys. 39 (1984) 938

1984BA1R   V.N. Baturin, A.V. Khanzadeev, V.P. Koptev, E.M. Maev, M.M. Makarov, V.V. Nelyubin, G.V. Shcherbakov and V.V. Sulimov, in Panic (1984) I11

1984BA1U   Bayukov et al., in Panic (1984) 125

1984BE1C   Belozerov et al., in Alma Ata (1984) 379

1984BE1F   Beer, Bull. Amer. Phys. Soc. 29 (1984) 1094

1984BE1H   J. Beer, M. Andree, H. Oeschger, U. Siegenthaler, G. Bonani, H. Hofmann, E. Morenzoni, M. Nessi, M. Suter, W. Wolfli, et al., Nucl. Instrum. Meth. Phys. Res. B233 (1984) 380

1984BI08   L. Bimbot, T. Hennino, J.C. Jourdain, Y. Le Bornec, F. Reide, N. Willis and J.F. Germond, Phys. Rev. C30 (1984) 739

1984BLZY   K.I. Blomqvist, A.M. Bernstein, J. Comuzzi, J.A. Nelson, B.H. Cottman, K. Min, P. Stoler, P.K. Teng, E.J. Winhold, M. Yamazaki et al., Bull. Amer. Phys. Soc. 29 (1984) 708, FI9

1984BO1D   A.R. Bodmer, Q.N. Usmani and J. Carlson, Nucl. Phys. A422 (1984) 510

1984BO1E   D. Bourles, G.M. Raisbeck, F. Yiou, J.M. Loiseaux, M. Lieuvin, J. Klein and R. Middleton, Nucl. Instrum. Meth. Phys. Res. B233 (1984) 365

1984BO1G   A.R. Bodmer, AIP Conf. Proc. 123 (1984) 806

1984BO1H   L.N. Bogdanova and V.E. Markushin, Fiz. Elem. Chastits At. Yadra 15 (1984) 808; Sov. J. Part. Nucl. 15 (1984) 361

1984BR22   T. Bressani, E. Chiavassa, S. Costa, G. Dellacasa, N. De Marco, M. Gallio, A. Musso, E. Aslanides, G. Bergdolt, P. Fassnacht et al., Phys. Rev. C30 (1984) 1745

1984BR25   B.A. Brown, C.R. Bronk and P.E. Hodgson, J. Phys. (London) G10 (1984) 1683

1984BY03   R.C. Byrd, C.E. Floyd, K. Murphy, P.P. Guss and R.L. Walter, Nucl. Phys. A427 (1984) 36

1984CH1A   Cherkasov, in Alma Ata (1984) 371

1984CH1G   H.Z. Chen, F. Zhuang, X.J. Shi and X.N. Jin, Chin. J. Nucl. Phys. 6 (1984) 303

1984CH1H   R.E. Chrien, AIP Conf. Proc. 123 (1984) 841

1984CO1D   P. Couvert, AIP Conf. Proc. 123 (1984) 689

1984DE46   A.S. Deineko, I.I. Zalyubovsky, V.D. Sarana, A.I. Tutubalin and N.A. Shlyakhov, Izv. Akad. Nauk. SSSR Ser. Fiz. 48 (1984) 1000; Bull. Acad. Sci. USSR Phys. Ser.48 (1984) 163

1984DE53   P. De Bievre, M. Gallet, N.E. Holden and I.L. Barnes, J. Phys. Chem. Ref. Data 13 (1984) 809

1984DEZX   L.C. Dennis and J.S. Hanspal, Bull. Amer. Phys. Soc. 29 (1984) 1047, DB3

1984DO17   I.V. Dogyust, V.I. Voloshchuk, V.V. Kirichenko and A.F. Khodyachikh, Yad. Fiz. 40 (1984) 1382; Sov. J. Nucl. Phys. 40 (1984) 878

1984DO1B D.J. Donahue, A.J.T. Jull and T.H. Zabel, Nucl. Instrum. Meth. Phys. Res. B233 (1984) 162

1984DO20 T.W. Donnelly and I. Sick, Rev. Mod. Phys. 56 (1984) 461

1984DZ1A R.I. Dzhibuti and Sh.M. Tsiklauri, Yad. Fiz. 39 (1984) 1115; Sov. J. Nucl. Phys. 39 (1984) 704

1984EL05 R.J. Ellis, K.S. Sharma, R.C. Barber, S.R. Loewen and H.E. Duckworth, Phys. Lett. B141 (1984) 306

1984EL1B D. Elmore, P.W. Kubick, L.E. Tubbs, H.E. Gove, R. Teng, T. Hemmick, B. Chrunyk and N. Conard, Nucl. Instrum. Meth. Phys. Res. B233 (1984) 109

1984EL1C D. Elmore, N. Conrad, P.W. Kubik and J. Fabryka-Martin, Nucl. Instrum. Meth. Phys. Res. B233 (1984) 233

1984EN1A P. Englert, S. Theis, R. Michel, C. Tuniz, R.K. Moniot, S. Vajda, T.H. Kruse, D.K. Pal and G.F. Herzog, Nucl. Instrum. Meth. Phys. Res. B233 (1984) 415

1984ER1A Eramzhyan, Majling, Zofka and Fetisov, in Panic (1984) M21

1984ER1B R.A. Eramzhyan, M. Gmitro, T.D. Kaipov, S.S. Kamalov and R. Mach, Proc. Wrkshp. on Perspectives in Nucl. Phys. at Intermediate Energ., Trieste, Italy, 10-14 Oct. 1983 (1984) 195

1984FR13 H. Friedrich, Phys. Lett. B146 (1984) 135

1984FR1A P. Frobrich, Phys. Rept. 116 (1984) 337

1984GO05 J. Gomez del Campo, J.A. Biggerstaff, R.A. Dayras, D. Shapira, A.H. Snell, P.H. Stelson and R.G. Stokstad, Phys. Rev. C29 (1984) 1722

1984GR08 R.E.L. Green, R.G. Korteling and K.P. Jackson, Phys. Rev. C29 (1984) 1806

1984HA43 Q. Haider and B. Cujec, Nucl. Phys. A429 (1984) 116

1984HA53 Q. Haider and F.B. Malik, At. Data Nucl. Data Tables 31 (1984) 185

1984HAZK J.S. Hanspal, L.C. Dennis, A.D. Frawley and R.A. Parker, Bull. Amer. Phys. Soc. 29 (1984) 1047, DB2

1984HE1B R.E.M. Hedges, Nucl. Instrum. Meth. Phys. Res. 220 (1984) 211

1984HE1C W. Henning, Nuovo Cim. A81 (1984) 191

1984HI1A A.S. Hirsch, A. Bujak, J.E. Finn, L.J. Gutay, R.W. Minich, N.T. Porile, R.P. Scharenberg and B.C. Stringfellow, Phys. Rev. C29 (1984) 508

1984HO1E H. Hofmann, G. Bonani, E. Morenzoni, M. Nessi, M. Suter and W. Wolfli, Nucl. Instrum. Meth. Phys. Res. B233 (1984) 254

1984HO23 H. Homeyer, M. Burgel, Ch. Egelhaaf, H. Fuchs and G. Thoma, Z. Phys. A319 (1984) 143

1984IM1A   M. Imamura, Y. Hashimoto, K. Yoshida, I. Yamane, H. Yamashita, T. Inoue, S. Tanaka, H. Nagai, M. Honda, K. Kobayashi et al., Nucl. Instrum. Meth. Phys. Res. B233 (1984) 211

1984IN03   M. Inoue and S.E. Koonin, Phys. Rev. C30 (1984) 175

1984KA1C   Kaipov and Kamalov, in Alma Ata (1984) 405

1984KL1A   J. Klein and R. Middleton, Nucl. Instrum. Meth. Phys. Res. B233 (1984) 129

1984KO1F   Kobayashi and Ikeda, in Panic (1984) M1

1984KO24   K. Koshigiri, H. Ohtsubo and M. Morita, Prog. Theor. Phys. 71 (1984) 1293

1984LOZZ   M.M. Lowry and R.T. Kouzes, Bull. Amer. Phys. Soc. 29 (1984) 629, AG6

1984MA1F   May et al., in Panic (1984) M3

1984MA1K   A. Mangini, M. Segl, G. Bonani, H.J. Hofmann, E. Morenzoni, M. Nessi, M. Suter, W. Wolfli and K.K. Turekian, Nucl. Instrum. Meth. Phys. Res. B233 (1984) 353

1984MAZT   F.B. Malik and Q. Haider, Bull. Amer. Phys. Soc. 29 (1984) 1047, DB1

1984ME11   C.R. Meitzler, A.E. Khalil, A.B. Robbins and G.M. Temmer, Phys. Rev. C30 (1984) 1105

1984MI1C   Millener, Gal, Dover and Dalitz, in Panic (1984) M7

1984MI1D   R. Middleton, J. Klein, L. Brown and F. Tera, Nucl. Instrum. Meth. Phys. Res. B233 (1984) 511

1984MI1E   D.J. Millener, AIP Conf. Proc. 123 (1984) 850

1984MIZM   I.A. Mitropolsky and E.F. Khefter, in Alma Ata (1984) 241

1984NA07   J. Napolitano and S.J. Freedman, Nucl. Phys. A417 (1984) 289

1984NE1C   D.E. Nelson, J.R. Southon, J.S. Vogel, R.G. Korteling and T.L. Ku, Nucl. Instrum. Meth. Phys. Res. B233 (1984) 139

1984NE1D   G. Newkirk, Jr., Nucl. Instrum. Meth. Phys. Res. B233 (1984) 404

1984NE1E   M. Nessi, E. Morenzoni, M. Suter, G. Bonani, H.J. Hofmann, C. Stoller and W. Wolfli, Nucl. Instrum. Meth. Phys. Res. B233 (1984) 238

1984NI12   H. Nishioka, J. Phys. (London) G10 (1984) 1713

1984PA1E   G. Paic, B. Antolkovic and K. Kadija, Fizika 16 (1984) 37

1984PO11   D.N. Poenaru and M. Ivascu, J. Phys. (Paris) 45 (1984) 1099

1984PO1C   G. Possnert, Nucl. Instrum. Meth. Phys. Res. B233 (1984) 159

1984RA1D   G.M. Raisbeck, F. Yiou, D. Bourles, J. Lestringuez and D. Deboffle, Nucl. Instrum. Meth. Phys. Res. B233 (1984) 175

1984RE14   S.M. Read and V.E. Viola, Jr., At. Data Nucl. Data Tables 31 (1984) 359

1984SA1D   R. Sarafin, G. Bonani, U. Herpers, P. Signer, H. Hofmann, M. Nessi, E. Morenzoni, M. Suter, R. Wieler and W. Wolfli, Nucl. Instrum. Meth. Phys. Res. B233 (1984) 411

1984SA37   M. Sakai, At. Data Nucl. Data Tables 31 (1984) 399

1984SE1B   M. Segl, A. Mangini, G. Bonani, H.J. Hofmann, M. Nessi, M. Suter, W. Wolfli, G. Friedrich, W.L. Pluger, A. Wiechowski et al., Nature 309 (1984) 540

1984SE1D   M. Segl, A. Magini, G. Bonani, H.J. Hofmann, E. Morenzoni, M. Nessi, M. Suter and W. Wolfli, Nucl. Instrum. Meth. Phys. Res. B233 (1984) 359

1984SH1J   M. Shoeb and M.Z. Khan, J. Phys. (London) G10 (1984) 1047

1984SH1K   Sherif, in Panic (1984) I35

1984SH1L   P. Sharma and B.L.K. Somavajulu, Isot. Geosci. 2 (1984) 89

1984SH1P   K. Shibata and K. Ioki, JAERI-M-84-165 (1984)

1984SH1R   K. Shibata, JAERI-M-84-226 (1984)

1984SO1A   J.R. Southon, J.S. Vogel, G. Richards and D.E. Nelson, Nucl. Instrum. Meth. Phys. Res. 219 (1984) 435

1984SO1B   B.L.K. Somayajulu, P. Sharma, J. Beer, G. Bonani, H.-J. Hofmann, E. Morenzoni, M. Nessi, M. Suter and W. Wolfli, Nucl. Instrum. Meth. Phys. Res. B233 (1984) 398

1984SP1B   R.J. Sparks, G. Wallace, C.M. Bartle, G.E. Coote, R.G. Ditchburn, D.C. Lowe, W.J. McCabe and K.P. Pohl, Nucl. Instrum. Meth. Phys. Res. B233 (1984) 155

1984ST1B   R.G. Stokstad, Comments on Nucl. Part. Phys. 13 (1984) 231

1984SU1B   Suter et al., Bull. Amer. Phys. Soc. 29 (1984) 1115

1984TE1A   Teh et al., Bull. Amer. Phys. Soc. 29 (1984) 1502

1984TR03   R.P. Trelle, J. Birkhauser, F. Hinterberger, S. Kuhn, D. Prasuhn and P. von Rossen, Phys. Lett. B134 (1984) 34

1984TR1C   J.W. Truran, Ann. Rev. Nucl. Part. Sci. 34 (1984) 53

1984TU02   M. Turk and B. Antolkovic, Nucl. Phys. A431 (1984) 381

1984TU1A   C. Tuniz, D.K. Pal, R.K. Moniot, W. Savin, T. Kruse and G.F. Herzog, Nuovo Cim. A81 (1984) 201

1984TU1C   C. Tuniz, R.K. Moniot, W. Savin, S. Vajda, T.H. Kruse, D.K. Pal, G.F. Herzog and M.J. Carr, Nucl. Instrum. Meth. Phys. Res. B233 (1984) 321

1984VA06   A.G.M. van Hees and P.W.M. Glaudemans, Z. Phys. A315 (1984) 223

1984VA07   O.I. Vasileva, V.M. Lebedev, A.V. Spassky, I.B. Teplov and L.N. Fateeva, Izv. Akad. Nauk. SSSR Ser. Fiz. 48 (1984) 155; Bull. Acad. Sci. USSR Phys. Ser. 48 (984) 157

1984VA1D   K. van der Borg, C. Alderliesten, H. Haitjema, G. Hut and N.A. van Zwol, Nucl. Instrum. Meth. Phys. Res. B233 (1984) 150

1984WA21 J.W. Watson, P.J. Pella, M. Ahmad, B.S. Flanders, N.S. Chant, P.G. Roos, D.W. Devins and D.L. Friesel, J. Phys. (Paris) 45 (1984) 91

1984YA1A J. Yang, M.S. Turner, G. Steigman, D.N. Schramm and K.A. Olive, Astrophys. J. 281 (1984) 493

1984ZH1B F. Zhuang, H.-Z. Chen and X.-N. Jin, Phys. Energ. Fortis Phys. Nucl. 8 (1984) 215

1984ZU01 R.Ya. Zulkarneev and R.Kh. Kutuev, Yad. Fiz. 39 (1984) 785; Sov. J. Nucl. Phys. 39 (1984) 495

1984ZW1A Zwarts, Unpublished Ph.D. Thesis, Utrecht Univ. (1984)

1985AH1A I. Ahmad, M. Mian and M.Z. Rahman Khan, Phys. Rev. C31 (1985) 1590

1985AJ01 F. Ajzenberg-Selove, Nucl. Phys. A433 (1985) 1; Erratum Nucl. Phys. A449 (1986) 155.

1985AL1G Aleksandrov et al., Questions in At. Phys. and in Tech., USSR (1985) 3

1985AN28 M.S. Antony, J. Britz, J.B. Bueb and A. Pape, At. Data Nucl. Data Tables 33 (1985) 447

1985BA1T Barnes, Lecture Notes in Phys. 219 (1985) 70

1985BE13 R.B. Begzhanov, E.A. Romanovsky, Yu.I. Denisov, A.M. Mukhamedzhanov, I.R. Gulamov, T. Iskhakov, G.K. Ni, R. Yarmukhamedov, G.S. Valiev and V.A. Stepanenko, Izv. Akad. Nauk. SSSR Ser. Fiz. 49 (1985) 111; Bull. Acad. Sci. USSR Phys. Ser. 49 (1985) 117

1985BE1A M. Beckerman, Phys. Rept. 129 (1985) 145

1985BE1D J. Beer, H. Oeschger, R.C. Finkel, G.C. Castagnoli, G. Bonino, M.R. Attolini and M. Galli, Nucl. Instrum. Meth. Phys. Res. B10-11 (1985) 415

1985BE1K A.M. Bernstein, AIP Conf. Proc. 133 (1985) 271

1985BE30 S.L. Belostotsky, S.S. Volkov, A.A. Vorobyev, Yu.V. Dotsenko, L.G. Kudin, N.P. Kuropatkin, O.V. Miklukho, V.N. Nikulin and O.E. Prokofyev, Yad. Fiz. 41 (1985) 1425; Sov. J. Nucl. Phys. 41 (1985) 903

1985BO1D Body and Mihaly, INDC (HUN)-22/L (1985)

1985CA41 G.R. Caughlan, W. A. Fowler, M.J. Harris and B.A. Zimmerman, At. Data Nucl. Data Tables 32 (1985) 197

1985CU1A B. Cujec, Lecture Notes in Phys. 219 (1985) 108

1985DE17 E. Descroix, M. Bedjidian, J.Y. Grossiord, A. Guichard, M. Gusakow, M. Jacquin, J.R. Pizzi and G. Bagieu, Nucl. Phys. A438 (1985) 112

1985DE19 A.S. Deineko, C. Hategan and N.A. Shliakhov, Rev. Roum. Phys. 30 (1985) 103

1985DEZY J. Derderian, R.E. Chrien, M. May, P. Pile, R. Sutter, P. Barnes, R. Eisenstein, G. Franklin, R. Grace, D. Marlow et al., Bull. Amer. Phys. Soc. 30 (1985) 793, IF2

1985DO16   Yu.V. Dotsenko and V.E. Starodubsky, Yad. Fiz. 42 (1985) 107; Sov. J. Nucl. Phys. 42 (1985) 66.

1985DY03   R. Dymarz, Phys. Lett. B155 (1985) 5

1985FR07   J. Franz, E. Rossle, C. Sauerwein, H. Schmitt, H.L. Woolverton, J. Ero, Z. Fodor, J. Kecskemeti, P. Koncz, Zs. Kovacs et al., Phys. Lett. B153 (1985) 382

1985GLZZ   C.W. Glover, E.E. Gross, A.W. Carpenter, J.A. Carr, R.J. Philpott, F. Petrovich, P. Schwandt, W.W. Jacobs and H.O. Meyer, Bull. Amer. Phys. Soc. 30 (1985) 701, AE9

1985GO1A   N.G. Goncharova, H.-R. Kissener and R.A. Eramzhyan, Fiz. Elem. Chastits At. Yadra 16 (985) 773; Sov. J. Part. Nucl. 16 (1985) 337

1985GU1C   Gulyamov et al., in Leningrad (1985) 291

1985GU1J   K.K. Gudima and V.D. Toneev, Yad. Fiz. 42 (1985) 645; Sov. J. Nucl. Phys. 42 (1985) 409

1985GUZQ   M.G. Gulyamov, M.A. Kayumov, K. Khamidova, F. Kadirov and M.Yu. Tashmetov, in Leningrad (1985) 321

1985HA18   S.S. Hanna and J.W. Hugg, Hyperfine Interactions 21 (1985) 59

1985HA1J   H.J. Hauser, T. Rohwer, F. Hoyler, G. Staudt, S. Abd el-Kariem, P. Grasshoff, H.V. Klapdor, A. Korber, W. Leitner, V. Rapp et al., AIP Conf. Proc. 125 (1985) 701

1985HU04   M.S. Hussein, B.V. Carlson, O. Civitarese and A. Szanto De Toledo, Phys. Rev. Lett. 54 (1985) 2659

1985IK1A   K. Ikeda, H. Bando and T. Motoba, Prog. Theor. Phys. Suppl. 81 (1985) 147

1985IM1A   N. Imanishi, T. Furuya, I. Fujiwara, A. Shinohara, H. Kaji and S. Iwata, Phys. Rev. A32 (1985) 2584

1985JA09   L. Jarczyk, B. Kamys, A. Magiera, A. Strzalkowski, A. Szczurek, K. Bodek, M. Hugi, J. Lang, R. Muller and E. Ungricht, J. Phys. (London) G11 (1985) 843

1985JA12   L. Jarczyk, B. Kamys, Z. Rudy, A. Strzalkowski, B. Styczen, G.P.A. Berg, A. Magiera, J. Meissburger, W. Oelert, P. von Rossen et al., Z. Phys. A322 (1985) 221

1985JA18   B.V. Jacak, D. Fox and G.D. Westfall, Phys. Rev. C31 (1985) 704

1985KAZQ   S.G. Kadmenskii, S.D. Kurgalin and Yu.M. Chuvilskii, in Leningrad (1985) 438

1985KI1B   A.Z. Kiss, E. Koltay, B. Nyako, E. Somorjai, A. Anttila and J. Raisanen, AIP Conf. Proc. 125 (1985) 851

1985KO04   D. Konnerth, W. Trombik, K.G. Bernhardt, K.A. Eberhard, R. Singh, A. Strzalkowski and W. Trautmann, Nucl. Phys. A436 (1985) 538

1985KO1J   Koonin, Lecture Notes in Phys. 219 (1985) 129

1985KO47   P.J.J. Kok, K. Abrahams, H. Postma and W.J. Huiskamp, Nucl. Instrum. Meth. Phys. Res. B12 (1985) 325

1985KW02 E. Kwasniewicz and L. Jarczyk, Nucl. Phys. A441 (1985) 77

1985LI1B   Lindstrom et al., Bull. Amer. Phys. Soc. 30 (1985) 747

1985LI1E   Y.-G. Li and W.-X. Ma, Phys. Energ. Fortis Phys. Nucl. 9 (1985) 291

1985MA10 J.F. Mateja, A.D. Frawley, D.G. Kovar, D. Henderson, H. Ikezoe, R.V.F. Janssens, G. Rosner, G.S.F. Stephans, B. Wilkins, K.T. Lesko et al., Phys. Rev. C31 (1985) 867

1985MA13 M.T. Magda, A. Pop and A. Sandulescu, J. Phys. (London) G11 (1985) L75

1985MAZG B.S. Mazitov and E.N. Rasulov, in Leningrad (1985) 298

1985MI1D J. Missimer and L.M. Simons, Phys. Rept. 118 (1985) 179

1985MO08 M. Morjean, J.L. Charvet, J.L. Uzureau, Y. Patin, A. Peghaire, Y. Pranal, L. Sinopoli, A. Billerey, A. Chevarier, N. Chevarier et al., Nucl. Phys. A438 (1985) 547

1985MU03 S.F. Mughabghab, Phys. Rev. Lett. 54 (1985) 986

1985NE05   J.E. Nelson, J. Napolitano and S.J. Freedman, Phys. Rev. C31 (1985) 2295

1985NE1C   Nemachkalo et al., in Leningrad (1985) 370

1985PE06   S.T. Perkins, E.F. Plechaty and R.J. Howerton, Nucl. Sci. Eng. 90 (1985) 83

1985PO02   L. Potvin and B. Cujec, Nucl. Phys. A433 (1985) 550

1985PO10   N.A.F.M. Poppelier, L.D. Wood and P.W.M. Glaudemans, Phys. Lett. B157 (1985) 120

1985PO11   D.N. Poenaru, M. Ivascu, A. Sandulescu and W. Greiner, Phys. Rev. C32 (1985) 572

1985RA1A   G.M. Raisbeck, F. Yiou, D. Bourles and D.V. Kent, Nature 315 (1985) 315

1985RO15   G. Roy, H.S. Sherif, E.D. Cooper, L.G. Greeniaus, G.A. Moss, J. Soukup, G.M. Stinson, R. Abegg, D.P. Gurd, D.A. Hutcheon et al., Nucl. Phys. A442 (1985) 686

1985RO17   F. Roig and J. Navarro, Nucl. Phys. A440 (1985) 659

1985RO1C   Roche et al., Bull. Amer. Phys. Soc. 30 (1985) 1284

1985SA1G   Y. Sakai, Mem. Fac. Sci. Kyoto Univ. Ser. Phys. Astrophys. Geophys. Chem. 36 (1985) 401

1985SA32   H. Sato and Y. Okuhara, Phys. Lett. B162 (1985) 217

1985SC08   H.R. Schelin, E. Farrelly Pessoa, W.R. Wylie, J.L. Cardoso, Jr. and R.A. Douglas, Nucl. Sci. Eng. 89 (1985) 87

1985SE15   R.E. Segel, S.M. Levenson, P. Zupranski, A.A. Hassan, S. Mukhopadhyay and J.V. Maher, Phys. Rev. C32 (1985) 721

1985SH1D   Shvedov and Nemets, in Leningrad (1985) 317

1985SM08   D.L. Smith, J.W. Meadows and P.T. Guenther, Nucl. Instrum. Meth. Phys. Res. A241 (1985) 507

1985TA18   I. Tanihata, H. Hamagaki, O. Hashimoto, Y. Shida, N. Yoshikawa, K. Sugimoto, O. Yamakawa, T. Kobayashi and N. Takahashi, Phys. Rev. Lett. 55 (1985) 2676

1985TE01   J.A. Templon, J.H. Dave, C.R. Gould and S. Singkarat, Nucl. Sci. Eng. 91 (1985) 451

1985TE1C   Ter-Akopian et al., in Dubna P15-85-775 (1985)

1985TR1A   Trentalange et al., Bull. Amer. Phys. Soc. 30 (1985) 727

1985TR1B   Trockel et al., in Visby (1985) 148

1985TU1B   W. Turchinetz, Nucl. Phys. A446 (1985) 23

1985WA02   A.H. Wapstra and G. Audi, Nucl. Phys. A432 (1985) 1

1985WA13   C.W. Wang, P.G. Roos, N.S. Chant, G. Ciangaru, F. Khazaie, D.J. Mack, A. Nadasen, S.J. Mills, R.E. Warner, E. Norbeck et al., Phys. Rev. C31 (1985) 1662

1985WA1K   T.P. Walker, G.J. Mathews and V.E. Viola, Astrophys. J. 299 (1985) 745

1985WE1A   Wefel, Guzik, Garcia-Munoz and Simpson, Bull. Amer. Phys. Soc. 30 (1985) 764

1985WI18   J.S. Winfield, N.A. Jelley, W.D.M. Rae and C.L. Woods, Nucl. Phys. A437 (1985) 65

1985WI1B   D. Wilkinson, Nucl. Phys. A434 (1985) 573

1985YI1A   Yiou et al., Nature 316 (1985) 616

1985ZI04   W. Ziegler, E.G. Auld, W.R. Falk, G.L. Giles, G. Jones, G.J. Lolos, B.J. McParland, P.L. Walden and D.F. Ottewell, Phys. Rev. C32 (1985) 301

1985ZI05   W. Zickendraht, Ann. Phys. 42 (1985) 113

1986AB10   S.N. Abramovich, B.Ya. Guzhovsky, A.V. Ershov and L.M. Lazarev, Izv. Akad. Nauk SSSR Ser. Fiz. 50 (1986) 2021; Bull. Acad. Sci. USSR Phys. Ser. 50 (1986) 148

1986AJ01   F. Ajzenberg-Selove, Nucl. Phys. A449 (1986) 1

1986AL1J   Allab, in Santa Fe (1985) 825

1986AN1F   B. Andersson, S. Garpman, G. Gustafson, H.-A. Gustafsson, B. Nilsson-Almqvist, I. Otterlund and E. Stenlund, Phys. Scripta 34 (1986) 451

1986AN1R   H.H. Ansari, M. Shoeb and M.Z.R. Rahman Khan, J. Phys. (London) G12 (1986) 1369

1986AR04   K.P. Artemov, M.S. Golovkov, V.Z. Goldberg, I.P. Petrov, V.P. Rudakov, I.N. Serikov and V.A. Timofeev, Yad. Fiz. 43 (1986) 529; Sov. J. Nucl. Phys. 43 (1986) 335

1986AV01   G.V. Avakov, L.D. Blokhintsev, A.M. Mukhamedzhanov and R. Yarmukhamedov, Yad. Fiz. 43 (1986) 824; Sov. J. Nucl. Phys. 43 (1986) 524

1986AV1A   V.V. Avdeichikov, A.I. Bogdanov, V.A. Budilov, N.K. Zhidkov, N.L. Gorshkova, A. Kotus, Yu.A. Murin, V.A. Nikitin, P.V. Nomokonov and M.D. Traikova, Yad. Fiz. 44 (1986) 440; Sov. J. Nucl. Phys. 44 (1986) 282

1986AV1B   Avdeichikov, in Dubna (1986) 122

1986BA1W H. Bando, Nucl. Phys. A450 (1986) 217c

1986BA1X Barker, 11th Ainse Nucl. Phys. Conf., Melbourne, Australia (1986) 89

1986BA40 F.M. Baumann, G. Domogala, H. Freiesleben, H.J. Paul, S. Puhlvers and H. Sohlbach, Nucl. Instrum. Meth. Phys. Res. A247 (1986) 359

1986BA69 D. Baye, Nucl. Phys. A460 (1986) 581

1986BA88 W. Bauhoff, At. Data Nucl. Data Tables 35 (1986) 429

1986BE1P Bernstein, Private Communication (1986)

1986BO1E A.R. Bodmer and Q.N. Usmani, Nucl. Phys. A450 (1986) 257c

1986CA1L Carnoy, Deutsch, Girard and Prieels, Proc. Int. Symp., Heidelberg, Germany (1986) 534

1986CA30 L. Carlen, H.-A. Gustafsson, B. Jakobsson, A. Kristiansson, A. Oskarsson, H. Ryde, M. Westenius, J.P. Bondorf, O.-B. Nielsen, G. Lovhoiden et al., Phys. Scr. 34 (1986) 475

1986CAZT D.D.P. Casavant and L.D. Knutson, Bull. Amer. Phys. Soc. 31 (1986) 1224, DB2

1986CH1P R.E. Chrien, Czech. J. Phys. B36 (1986) 410

1986CO14 C.M. Conneely, W.V. Prestwich and T.J. Kennett, Nucl. Instrum. Meth. Phys. Res. A248 (1986) 416

1986CR1A Crawford et al., Bull. Amer. Phys. Soc. 31 (1986) 888

1986CS1A L.P. Csernai and J.I. Kapusta, Phys. Rept. 131 (1986) 223

1986CU02 B. Cujec, B. Dasmahapatra, Q. Haider, F. Lahlou and R.A. Dayras, Nucl. Phys. A453 (1986) 505

1986DA1B D.H. Davis and J. Pniewski, Contemp. Phys. 27 (1986) 91

1986DE25 F.W.N. De Boer, K. Abrahams, A. Balanda, H. Bokemeyer, R. van Dantzig, J.F.W. Jansen, B. Kotlinski, M.J.A. De Voigt and J. van Klinken, Phys. Lett. B180 (1986) 4

1986DO12 P. Doll, G. Fink, F.P. Brady, R. Garrett, H.O. Klages and H. Krupp, Nucl. Instrum. Meth. Phys. Res. A250 (1986) 526

1986DO1E Dolbilskii et al., in Kharkov (1986) 352

1986DU1G Du and Zhang, Proc. 4th Int. Symp., Smolenice, Czechoslovakia, 1985 (1986) 108

1986EN1A Engelmann and Bardy, Rept. CEA-R-5340 (1986)

1986ER1B Ergakov et al., Czech. J. Phys. 36 (1986) 985

1986FRZZ M.B. Frodyma, B. Debebe, J. Dubach, R.S. Hicks, R.L. Huffman, G.A. Peterson, R.P. Singhal and A. Hotta, Bull. Amer. Phys. Soc. 31 (1986) 877, JJ13

1986GA1F M. Gazdzicki, K. Iovchev, E. Kladnitskaya, E. Okonov and E.Z. Skrzypczak, Z. Phys. C31 (1986) 549

1986GA1H A. Gal, AIP Conf. Proc. 150 (19860 127

1986GI10 A. Gillibert, L. Bianchi, A. Cunsolo, B. Fernandez, A. Foti, J. Gastebois, Ch. Gregoire, W. Mittig, A. Peghaire, Y. Schutz et al., Phys. Lett. B176 (1986) 317

1986GL1A Glaudemans, AIP Conf. Proc. 142 (1986) 316

1986GLZV Yu.A. Glukhov, E.I. Koshchy, Yu.G. Mashkarov, E.Yu. Nikolsky, A.T. Rudchik,S.B. Sakuta and K.F. Ustimenkov, in Kharkov (1986) 370

1986GO1L Gould et al., in Santa Fe 85 (1986) 139

1986GO28 N.F. Golovanova and V.V. Kurovsky, Izv. Akad. Nauk SSSR Ser. Fiz. 50 (1986) 963; Bull. Acad. Sci. USSR Phys. Ser. 50 (1986) 131

1986GU1G Gurev and Zolewnko, in Harrogate (1986) C260

1986HA1B B.G. Harvey, J. Phys. Colloq. (Paris) 47 (1986) C4-29

1986HA1K Y. Haneishi and T. Fujita, Phys. Rev. C33 (1986) 260

1986HA1M Han, Jeong, Park and Cheon, New Phys. 26 (1986) 16

1986HO23 B. Hoistad, M. Barlett, G.S. Adams, M. Gazzaly, B. Aas, G. Pauletta, F. Irom, K. Jones and J.A. McGill, Phys. Lett. B177 (1986) 299

1986IS04 Y. Iseri and M. Kawai, Phys. Rev. C34 (1986) 38

1986KO1R Korteling et al., Int. Conf. on Nucl. Radiochem., 1-5 Sept. 1986, Beijing, China (1986) 37

1986MA19 J.F. Mateja, A.D. Frawley, L.C. Dennis and K. Sartor, Phys. Rev. C33 (1986) 1649

1986MA1C L. Majling, J. Zofka, V.N. Fetisov and R.A. Eramzhyan, Nucl. Phys. A450 (1986) 189c

1986MA1W M. May, Nucl. Phys. A450 (1986) 179c

1986ME06 M.C. Mermaz, T. Suomijarvi, R. Lucas, B. Berthier, J. Matuszek, J.P. Coffin, G. Guillaume, B. Heusch, F. Jundt and F. Rami, Nucl. Phys. A456 (1986) 186

1986MEZZ M. Meier, D. Holtkamp, G. Morgan, H. Robinson, G. Russell, R. Whitaker, W. Amian and N. Paul, Bull. Amer. Phys. Soc. 31 (1986) 1111

1986MO13 D.J. Morrissey, C. Bloch, W. Benenson, E. Kashy, R.A. Blue, R.M. Ronningen and R. Aryaeinejad, Phys. Rev. C34 (1986) 761

1986MOZV D.J. Morrissey, C. Bloch, W. Benenson and E. Kashy, Bull. Amer. Phys. Soc. 31 (1986) 840

1986MU07 K. Murphy, R.C. Byrd, C.E. Floyd, P.P. Guss and R.L. Walter, Nucl. Phys. A455 (1986) 525

1986MU08 K. Murphy, R.C. Byrd, C.R. Howell and R.L. Walter, Radiat. Eff. 92 (1986) 219

1986MU1B Mughabghab, Phys. Rev. Lett. 56 (1986) 399

1986NA15 K. Nakayama and G. Bertsch, Phys. Rev. C34 (1986) 2190

1986NI1A Nishizumi et al., Nature 319 (1986) 134

1986OV1A Overley, Bull. Amer. Phys. Soc. 31 (1986) 1309

1986PE05 J.P. Perroud, A. Perrenoud, J.C. Alder, B. Gabioud, C. Joseph, J.F. Loude, N. Morel, M.T. Tran, E. Winkelmann, H. Von Fellenberg et al., Nucl. Phys. A453 (1986) 542

1986PO06 D.N. Poenaru, W. Greiner, K. Depta, M. Ivascu, D. Mazilu and A. Sandulescu, At. Data Nucl. Data Tables 34 (1986) 423

1986PO1H B. Povh, Nucl. Phys. A450 (1986) 573c

1986RA16 G. Ramachandran and V. Ravishankar, J. Phys. G12 (1986) 1221

1986RA1B Raman and Lynn, Phys. Rev. Lett. 56 (1986) 398

1986RO03 R. Rockmore and B. Saghai, Phys. Rev. C33 (1986) 576

1986RO12 G. Royer, J. Phys. (London) G12 (1986) 623

1986SA30 H. Sato and Y. Okuhara, Phys. Rev. C34 (1986) 2171

1986SAZR E.T. Sadowski, H.D. Knox, D.A. Resler and R.O. Lane, Bull. Amer. Phys. Soc. 31 (1986) 1209

1986SH1F W.Q. Shen, S.Z. Yin, Z.Y. Guo, W.L. Zhan, Y.T. Zhu, G.M. Jin, W.M. Qiao, E.C. Wu and C.L. Jiang, Chin. Phys. 6 (1986) 80

1986SH1M Shardanov and Yurev, Vestn. Mosk. Univ. Ser. 3 (1986) 66

1986SIZS P.J. Simmonds, N.M. Clarke, K.I. Pearce, R.J. Griffiths, C.A. Ogilvie and M. Mannion, in Harrogate (1986) 315

1986SO10 L.G. Sobotka, D.G. Sarantites, H. Puchta, F.A. Dilmanian, M. Jaaskelainen, M.L. Halbert, J.H. Barker, J.R. Beene, R.L. Ferguson, D.C. Hensley et al., Phys. Rev. C34 (1986) 917

1986ST1E E. Steffens, J. Phys. Soc. Jpn. Suppl. 55 (1986) 459

1986SU1H Suter, Bull. Amer. Phys. Soc. 31 (1986) 1267

1986TE1A G.M. Ter-Akopian, Pham Ngoc Chuong, N.V. Yeremin, V.F. Strizhov, A.P. Kabachenko and L.P. Chelnokov, Nucl. Instrum. Meth. Phys. Res. B17 (1986) 393, and Private Communication (1986)

1986UT01 H. Utsunomiya, E.C. Deci, R.A. Blue, L.H. Harwood, R.M. Ronningen, K. Siwek-Wilczynska, J. Wilczynski and D.J. Morrissey, Phys. Rev. C33 (1986) 185

1986VDZY A.I. Vdovin, I.G. Golikov, A.V. Golovin, M.H. Zhukov, I.I. Loshchakov and V.I. Ostroumov, in Kharkov (1986) 290

1986WA1J X.-C. Wang, H. Takaki and H. Bando, Prog. Theor. Phys. 76 (1986) 865

1986WE1E Wei et al., Bull. Amer. Phys. Soc. 31 (1986) 1294

1986WI04 D.H. Wilkinson, Nucl. Phys. A452 (1986) 296

1986XU02 H.M. Xu, D.J. Fields, W.G. Lynch, M.B. Tsang, C.K. Gelbke, M.R. Maier, D.J. Morrissey, J. Pochodzalla, D.G. Sarantites, L.G. Sobotka et al., Phys. Lett. B182 (1986) 155

1986XU1B H.M. Xu and W.G. Lynch, Int. Conf. on Nucl. Radiochem., 1-5 Sept. 1986, Beijing, China (1986) 54

1986YA07 M. Yamazaki, K. Shoda, M. Torikoshi, O. Sasaki and H. Tsubota, Phys. Rev. C34 (1986) 1123

1986YA15 K. Yabana and H. Horiuchi, Prog. Theor. Phys. 76 (1986) 1071

1986YA1F Y. Yamamoto, Prog. Theor. Phys. 75 (1986) 639

1986ZH03 M.A. Zhusupov, O. Imambekov and Yu.N. Uzikov, Izv. Akad. Nauk SSSR Ser. Fiz. 50 (1986) 178; Bull. Acad. Sci. USSR Phys. Ser. 50 (1986) 172

1986ZH1B F. Zhuang and H.Z. Chen, Chin. J. Nucl. Phys. 8 (1986) 325

1987AB09 S.N. Abramovich, L.A. Morkin, V.I. Serov and Yu.V. Strelnikov, Izv. Akad. Nauk SSSR Ser. Fiz. 51 (1987) 930; Bull. Acad. Sci. USSR Phys. Ser. 51 (1987) 92

1987AB15 S.N. Abramovich, B.Ya. Guzhovsky, A.V. Ershov and L.M. Lazarev, Yad. Fiz. 46 (1987) 499; Sov. J. Nucl. Phys. 46 (1987) 269

1987AB1H Abramovich et al., in Yurmala (1987) 521

1987AH02 M.H. Ahsan, S.A. Siddiqui and H.H. Thies, Nucl. Phys. A469 (1987) 381

1987AK1A Akhverdyan et al., in Panic (1987) 708

1987ALZG D.V. Aleksandrov, Yu.A. Glukhov, E.Yu. Nikolsky, B.G. Novatsky, A.A. Ogloblin and D.N. Stepanov, in Yurmala (1987) 393

1987AR19 S.E. Arnell, S. Mattsson, H.A. Roth, M. Rydehell, O. Skeppstedt, A. Johnson, J. Nyberg, A. Kerek and A. Nilsson, Phys. Scr. 36 (1987) 214

1987AR1C Arnould, Phil. Trans. Roy. Soc. (London) 323 (1987) 251

1987AU1A J. Audouze, J. Astrophys. Astron. 8 (1987) 147

1987BA2J W.A. Bardeen, R.D. Peccei and T. Yanagida, Nucl. Phys. B279 (1987) 401

1987BA34 S. Barhoumi, M. Allab, H. Beaumevieille, A.C. Chami and Z. Meliani, Nucl. Instrum. Meth. Phys. Res. B24-25 (1987) 477

1987BA38 G.J. Balster, P.C.N. Crouzen, P.B. Goldhoorn, R.H. Siemssen and H.W. Wilschut, Nucl. Phys. A468 (1987) 93

1987BA39 G.J. Balster, H.W. Wilschut, R.H. Siemssen, P.C.N. Crouzen, P.B. Goldhoorn and Z. Sujkowski, Nucl. Phys. A468 (1987) 131

1987BE1X Beer et al., Nucl. Instrum. Meth. Phys. Res. B29 (1987) 203

1987BEYI A.V. Belozyorov, C. Borcea, Z. Dlouhy, A.M. Kalinin, N.H. Chau and Yu.E. Penionzhkevich, JINR-E15-87-733 (1987)

1987BI1C   Bimbot et al., in Panic (1987) 370

1987BL18   R. Blumel and K. Dietrich, Nucl. Phys. A471 (1987) 453

1987BO1L   A.R. Bodmer and Q.N. Usmani, Nucl. Phys. A463 (1987) 221c

1987BO1O   A.R. Bodmer and Q.N. Usmani, Nucl. Phys. A468 (1987) 653

1987BR1Q   Brown, Phil. Trans. Roy. Soc. (Lodon) A323 (1987) 75

1987BR1U   Brown et al., Nucl. Instrum. Meth. Phys. Res. B29 (1987) 232

1987BU07   M. Burgel, H. Fuchs, H. Homeyer, G. Ingold, U. Jahnke and G. Thoma, Phys. Rev. C36 (1987) 90

1987BU27   N.T. Burtebaev, A.D. Duisebaev, V.S. Sadkovskii and G.A. Feofilov, Izv. Akad. Nauk SSSR Ser. Fiz. 51 (1987) 615; Bull. Acad. Sci. USSR Phys. Ser. 51 (1987) 191

1987CH26   Z. Chen, C.K. Gelbke, J. Pochodzalla, C.B. Chitwood, D.J. Fields, W.G. Gong, W.G. Lynch and M.B. Tsang, Nucl. Phys. A473 (1987) 564

1987CO16   J. Cook, M.N. Stephens and K.W. Kemper, Nucl. Phys. A466 (1987) 168

1987DE1P   de Boer et al., Nucl. Instrum. Meth. Phys. Res. B29 (1987) 322

1987DE37   F. Deak, A. Kiss, Z. Seres, G. Caskey, A. Galonsky and B. Remington, Nucl. Instrum. Meth. Phys. Res. A258 (1987) 67

1987DE43   H. De Vries, C.W. De Jager and C. De Vries, At. Data Nucl. Data Tables 36 (1987) 495

1987EI1A   Eisenhauer et al., Nucl. Instrum. Meth, Phys. Res. B29 (1987) 326

1987EL1E   Elmore et al., Nucl. Instrum. Meth. Phys. Res. B29 (1987) 207

1987FE1A   E.-P. Feng, Q. Wang, Y.-T. Zhu, X. Yin, H.-B. Miao, S.-M. Sun, S.-L. Li, Z.-L. Wu, G.-Y. Fan, Y.-X. Xie et al., Chin. Phys. 7 (1987) 121

1987FL1A   Flerov, in Dubna (1987) 9

1987FR16   J. Franz, E. Rossle, C. Sauerwein, H. Schmitt, H.L. Woolverton, J. Ero, Z. Fodor, J. Kecskemeti, P. Koncz, Zs. Kovacs et al., Nucl. Phys. A472 (1987) 733

1987GA08   E. Gadioli and E. Gadioli Erba, Z. Phys. A327 (1987) 81

1987GA20   A.K. Ganguly, B. Chaudhuri and B.B. Baliga, Nuovo Cim. A97 (1987) 639

1987GE1B   C.-K. Gelbke and D.H. Boal, Prog. Part. Nucl. Phys. 19 (1987) 33

1987GIZZ   R.A. Giannelli, J.R. Comfort, J.A. McGill, C. Glashausser, C.L. Morris, L.C. Bland, P.A. Seidl, A. Boudard, B. Bonin, B. Silverman et al., Bull. Amer. Phys. Soc. 32 (1987) 1120, KF3

1987GL06   H. Glattli, J. Coustham, A. Malinovski and M. Pinot, Z. Phys. A327 (1987) 149

1987GO1W   Gove, Litherland and Purser, Nucl. Instrum. Meth. Phys. Res. B29 (1987) 437

1987GR11   R.E.L. Green, R.G. Korteling, J.M. D'Auria, K.P. Jackson and R.L. Helmer, Phys. Rev. C35 (1987) 1341

1987GR1Q   Graf et al., Nucl. Instrum. Meth. Phys. Res. B29 (1987) 262

1987GU04   R.K. Gupta, S. Gulati, S.S. Malik and R. Sultana, J. Phys. G13 (1987) L27

1987GUZZ   I.R. Gulamov, T. Iskhakov, A.M. Mukhamedzhanov, Sh. Kayumov, A.A. Karakhodzhaev, G.K. Ni, E.A. Romanovsky and G.S. Valiev, in Yurmala (1987) 344

1987HA1O   Hallin et al., Nucl. Instrum. Meth. Phys. Res. B24-25 (1987) 276

1987HA1R   Hansen, Nature 328 (1987) 476

1987HA30   P.G. Hansen and B. Jonson, Europhys. Lett. 4 (1987) 409

1987HAZS   L.F. Hansen, F.S. Dietrich and R.L. Walter, Bull. Amer. Phys. Soc. 32 (1987) 1567, DB8

1987HE1H   T.K. Hemmick, D. Elmore, P.W. Kubik, S.L. Olsen, T. Gentile, D. Nitz, D. Ciampa, H. Kagan, P. Haas, P.F. Smith et al., Nucl. Instrum. Meth. Phys. Res. B29 (1987) 389

1987HI05   D. Hilscher, H. Rossner, A. Gamp, U. Jahnke, B. Cheynis, B. Chambon, D. Drain, C. Pastor, A. Giorni, C. Morand et al., Phys. Rev. C36 (1987) 208

1987HI1F   Hicks et al., in Panic (1987) 632

1987HO1P   Hofmann et al., Nucl. Instrum. Meth. Phys. Res. B29 (1987) 32

1987HU13   J.R. Hurd, J.S. Boswell, R.C. Minehart, Y. Tzeng, H.J. Ziock, K.O.H. Ziock, L.C. Liu and E.R. Siciliano, Nucl. Phys. A475 (1987) 743

1987IN1A   K.G.W. Inn, S. Raman, B.M. Coursey, J.D. Fassett and R.L. Walker, Nucl. Instrum. Meth. Phys. Res. B29 (1987) 27

1987JA06   B.V. Jacak, G.D. Westfall, G.M. Crawley, D. Fox, C.K. Gelbke, L.H. Harwood, B.E. Hasselquist, W.G. Lynch, D.K. Scott, H. Stocker et al., Phys. Rev. C35 (1987) 1751

1987JA1G   Jansen et al., Nucl. Instrum. Meth. Phys. Res. B29 (1987) 311

1987KA25   K. Kadija, G. Paic, D. Vranic, A. Berdoz, F. Foroughi, Ch. Nussbaum, H.H. Muller, P. Schober and St. Steiner, Nucl. Phys. A469 (1987) 183

1987KAZL   F. Kadirov, M.A. Kayumov, Sh. Kayumov, A.M. Mukhamedzhanov, U.I. Faizullaev, K. Khamidova and R. Yarmukhamedov, in Yurmala (1987) 343

1987KI05   A. Kiss, F. Deak, Z. Seres, G. Caskey, A. Galonsky, L. Heilbronn, B.A. Remington and J. Kasagi, Phys. Lett. B184 (1987) 149

1987KI1C   H.R. Kissener, I. Rotter and N.G. Goncharova, Fortschr. Phys. 35 (1987) 277

1987KO15   T. Kozik, J. Buschmann, K. Grotowski, H.J. Gils, N. Heide, J. Kiener, H. Klewe-Nebenius, H. Rebel, S. Zagromski, A.J. Cole et al., Z. Phys. A326 (1987) 421

1987KO1Y   Kobayashi et al., in Panic (1987) 476

1987KU1L   M. Kusakabe, T.L. Ku, J.R. Southon, J.S. Vogel, D.E. Nelson, C.I. Measures and Y. Nozaki, Nucl. Instrum. Meth. Phys. Res. B29 (1987) 306

1987KU23   Y. Kuno, K. Nagamine and T. Yamazaki, Nucl. Phys. A475 (1987) 615

1987KW01   E. Kwasniewicz and J. Kisiel, J. Phys. (London) G13 (1987) 121

1987LA16   D. Lal, K. Nishiizumi, R.C. Reedy, M. Suter and W. Wolfli, Nucl. Phys. A468 (1987) 189; Erratum Nucl. Phys. A481 (1988) 834

1987LA1G   Lal et al., Nature 328 (1987) 139

1987LA1I   Lal, Nucl. Instrum. Meth. Phys. Res. B29 (1987) 238

1987LE1E   Leisi et al., Helv. Phys. Acta. 60 (1987) 316

1987LE33   F.S. Levin, Nucl. Phys. A463 (1987) 487c

1987LY01   J.E. Lynn, S. Kahane and S. Raman, Phys. Rev. C35 (1987) 26

1987LY04   W.G. Lynch, Nucl. Phys. A471 (1987) 309c

1987MI38   M. Mian, Phys. Rev. C35 (1987) 1463

1987MO04   A. Moalem, D. Frekers, S.A. Gurvitz, R. Abegg, C. Davis, K.P. Jackson, C.A. Miller, R.S. Henderson, S. Yen, R.L. Helmer et al., Phys. Lett. B183 (1987) 269

1987MO1F   Morinaga, Proc. Beijing Int. Symp. on Phys. at Tandem, 1986 (1987) 583

1987MU03   J.A. Muzycka and B.I. Pustylnik, Yad. Fiz. 45 (1987) 90; Sov. J. Nucl. Phys. 45 (1987) 57

1987MU13   D.E. Murnick, E.G. Myers, M.M. Lowry and F.P. Calaprice, Phys. Rev. Lett. 59 (1987) 1088

1987NA01   M.N. Namboodiri, R.K. Choudhury, L. Adler, J.D. Bronson, D. Fabris, U. Garg, P.L. Gonthier, K. Hagel, D.R. Haenni, Y.W. Lui et al., Phys. Rev. C35 (1987) 149

1987NA04   J. Navarro and F. Roig, Nucl. Phys. A465 (1987) 628

1987NA1M   Nagai et al., Nucl. Instrum. Meth. Phys. Res. B29 (1987) 266

1987OE1A   Oeschger, Beer and Andree, Phil. Trans. Roy. Soc. (London) A323 (1987) 45

1987PE1C   Penionshkevich, in Dubna (1987) 364

1987PO1H   B. Povh, Prog. Part. Nucl. Phys. 18 (1987) 183

1987PO23   J. Pochodzalla, Nucl. Phys. A471 (1987) 289c

1987RA01   S. Raman, C.H. Malarkey, W.T. Milner, C.W. Nestor, Jr. and P.H. Stelson, At. Data Nucl. Data Tables 36 (1987) 1

1987RA1D   R. Ramaty and R.J. Murphy, Space Sci. Rev. 45 (1987) 213

1987RA1N   Raisbeck et al., Nucl. Instrum. Meth. Phys. Res. B29 (1987) 22

1987RA36   M. Rahman, H.M. Sen Gupta, Md.A. Rahman and A.B. Siddique, Nuovo Cim. A98 (1987) 513

1987RE1H   Reedy, Nucl. Instrum. Meth. Phys. Res. B29 (1987) 251

1987RI03   J. Richert and P. Wagner, Nucl. Phys. A466 (1987) 132

1987RO10   G. Royer, Y. Raffray, A. Oubahadou and B. Remaud, Nucl. Phys. A466 (1987) 139

1987RO25   C. Rolfs, H.P. Trautvetter and W.S. Rodney, Rept. Prog. Phys. 50 (1987) 233

1987SA15   H. Sagawa and H. Toki, J. Phys. (London) G13 (1987) 453

1987SAZW K. Sartor, L.C. Dennis and X. Aslanoglou, Bull. Amer. Phys. Soc. 32 (1987) 1061

1987SAZX E.T. Sadowski, H.D. Knox, D.A. Resler and R.O. Lane, Bull. Amer. Phys. Soc. 32 (1987) 1061

1987SE05   K.K. Seth, M. Artuso, D. Barlow, S. Iversen, M. Kaletka, H. Nann, B. Parker and R. Soundranayagam, Phys. Rev. Lett. 58 (1987) 1930

1987SE1D   J.P.F. Sellschop, Nucl. Instrum. Meth. Phys. Res. B29 (1987) 439

1987SE1E   Segl et al., Nucl. Instrum. Meth. Phys. Res. B29 (1987) 332

1987SH1N   Sharma et al., Nucl. Instrum. Meth. Phys. Res. B29 (1987) 335

1987SI18   P.B. Siegel and W.R. Gibbs, Phys. Rev. C36 (1987) 2473

1987SN01   K. Sneppen, Nucl. Phys. A470 (1987) 213

1987SO1E   C.P. Sonett, G.E. Morfill and J.R. Jokipii, Nature 330 (1987) 458

1987ST01   G.S.F. Stephans, R.V.F. Janssens, D.G. Kovar and B.D. Wilkins, Phys. Rev. C35 (1987) 614

1987SU06   T. Suzuki, D.F. Measday and J.P. Roalsvig, Phys. Rev. C35 (1987) 2212

1987TAZU I. Tanihata, H. Hamagaki, O. Hashimoto, Y. Shida, O. Yamakawa, T. Kobayashi, K. Sugimoto and N. Takahashi, in Panic (1987) 474; LBL-22820 (1987) 82

1987TR05   W. Trautmann, K.D. Hildenbrand, U. Lynen, W.F.J. Muller, H.J. Rabe, H. Sann, H. Stelzer, R. Trockel, R. Wada, N. Brummund et al., Nucl. Phys. A471 (1987) 191c

1987VA13   O.I. Vasileva, G.S. Gurevich, A.V. Ignatenko, V.M. Lebedev, N.V. Orlova, A.V. Spassky, I.B. Teplov, L.N. Fateeva, G.V. Shakhvorostova and A.Kh. El-Kamkhavi, Yad. Fiz. 45 (1987) 312; Sov. J. Nucl. Phys. 45 (1987) 195

1987VA1I   Valiev et al., in Yurmala (1987) 346

1987VA1S   van der Borg et al., Nucl. Instrum. Meth. Phys. Res. B29 (1987) 143

1987VI02   F. Videbaek, S.G. Steadman, G.G. Batrouni and J. Karp, Phys. Rev. C35 (1987) 2333

1987VI14   V.E. Viola, Nucl. Phys. A471 (1987) 53c

1987WA09 R. Wada, K.D. Hildenbrand, U. Lynen, W.F.J. Muller, H.J. Rabe, H. Sann, H. Stelzer, W. Trautmann, R. Trockel, N. Brummund et al., Phys. Rev. Lett. 58 (1987) 1829

1987WU05 R. Wunsch and J. Zofka, Phys. Lett. B193 (1987) 7

1987YA16   Yu.P. Yakovlev, Yad. Fiz. 46 (1987) 459; Sov. J. Nucl. Phys. 46 (1987) 244

1987ZA01 M. Zadro, S. Blagus, D. Miljanic and D. Rendic, Nucl. Sci. Eng. 95 (1987) 79

1988AB05 V.V. Abaev, E.P. Fedorova-Koval, A.B. Gridnev, V.P. Koptev, S.P. Kruglov,Yu.A. Malov, G.V. Scherbakov, I.I. Strakovsky and N.A. Tarasov, J. Phys. G14 (1988) 903

1988ABZW S.N. Abramovich, B.Ya. Guzhovsky and V.N. Protopopov, in Baku (1988) 299

1988AJ1B F. Ajzenberg-Selove, Interact. and Struct. in Nucl., Proc. in Honor of D.H. Wilkinson, Sussex, 7-9 Sept. 1987 (1988) 181

1988AL1G Aleksandrov et al., in Baku (1988) 377

1988BE1B J. Beer, U. Siegenthaler, G. Bonani, R.C. Finkel, H. Oeschger, M. Suter and W. Wolfli, Nature 331 (1988) 675

1988BE1I Bekbaev et al., in Baku (1988) 442

1988BEYJ A.V. Belozerov, K. Borcha, I. Vintsour, Z. Dlougy, N.K. Tyau and Yu.Eh. Penionzhkevich, in Baku (1988) 380.

1988BL09 C. Bloch, W. Benenson, A.I. Galonsky, E. Kashy, J. Heltsley, L. Heilbronn, M. Lowe, R.J. Radtke, B. Remington, J. Kassagi et al., Phys. Rev. C37 (1988) 2469

1988BO47 K. Bodek, B. Bruggemann, J. Krug, P. Lekkas, W. Lubcke, H. Ruhl, M. Steinke, M. Stephan, A. Szczurek and D. Kamke, Few-Body Syst. 3 (1988) 135

1988BRZZ B.A. Brown, R.E. Julies and W.A. Richter, Bull. Amer. Phys. Soc. 33 (1988) 931

1988CA06 G. Caskey, L. Heilbronn, B. Remington, A. Galonsky, F. Deak, A. Kiss and Z. Seres, Phys. Rev. C37 (1988) 696

1988DI02 S.S. Dietrich and B.L. Berman, At. Data Nucl. Data Tables 38 (1988) 199

1988FE1A Ferrando et al., Phys. Rev. C37 (1988) 1490

1988GI02 T.A. Girard, A.S. Carnoy, J. Deutsch, R. Prieels and M.L. Schmit, Z. Phys. A330 (1988) 51

1988GI1B B.F. Gibson, Nucl. Phys. A479 (1988) 115c

1988GIZT Yu.R. Gismatullin, A.A. Melentev, V.I. Ostroumov, A.M. Petukhov and M.A. Stalevich, in Baku (1988) 294

1988GIZU Yu.R. Gismatullin, A.A. Melentev, V.I. Ostroumov, A.M. Petukhov and M.A. Stalevich, in Baku (1988) 293

1988GOZB S.A. Goncharov, E.A. Romanovsky and N.K. Timofeyuk, in Baku (1988) 349

1988GUZW I.R. Gulamov, A.M. Mukhamedzhanov and G.K. Ni, in Baku (1988) 300

1988HA1M W.C. Haxton and C.W. Johnson, Nature 333 (1988) 325

1988HE08 R. Henneck, C. Gysin, P. Haffter, M. Hammans, W. Lorenzon, M.A. Pickar, I. Sick and S. Burzynski, Phys. Rev. C37 (1988) 2224

1988JO1C B. Jonson, S. Mattsson, G. Nyman, O. Tengblad, M.J.G. Borge, P.G. Hansen and K. Riisager, AIP Conf. Proc. 164 (1988) 223

1988KA2E   Kayomov et al., in Baku (1988) 301

1988KI05   J.M. Kidd, P.J. Lindstrom, H.J. Crawford and G. Woods, Phys. Rev. C37 (1988) 2613

1988KOZL   L.P. Korda, B.A. Nemashkalo, G.K. Khomyakov, A.S. Kachan and A.N. Vodin, in Baku (1988) 586

1988KR11   L. Kraus, A. Boucenna, I. Linck, B. Lott, R. Rebmeister, N. Schulz, J.C. Sens, M.C. Mermaz, B. Berthier, R. Lucas et al., Phys. Rev. C37 (1988) 2529

1988KR1G   Krombel and Wiedenbeck, Astrophys. J. 328 (1988) 940

1988KRZY   M. Kroupa, S.J. Freedman, R. Holzmann, J. Napolitano, J. Nelson, P. Barker and S. Ferguson, Bull. Amer. Phys. Soc. 33 (1988) 902

1988KW02   E. Kwasniewicz and J. Kisiel, Acta Phys. Pol. B19 (1988) 141

1988LE06   M. LeMere and Y.C. Tang, Phys. Rev. C37 (1988) 1369

1988MA07   J.F. Mateja, G.L. Gentry, N.R. Fletcher, L.C. Dennis and A.D. Frawley, Phys. Rev. C37 (1988) 1004

1988MU05   S.F. Mughabghab, J. Phys. (London) G14 Suppl. (1988) S231

1988OR1C   Ormand and Brown, NBI-87-63 (1988)

1988POZS   N.A.F.M. Poppelier, J.H. de Vries, A.A. Wolters and P.W.M. Glaudemans, AIP Conf. Proc. 164 (1988) 334

1988RE1B   R. Rebolo, P. Molaro, C. Abia and J.E. Beckman, Astron. Astrophys. 193 (1988) 193

1988RIZZ   B.G. Ritchie, D. Rothenberger, J.R. Comfort, R.A. Giannelli, J. Tinsley, N.S. Chant, D. Mack, P.G. Roos, J.D. Silk, G.S. Kyle et al., Bull. Amer. Phys. Soc. 33 (1988) 903, AI11

1988RU01   V.A. Rubchenya and S.G. Yavshits, Z. Phys. A329 (1988) 217

1988SA19   H. Sato, Phys. Rev. C37 (1988) 2902

1988SI01   J.D. Silk, H.D. Holmgren, D.L. Hendrie, T.J.M. Symons, G.D. Westfall, P.H. Stelson, S. Raman, R.L. Auble, J.R. Wu and K. Van Bibber, Phys. Rev. C37 (1988) 158

1988ST06   J. Stevenson, B.A. Brown, Y. Chen, J. Clayton, E. Kashy, D. Mikolas, J. Nolen, M. Samuel, B. Sherrill, J.S. Winfield et al., Phys. Rev. C37 (1988) 2220

1988SU14   T. Suda, O. Konno, I. Nomura, T. Suzuki, T. Terasawa, Y. Torizuka, J. Yokokawa, K. Maeda, J. Eden, G. O'Keefe et al., J. Phys. Soc. Jpn. 57 (1988) 5

1988TS03   M.B. Tsang, W.G. Lynch, R.M. Ronningen, Z. Chen, C.K. Gelbke, T. Nayak, J. Pochodzalla, F. Zhu, M. Tohyama, W. Trautmann et al., Phys. Rev. Lett. 60 (1988) 1479

1988VA03   A.G.M. van Hees, A.A. Wolters and P.W.M. Glaudemans, Nucl. Phys. A476 (1988) 61

1988WA18   A.H. Wapstra, G. Audi and R. Hoekstra, At. Data Nucl. Data Tables 39 (1988) 281

1988WO04 A.A. Wolters, A.G.M. van Hees and P.W.M. Glaudemans, Europhys. Lett. 5 (1988) 7

1988ZVZZ A.G. Zvenigorodsky, S.N. Abramovich, B.Ya. Guzhovsky and O.A. Pelipenko, in Baku (1988) 297

1990AJ01 F. Ajzenberg-Selove, Nucl. Phys. A506 (1990) 1