Energy Levels of Light Nuclei
$A = 13$

F. Ajzenberg-Selove

University of Pennsylvania, Philadelphia, Pennsylvania 19104-6396

Abstract: An evaluation of $A = 13$–15 was published in *Nuclear Physics A*268 (1976), p. 1. This version of $A = 13$ differs from the published version in that we have corrected some errors discovered after the article went to press. Figures and introductory tables have been omitted from this manuscript. Reference key numbers have been changed to the NNDC/TUNL format.

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^{13}Li

(Not illustrated)

^{13}Li is not observed in the 4.8 GeV proton bombardment of a uranium target: the cross section is $\lesssim 0.2\ \mu$b (1974BO05). ^{13}Li is predicted to have an atomic mass excess of 61.56 MeV: it is then unstable for breakup into ^{12}Li + n and ^{11}Li + 2n by 0.6 and 4.5 MeV, respectively (1974TH01). The modified mass equation leads to a calculated amu of 60.34 MeV: ^{13}Li would then be stable with respect to breakup into ^{12}Li + n by 0.7 MeV, assuming the amu of ^{12}Li to be 52.94 MeV, but would be unstable with respect to ^{11}Li + 2n by 3.3 MeV (1975JE02). See also (1972TH13, 1975BE31).

^{13}Be

(Not illustrated)

^{13}Be is not observed in the 5.5 GeV proton bombardment of uranium (1968PO04) nor in the bombardment of ^{232}Th by 145 MeV ^{15}N ions (1970AR27). ^{13}Be is predicted to have an atomic mass excess of 35.35 MeV. It is then unstable with respect to decay into ^{12}Be + n by 2.32 MeV (1974TH01). The modified mass equation leads to an amu of 34.60 MeV; ^{13}Be would then be unstable with respect to decay into ^{12}Be + n by 1.50 MeV (1975JE02). See also (1972TH13, 1973BA34, 1973KO1D, 1973VO1D, 1975BE31).

^{13}B

(Figs. 1 and 4)

GENERAL: (See also (1970AJ04).):

Special reactions: (1971AR02, 1973KO1D, 1975AB14, 1975FO09).

Theoretical papers: (1972AN05, 1973KI12, 1973MU11, 1973MU1B, 1973NA1H, 1973NA14, 1973SA30, 1973WI15, 1975BE31, 1975HU14).

$Q = 0.048 \pm 0.005$ b (1973HAVZ, 1974SHYR).

$\mu = 3.1771 \pm 0.0005$ nm (1971WI09, 1973HAVZ).

See also (1973TO16).

1. ^{13}B(β^-)^{13}C $\qquad Q_{\rm m} = 13.437$

Table 13.1: Energy levels of ^{13}B

E_x (MeV ± keV)	$J^\pi; T$	τ or Γ_{cm} (keV)	Decay	Reactions
g.s.	$\frac{3}{2}^-; \frac{3}{2}$	$\tau_{1/2} = 17.36 \pm 0.16$ msec	β^-	1, 2, 3, 4, 5
3.483 ± 5	$(\frac{1}{2}, \frac{3}{2}, \frac{5}{2})^+$		γ	2, 4
3.5347 ± 3.1	$(\frac{1}{2}, \frac{5}{2}, \frac{5}{2})^-$	$\tau_m > 0.3$ psec	γ	2, 4
3.681 ± 5	$(\frac{1}{2}, \frac{3}{2}, \frac{5}{2})^+$		(γ)	2, 4, 5
3.712 ± 5	$(\frac{1}{2}, \frac{5}{2}, \frac{7}{2})^-$	$\tau_m < 0.38$ psec	(γ)	2, 4, 5
4.131 ± 5	$(\frac{1}{2}, \frac{5}{2}, \frac{7}{2})^-$	$\tau_m = 0.062 \pm 0.050$ psec	γ	2, 4
4.828 ± 6			(γ)	2, 4
5.023 ± 6				2, 4
5.109 ± 10		$\Gamma = 60 \pm 8$ keV		4
5.390 ± 7		15 ± 5		2, 4
5.557 ± 7				2
6.168 ± 7				2, 4
6.419 ± 8				2
6.939 ± 15				2
7.516 ± 8				2
7.859 ± 20				2
8.129 ± 10				2
8.682 ± 9				2

The half-life of ^{13}B is 17.33 ± 0.17 msec (1971WI07), 17.6 ± 0.4 msec (1962MA19): the mean value is 17.36 ± 0.16 msec (1971WI07). This value leads to $(ft)^+/(ft)^- = 1.166 \pm 0.026$ (see ^{13}O). The induced tensor coupling constant, $g_{IT} = (2.6 \pm 0.5) \times 10^{-3}$ (1971WI07).

The branching ratios to various ^{13}C states are shown in Table 13.2 (1962MA19, 1969JO21, 1974AL12): they indicate $J^\pi = \frac{1}{2}^-$ or $\frac{3}{2}^-$ for $^{13}B_{g.s.}$. See also (1974AL11) and (1971WI18, 1972WI1C, 1973HA49, 1973KU1D, 1973MA1K, 1973TO14, 1973WI11, 1974CH46, 1975GR03, 1975WI1E; theor.).

2. ^{7}Li(^{7}Li, p)^{13}B $\qquad Q_m = 5.966$

Observed proton groups are shown in Table 13.3 (1959MO12, 1963CA09, 1972WY01). Angular distribution measurements have been reported by (1969CA1A; p_0, p_{1+2}, p_{3+4}, p_5, p_7). The lifetimes of ^{13}B*(3.53, 3.71, 4.13) are, repectively, > 0.3, < 0.38 and 0.062 ± 0.050 psec: $E_\gamma = 3536.3 \pm 4.2$ and 4133.4 ± 7.8 keV (1969TH01). See also ^{14}C.

Table 13.2: Beta decay of ^{13}B [a]

Decay to ^{13}C* (MeV)	J^π	Branch (%)	log ft [c]
0	$\frac{1}{2}^-$	92.1 ± 0.8	4.01 ± 0.01
3.09	$\frac{1}{2}^+$	≤ 0.7	≥ 5.7
3.68	$\frac{3}{2}^-$	7.6 ± 0.8	4.45 ± 0.04
3.85	$\frac{5}{2}^+$	≤ 0.7	≥ 5.5
7.55 [d]	$\frac{5}{2}^-$	0.094 ± 0.020 [b]	5.33 ± 0.08
8.86	$\frac{1}{2}^-$	0.16 ± 0.03 [b]	4.60 ± 0.08
9.50	$(\frac{3}{2}^-)$	< 0.01	> 5.2
9.90	$\frac{3}{2}^-$	0.022 ± 0.007	4.95 ± 0.12

[a] (1962MA19, 1969JO21, 1974AL12). See also Table 13.30.
[b] See also (1965PO03, 1968CH28).
[c] See also (1970ES03). log ft shown here are based on $\tau_{1/2} = 17.33 \pm 0.17$ msec.
[d] $E_x = 7.577 \pm 0.030$ MeV (1974AL12).

3. ^{10}Be(α, p)^{13}B $\qquad Q_m = -8.818$

See ^{14}C (1974GO1T).

4. ^{11}B(t, p)^{13}B $\qquad Q_m = -0.233$

Observed proton groups are displayed in Table 13.3. Angular distributions have been measured at $E_t = 11$ MeV (1964MI04) and 23 MeV (1975AJ1C). See also (1970AJ04) and (1971WI09).

5. ^{14}C(d, ^{3}He)^{13}B $\qquad Q_m = -15.338$

At $E_d = 52$ MeV angular distributions for ^{13}B*(0, 3.7) have been reported (1975MA41).

Table 13.3: Proton groups from ^{7}Li(^{7}Li, p)^{13}B and ^{11}B(t, p)^{13}B

^{7}Li(^{7}Li, p)^{13}B		^{11}B(t, p)^{13}B			
(1959MO12, 1963CA09)	(1972WY01)	(1964MI04)			(1975AJ1C) [f]
E_x (MeV ± keV)		E_x (MeV ± keV)	L	J^π	E_x (MeV ± keV)
0		0	0	$\frac{3}{2}^-$	0
		3.483 ± 5	1	$(\frac{1}{2}, \frac{3}{2}, \frac{5}{2})^+$	3.483 ± 10
3.50 ± 50 [a]					
		3.533 ± 5	2	$(\frac{1}{2}, \frac{5}{2}, \frac{7}{2})^-$	3.532 ± 10
		3.681 ± 5	1	$(\frac{1}{2}, \frac{3}{2}, \frac{5}{2})^+$	3.683 ± 10
3.70 ± 50 [b]					
		3.712 ± 5	2	$(\frac{1}{2}, \frac{5}{2}, \frac{7}{2})^-$	3.716 ± 10
4.16 ± 50 [c]	[d]	4.13 ± 10	2	$(\frac{1}{2}, \frac{5}{2}, \frac{7}{2})^-$	4.130 ± 10
	4.833 ± 10	4.82 ± 10			4.832 ± 10
5.05 ± 80	5.033 ± 8	5.01 ± 10	1	$(\frac{1}{2}, \frac{3}{2}, \frac{5}{2})^+$	5.020 ± 10
					5.109 ± 10 [g]
	5.391 ± 8	5.38 ± 10 [e]			5.388 ± 10 [h]
	5.557 ± 8				
	6.169 ± 8	6.17 ± 20			6.165 ± 10
	6.419 ± 8				
	6.939 ± 15				
	7.516 ± 8				
	7.859 ± 20				
	8.129 ± 10				
	8.682 ± 9				

[a] The decay is by γ_0.

[b] The decay is primarily by γ_0: the upper limit to the cascade via ^{13}B*(3.5) is 10%.

[c] The decay is 75 ± 10%, 25 ± 10% and < 10%, respectively to ^{13}B*(0, 3.5, 3.7).

[d] All values in this column are based on $E_x = 4131$ keV for ^{13}B*(4.13).

[e] $\Gamma = 15 \pm 5$ keV.

[f] And O. Hansen, private communication.

[g] $\Gamma_{cm} = 60 \pm 8$ keV.

[h] $\Gamma_{cm} = 10 \pm 10$ keV.

^{13}C
(Figs. 2 and 4)

GENERAL (See also (1970AJ04).):

Shell model: (1970CO1H, 1970HS02, 1970TA1J, 1971AR1R, 1971GR02, 1971NO02, 1972DE1H, 1972EL1C, 1972GU05, 1972LE1L, 1973DE13, 1973HA49, 1973KU03, 1973MA1X, 1973MA1K, 1973MU18, 1973SA30, 1974PH1D, 1975ME24, 1975MI12).

Collective and deformed models: (1971AR1R).

Cluster model: (1969BA1J, 1971NO02, 1972LE1L, 1973KU03).

Special levels: (1970FR1C, 1970PE18, 1971AR03, 1971AR1R, 1971GR02, 1971JA13, 1971NO02, 1971SE1C, 1972BE1E, 1972DE1H, 1973MU18, 1973SA30, 1974HA1G, 1974PH1D, 1974TA1E, 1975KU21, 1975ME24, 1975MI12).

Giant resonance: (1970AL1E, 1971JA14, 1972GO27, 1972HA16, 1972LE06, 1973HA1Q, 1973MA1X, 1974HA1C, 1974MU13).

Electromagnetic transitions: (1971DI1G, 1971GR02, 1971JA13, 1972GU05, 1972NA05, 1973HA49, 1973HA1Q, 1973SA25, 1973SA30, 1974AD1B, 1974CH46, 1974HA1C, 1974MU13, 1974RO1R, 1974RO1T, 1975FO1L, 1975KU21, 1975ME24).

Special reactions: (1969GA18, 1971AR02, 1973KO1D, 1973KU03, 1974KO25, 1975HU14, 1975KU01).

Astrophsyical questions: (1972CL1A, 1972UL1A, 1973AR1E, 1973AU1B, 1973AU1D, 1973AU1C, 1973BO1R, 1973CO1B, 1973DA1L, 1973SA1J, 1973SC1T, 1973SM1A, 1973TA1D, 1973TR1B, 1973UL1B, 1974BE1R, 1974BO2K, 1974DA1N, 1974LA1J, 1974LA1K, 1974SC1F, 1974TO1C, 1975AR1E, 1975AU1D, 1975BR1J, 1975DE1F, 1975DE1H, 1975EN1A, 1975KI1D, 1975NO1D, 1975SC1H, 1975SN1A, 1975TO1B, 1975TR1A).

Muon and neutrino capture and reactions: (1972BU29, 1973KI12, 1973MU11, 1973MU1B).

Pion capture and reactions (See also reaction 37.): (1970BJ1A, 1970DO04, 1970WE1D, 1971DA10, 1971IN1A, 1971KA62, 1973AL1D, 1973AU06, 1973DI08, 1973EI01, 1973MI1H, 1973NA1H, 1973NA14, 1973RO10, 1974HO13, 1974KA07, 1974LE25, 1974LI15, 1974MI06, 1974MI11, 1974RE1E, 1974UL02, 1975AL1K, 1975EI1D, 1975GI1B, 1975HU1D, 1975KA1R, 1975KI1E, 1975RE01, 1975TO01, 1976GI01, 1976SH01).

Other topics: (1969WA1C, 1970CO1H, 1970PE18, 1970SH1C, 1970SU1B, 1971AR03, 1971AU1G, 1971BA2Y, 1971GR16, 1971JA13, 1971SE1C, 1971NG01, 1972AN05, 1972CA37, 1972CH16, 1972HA57, 1972LE1L, 1973DE13, 1973GO1H, 1973JU2A, 1973KO1J, 1973KU03, 1973MA48, 1973RA1E, 1973SA25, 1973WI15, 1974CA1H, 1974MU13, 1974SI04, 1974ZU1A, 1975GR03, 1975KU01, 1975MO1M, 1976MA04, 1976PA03).

Table 13.4: Energy levels of ^{13}C [a]

E_x (Mev $\pm$ keV)	$J^\pi; T$	τ_m or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
g.s.	$\frac{1}{2}^-; \frac{1}{2}$		stable	9, 10, 11, 12, 14, 16, 17, 18, 25, 26, 27, 28, 29, 30, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 82, 83, 84, 86, 87, 88, 89, 90, 91
3.0884 ± 0.2	$\frac{1}{2}^+$	$\tau_m = 1.55 \pm 0.15$ fsec	γ	9, 10, 11, 14, 16, 25, 27, 31, 37, 38, 39, 42, 45, 49, 53, 55, 56, 57, 58, 59, 60, 64, 65, 72, 73, 75, 76, 78, 82, 83, 86
3.68437 ± 0.14 [b]	$\frac{3}{2}^-$	1.59 ± 0.13 fsec	γ	9, 10, 12, 14, 16, 17, 25, 27, 30, 38, 39, 41, 45, 48, 49, 53, 56, 57, 58, 60, 64, 65, 66, 72, 73, 74, 75, 76, 82, 83, 86, 88
3.85362 ± 0.15 [b]	$\frac{5}{2}^+$	12.2 ± 0.4 psec	γ	10, 11, 14, 16, 25, 27, 37, 38, 39, 40, 41, 42, 45, 56, 57, 58, 60, 64, 65, 72, 73, 76, 82, 86
6.864 ± 3	$\frac{5}{2}^+$	$\Gamma = 6$ keV	γ, n	9, 10, 15, 16, 25, 27, 31, 37, 38, 53, 57, 58, 75, 76, 82
7.492 ± 10	$(\frac{7}{2}^+)$	< 5		9, 15, 25, 27, 37, 38, 58, 75, 76, 82
7.547 ± 3	$\frac{5}{2}^-$	1.2 ± 0.3	γ, n	9, 15, 25, 27, 31, 37, 38, 48, 53, 57, 58, 75, 76, 82
7.677 ± 12	$\frac{3}{2}^+$	70 ± 10	n	15, 25, 27, 31, 37, 38, 76
8.2 ± 100	$\frac{3}{2}^+$	1000 ± 100	n	31, 38
8.860 ± 20	$\frac{1}{2}^-$	150 ± 20	γ, n	25, 27, 31, 38, 48, 53, 57, 72, 75, 76, 82, 83
9.498 ± 4	$(\frac{3}{2}^-)$	5	n	9, 15, 25, 27, 31, 32, 37, 38, 57, 75, 76, 82
9.897 ± 5	$\frac{3}{2}^-$	26 ± 3	γ, n	9, 15, 25, 27, 31, 32, 38, 48, 53, 76
10.46		200	n	32
10.753 ± 4	$\frac{7}{2}^-$	55 ± 2	n	15, 25, 31, 32, 38, 76

Table 13.4: Energy levels of ^{13}C [a] (continued)

E_x (Mev ± keV)	$J^\pi; T$	τ_m or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
10.818 ± 5	$(\frac{5}{2}^-)$	24 ± 3	n	9, 15, 25, 32, 38, 76
10.996 ± 6	$(\frac{1}{2}^+)$	37 ± 4	n, α	5, 25, 31, 32, 38, 76
11.080 ± 5	$(\frac{1}{2}^-)$	< 4	γ, n, α	5, 25, 31, 32, 38, 53, 76, 82
11.748 ± 10		107 ± 14	n	25, 31, 38, 53, 76, 82
11.851 ± 5	$(\frac{3}{2}^-)$	68 ± 4	n	12, 32, 38, 53, 57, 74, 75, 82
11.97 ± 40 [c]	$(\frac{7}{2}^-, \frac{5}{2}^+)$	≈ 200	n, α	5, 8, 9, 38
12.106 ± 5	$(> \frac{7}{2})$	81 ± 8	n, α	5, 9, 31, 32, 38, 76
12.40 ± 50	$\frac{7}{2}^-$	150	n, α	5, 31, 32, 82
(13.28)	$(\frac{3}{2}^-)$	340	α	8
13.3 ± 1000		5000 ± 1000	γ, n	50
13.41	$(\frac{9}{2}^-)$	35 ± 3	n, α	5, 8, 9
13.56	$(\frac{3}{2}^+, \frac{5}{2}^+)$	500	n, α	5, 8, 31, 32
13.76	$(\frac{5}{2}^+, \frac{3}{2}^+)$	300	n, α	5, 8
14.12 [b]	$(\frac{5}{2}^-)$	≈ 200	n, α	5, 8, 9
14.39 ± 100	$(\frac{1}{2}^-, \frac{5}{2}^-)$	260	n, α	5, 9
14.63		210	n, α	5, 9
14.94 ± 50	$(\frac{3}{2}^+)$	380	n, α	5
15.106 ± 2 [d]	$\frac{3}{2}^-; \frac{3}{2}$	5.0 ± 0.7	γ, n, α	9, 25, 31, 53, 57, 66, 82
15.55 ± 50		220	n, α	5
16.01		210	n, α	5, 31
16.15 ± 50		230	n, α	5, 31, 53
16.95 ± 50		330	n, α	5, 53
17.36 ± 100		190	n, α	5
17.71 ± 50		170	n, α	5, 53
18.30 ± 50		300	n, α	5, 53
18.75 ± 30		70	n, α	5
19.5	$(\frac{1}{2}, \frac{3}{2}, \frac{5}{2})^-$	≈ 450	n, d	19, 31, 32
19.9		≈ 600	n, p, d	19, 20
20.24		≈ 200	(γ), n, d, α	18, 19, 23
20.52 ± 10		116 ± 10	(γ), n, p, d	18, 19, 20
21.28 ± 15		159 ± 15	n, p, d	19, 20

Table 13.4: Energy levels of ^{13}C [a] (continued)

E_x (Mev ± keV)	$J^\pi; T$	τ_m or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
21.81 ± 20		114 ± 12	n, d	19
≈ 22 [e]		≈ 7000	γ, n	50
22.23		broad	n, d	19, 53
23		≈ 1000	n	31
23.5 [e]		≈ 3000	γ, p	51
25.5		broad	γ, n, p	50, 51, 53
26.8			n, d	19
27.5			n, d	19, 53

[a] See also Tables 13.5, 13.6 and 13.7.

[b] See (1969AL17).

[c] May be unresolved.

[d] See also Table 13.7.

[e] In ^{13}C(e, e) the giant resonance is reported split into two peaks near $E_x = 20.5$ and 24.5 MeV, with widths of ≈ 3 and ≈ 4 MeV and $T = \frac{1}{2}$ and $\frac{3}{2}$, respectively (1971BE51): see reaction 53 and see also Table 13.21.

Ground state: (1969LE1B, 1971TA1A, 1972GL06, 1972GU05, 1972LE1L, 1972LE1N, 1972VA36, 1973MA1K, 1973SA25, 1973SA30, 1973SU1C, 1974DE1E, 1974HA27, 1974MU13, 1974NE1B, 1975AL19, 1975BE31, 1975ME24, 1976PA03).

Mass of ^{13}C:

$$13.003354831(\pm 10 \times 10^{-9}) \text{ amu (1975SM02);}$$

$$\mu = +0.702381 \pm 0.000002 \text{ nm (1964LI14);}$$

$$\mu = 0.7020 \pm 0.0004 \text{ nm (1973CO1P).}$$

See also (1969WO03, 1971SH26, 1973SU1B, 1974SHYR).

1. (a) ^{6}Li(^{7}Li, n)^{12}C $\quad Q_m = 20.924 \quad E_b = 25.871$
   (b) ^{6}Li(^{7}Li, p)^{12}B $\quad Q_m = 8.337$
   (c) ^{6}Li(^{7}Li, 2n)^{11}C $\quad Q_m = 2.203$
   (d) ^{6}Li(^{7}Li, d)^{11}B $\quad Q_m = 7.192$
   (e) ^{6}Li(^{7}Li, t)^{10}B $\quad Q_m = 1.993$
   (f) ^{6}Li(^{7}Li, α)^{9}Be $\quad Q_m = 15.223$

Table 13.5: Lifetimes of low-lying states of ^{13}C

^{13}C* (MeV)	τ_m	Refs.
3.09	1.0 ± 0.3 fsec	(1970WI04)
	1.50 ± 0.17 fsec	(1968RO02)
	1.7 ± 0.3 fsec	(1975RA22)
	1.55 ± 0.15 fsec	mean of last two values
3.68	1.50 ± 0.15 fsec	(1969RA20)
	1.83 ± 0.25 fsec	(1970WI04)
	1.59 ± 0.13 fsec	mean
3.85	7.5 ± 2.5 psec	(1962SI08)
	15 ± 2 psec	(1968AL03)
	9.0 ± 2.5 psec	(1968RI16)
	10.7 ± 1 psec	(1969HE22)
	9.9 ± 0.9 psec	(1970GA01)
	12.4 ± 0.8 psec	(1974BE48)
	13.0 ± 0.4 psec	(1975RA29)
	12.2 ± 0.4 psec	mean of last five values

Table 13.6: Summary of results on the total radiation widths of the low-lying levels of ^{13}C–^{13}N [a]

$J^\pi_i \rightarrow J^\pi_f$	^{13}C* (MeV)	Γ_γ (eV)	Refs.	^{13}N* (MeV)	Γ_γ (eV)	Refs.
$\frac{1}{2}^+ \rightarrow \frac{1}{2}^-$	3.09 [b]	0.43 ± 0.04	Table 13.5	2.37	0.64 ± 0.07	see (1975FO1L) [g]
$\frac{3}{2}^- \rightarrow \frac{1}{2}^-$	3.68 [c]	0.41 ± 0.04	Table 13.5	3.51 [f]	0.53	(1963YO06)
$\frac{5}{2}^+ \rightarrow \frac{1}{2}^-$	3.85 [d]	$(5.4 \pm 0.3) \times 10^{-5}$ [e]	Table 13.5	3.55	$< 2 \times 10^{-3}$	(1963YO06)

[a] See also Tables 13.20 and 13.26.
[b] B(E1) $= 0.040 \pm 0.005$ W.u.: $\delta = -0.69 \pm 0.05$ (see (1975MA21)).
[c] Branching ratios for cascade via ^{13}C*(3.09) is $1.6 \pm 0.3\%$ (1975TR07).
[d] Branching ratios for cascades via ^{13}C*(3.68, 3.09) are $35 \pm 2\%$ and $1.6 \pm 0.4\%$, respectively (1969LI07), $36.0 \pm 0.7\%$ and $0.6 \pm 0.2\%$, respectively (1975TR07).
[e] Assuming the ground state branching ratio to be $69 \pm 4\%$ [but see footnote [b]] and the mixing ratio δ(E3/M2) $= +(0.12 \pm 0.03)$ (1966PO11), Γ(E3) $= (5.2 \pm 2.6) \times 10^{-7}$ eV and Γ(M2) $= (3.61 \pm 0.23) \times 10^{-5}$ eV: then $|M(\text{E3})|^2 = 2.0 \pm 1.0$ single particle units (1975RA29).
[f] Branching ratio for cascade via ^{13}N*(2.37) is $8 \pm 1\%$ (1974RO29).
[g] See also (1968RI16, 1975MA21).

Table 13.7: Parameters of the first $T = \frac{3}{2}$ states in ^{13}C and ^{13}N [a]

	^{13}C*(15.11)	^{13}N*(15.07)
E_x (MeV)	15.106 ± 0.002	15.0651 ± 0.0009
J^π	$\frac{3}{2}^-$	$\frac{3}{2}^-$
Γ_{cm} (keV) [b]	5.0 ± 0.7	1.10 ± 0.09
Γ_{γ_0} (eV)	22.7 ± 2.6 (M1)[0.32 ± 0.04 W.u.]	24.2 ± 1.5 (M1)[0.34 ± 0.02 W.u.] [f]
	0.59 ± 0.11 (E2)[0.52 ± 0.10 W.u.]	0.32 ± 0.12 (E2)[0.28 ± 0.11 W.u.] [g]
Γ_{γ_1} (eV)	4.12 ± 0.74 (E1)[$(6.4 \pm 1.1) \times 10^{-3}$ W.u.]	$\leq (2.82 \pm 0.30)$ (E1) [$\leq (3.7 \pm 0.4) \times 10^{-3}$ W.u.] [h]
Γ_{γ_2} (eV)	18.2 ± 2.4 (M1)[0.59 ± 0.08 W.u.] [e]	19.6 ± 1.4 (M1)[0.61 ± 0.04 W.u.] [e,i]
Γ_{n_0} or Γ_{p_0} (keV) [c]	0.35 ± 0.10	0.210 ± 0.011
Γ_{n_1} or Γ_{p_1} (keV) [c]	1.31 ± 0.24	0.165 ± 0.018
Γ_{n_2} or Γ_{p_2} (keV) [c]	0.130 ± 0.092	0.058 ± 0.017
Γ_{α_0} (keV) [d]	0.095 ± 0.028	0.044 ± 0.027
Γ_{α_1} (keV) [d]		0.035 ± 0.035
Γ_{α_2} (keV) [d]		0.065 ± 0.044

[a] (1973AD02, 1973HU07, 1975HI07, 1975MA21). See also Table 13.8 in (1970AJ04) and reactions 13, 15 and 16 in ^{13}N.

[b] Total Γ_{cm} adopted by (1973AD02).

[c] Widths for ^{13}C*(15.11) $\rightarrow$ $^{12}C_{g.s.} + n_0$ or ^{13}N*(15.07) $\rightarrow$ $^{12}C_{g.s.} + p_0$ [n_1, p_1 and n_2, p_2 correspond to the decays to ^{12}C*(4.4, 7.7) respectively].

[d] Widths for ^{13}C*(15.11) $\rightarrow$ $^{9}Be_{g.s.} + \alpha_0$ or ^{13}N*(15.07) $\rightarrow$ $^{9}B_{g.s.} + \alpha_0$ [α_1 and α_2 refer to the decays to ^{9}B*(1.6, 2.4)].

[e] May contain a small component of γ_3 (1975MA21).

[f] $\delta = -0.07 \pm 0.13$ (1975MA21).

[g] $\delta = 0.82^{+1.2}_{-0.6}$ (1975MA21).

[h] $\delta \geq 0.83 \pm 0.29$ (1975MA21).

[i] $\delta = -0.04 \pm 0.14$ (1975MA21).

The yield curves for d_0 ($E(^6\text{Li}) = 4$ to 14 MeV), t_0 ($E(^7\text{Li}) = 5$ to 14 MeV) and α_0 ($E(^6\text{Li}) = 4$ to 14 MeV) show broad, uncorrelated structures. Energy-averaged differential cross sections are also reported for a number of ^{12}B, ^{11}B and ^{10}B states (1971WY01). Total cross section measurements have been measured for $E(^7\text{Li}) = 3.8$ to 6.0 MeV for $p_0 \rightarrow p_2$, p_{3+4}, p_5; $d_0 \rightarrow d_3$, d_{4+5}, d_6; $t_0 \rightarrow t_2$; and α_0: the total cross sections generally increase smoothly with energy without showing any structure (1967KI03). The ^{11}C yield has been measured for $E(^6\text{Li}) = 1.2$ to 3.6 MeV by (1961NO05). See also ^{9}Be and ^{10}B in (1974AJ01), ^{11}B and ^{12}B in (1975AJ02), (1969KA1E) and (1972GA1E).

2. ^{7}Li(^{7}Li, n)^{13}C $\qquad Q_m = 18.620$

See (1970AJ04).

3. ^{7}Li(^{11}B, αn)^{13}C $\qquad Q_m = 9.955$

See (1970AJ04).

4. ^{9}Be(α, γ)^{13}C $\qquad Q_m = 10.648$

Earlier reports of the excitation of the first $T = \frac{3}{2}$ state in this reaction have not been published: see (1970AJ04).

5. (a) ^{9}Be(α, n)^{12}C $\qquad Q_m = 5.702$ $\qquad E_b = 10.648$
(b) ^{9}Be(α, 2n)^{11}C $\qquad Q_m = -13.020$

Resonances for n_0 and n_1, for γ-rays from ^{12}C*(4.4, 12.7, 15.1) and resonances in the total neutron cross section are given in Table 13.8. The yield of neutrons to ^{12}C*(7.66, 9.64) has been measured for $E_\alpha = 2.9$ to 6.4 MeV and 5.9 to 6.4 MeV, respectively (1972OB01). The n_0 and n_1 yields for $E_\alpha = 1.5$ to 7.5 MeV and the n_2 yield for $E_\alpha = 3.8$ to 7.5 MeV are reported by (1970VA23).

Polarization measurements have been reported at $E_n = 1.75$ and 1.96 MeV (1969KL09; n_0), 2.55 MeV (1970ST15, 1970ST16; n_0), 2.6 MeV (1971KL04; n_0), 4.5 to 5.85 MeV (1973DE14 † ; n_0, n_1) and 22.9 MeV (1973OK06; n_0, n_1). For earlier measurements see (1970AJ04). See also (1970TA06). For astrophysical implications see (1968DA1D, 1972OB01, 1975FO19). See also (1971AN1L, 1975KA26), (1971WA1D) and (1971EL1B; applied). Reaction (b) has been studied at a number of energies in the range $E_\alpha = 17$ to 44 MeV (1970KR09).

† The n_0 cross section and polarization are described for $E_n = 4$ to 6 MeV in terms of five broad states: see Table 13.8.

Table 13.8: Resonances in ^{9}Be(α, n)^{12}C

E_{α} [a] (MeV)	E_{α} [b] (MeV)	E_{α} [c] (MeV)	Γ_{cm} (keV)	J^{π}	^{13}C* [d] (MeV)	Refs.
0.52	0.52		≈ 55 [e]	$(\frac{1}{2}^{+})$	11.01	(1956JA28, 1968DA05)
0.60	0.60		< 4 [e]		11.06	(1968DA05)
1.9	1.905	1.92	130	$(\frac{7}{2}^{-})$	11.97	(1953TA06, 1954BE08, 1955TA28, 1956BO61, 1956JA28, 1965GI02, 1970VA23)
2.24		2.25	280		12.20	(1956BO61, 1965GI02)
2.58	2.6	2.58	≈ 200	$(\frac{1}{2}^{-})$	12.43	(1953TA06, 1956BO61, 1956JA28, 1965GI02, 1965GR22)
4.00	3.98	4.00	35 ± 3 [g]		13.41	(1956BO61, 1959GI47, 1963SE04, 1965GI02, 1965GR22, 1972OB01)
4.18			570	$(\frac{3}{2}^{+})$	13.54	(1957RI38, 1965GR22, 1973DE14)
4.50	4.47	4.50	≈ 350	$(\frac{5}{2}^{+})$	13.76	(1956BO61, 1959GI47, 1963SE04, 1965GI02, 1965GR22, 1973DE14)
5.0	5.02	5.0	≈ 200		14.12	(1956BO61, 1963SE04, 1965GI02)
5.40 ± 0.10	5.3 [f]		260	$(\frac{1}{2}^{-}, \frac{5}{2}^{-})$	14.39 ± 0.1	(1963SE04, 1965GR22, 1966MI12, 1973DE14)
	5.75	5.75	210		14.63	(1959GI47, 1963SE04, 1965GI02, 1965GR22, 1966MI12)
6.20 ± 0.05			380	$(\frac{3}{2}^{+})$	14.94 ± 0.05	(1965GR22, 1966MI12, 1973DE14)
		(6.7)	broad		(15.29)	(1965GI02)
7.10 ± 0.05	7.00		220		15.56 ± 0.05	(1963SE04, 1965GR22, 1966MI12)
	7.75	7.8	210		16.01	(1959GI47, 1963SE04, 1965GI02, 1965GR22)
7.95 ± 0.05			230		16.15 ± 0.05	(1965GR22, 1966MI12)
9.10 ± 0.05		9.1	330		16.95 ± 0.05	(1965GI02, 1965GR22, 1966MI12)
9.7 ± 0.10	9.70		190		17.36 ± 0.1	(1965GR22, 1966MI12)
10.2 ± 0.05			170		17.71 ± 0.05	(1965GR22, 1966MI12)
(10.60)			40		(17.99)	(1965GR22)
11.05 ± 0.05			300		18.30 ± 0.05	(1965GR22, 1966MI12)
11.70 ± 0.03	11.60		70		18.75 ± 0.03	(1965GR22, 1966MI12)

[a] Resonances in neutron yield.
[b] Resonances in n_1 group and for 4.4 MeV γ-rays.
[c] Resonances in total cross section.
[d] Not corrected for effects of Coulomb barrier penetration.
[e] $\omega\gamma = 3.79$ and 0.88 eV, respectively (1968DA05).
[f] (1973DE14) suggest the possibility that ^{13}C*(14.4) is composed of two states with the same J^π.
[g] J.L. Weil, private communication.

6. ^{9}Be(α, p)^{12}B $\quad Q_m = -6.886 \quad E_b = 10.648$

See (1968AJ02).

7. (a) ^{9}Be(α, d)^{11}B $\quad Q_m = -8.031 \quad E_b = 10.648$
(b) ^{9}Be(α, t)^{10}B $\quad Q_m = -13.229$

Excitation curves have been measured for $E_\alpha = 26.5$ to 27.5 MeV for the $d_0 \rightarrow d_3$, d_{4+5} and d_6 groups: no structure is observed (1975PU01). See also ^{11}B in (1975AJ02). At $E_\alpha = 26.0$ to 27.5 MeV yield curves have been obtained for the t_0, t_1 and t_3 groups: the t_2 group to ^{10}B*(1.74) is not populated at $\theta = 25°$ and $45°$; the yield curves do not display structure (1974KE06).

8. (a) ^{9}Be(α, α)^{9}Be $\quad E_b = 10.648$
(b) ^{9}Be(α, αn)^{8}Be $\quad Q_m = -1.6651$
(c) ^{9}Be(α, n)^{4}He^{4}He^{4}He $\quad Q_m = -1.573$

A number of excitation functions have been measured for elastically scattered alpha particles (reaction (a)) for $E_\alpha = 1.4$ to 20 MeV: these show considerable resonance structure with the variations being most prominent below 10 MeV but persisting up to 20 MeV (1965TA04, 1970GO1G, 1973GO15, 1974SA16). The parameters resulting from a best-fit of the excitation functions are displayed in Table 13.9: see footnotes to that table for a summary of the most important caveats (1973GO15). For reactions (a) and (b) see ^{9}Be in (1974AJ01). For reaction (b) see (1973WE03). For a spallation study see (1974RA11).

9. ^{9}Be(^{6}Li, d)^{13}C $\quad Q_m = 9.174$

Table 13.9: Resonances in ^{9}Be(α, α_0) [a]

E_α (MeV)	Γ_{cm} (keV)	l_α	J^π	^{13}C* (MeV)
1.93 [e]	180 [e]	1, 0	$\frac{5}{2}^+$	11.98
3.80	343	0, 2	$\frac{3}{2}^-$ [b]	13.28
4.00	58	(4, 6)	$(\frac{9}{2}^-)$	13.42
4.20	685	1, 3	$\frac{5}{2}^+$ [c]	13.56
4.50	247	1, 3	$\frac{3}{2}^+$ [c]	13.76
5.00	75	2, 4	$\frac{5}{2}^-$ [d]	14.11
5.075	73	3, 5	$\frac{7}{2}^+$ [d]	14.162
(5.50)	400	(1, 3)	$(\frac{5}{2}^+)$	(14.46)

[a] (1973GO15): from analysis in the single-level approximation. This assumes the J^π ordering suggested by (1965LI09).

[b] Favored by the analysis but the assignment is not certain and more than one state may be involved.

[c] (1973DE14) suggest the opposite ordering [$\frac{3}{2}^+$, $\frac{5}{2}^+$]: see Table 13.8.

[d] An equally good fit to the data is obtained with a $\frac{7}{2}^-$ state at 5.0 MeV and a $(\frac{3}{2}, \frac{5}{2}, \frac{7}{2})^+$ state at 5.08 MeV.

[e] This resonance is reported by (1974SA16). It is not clear whether the Γ is in the c.m. or lab systems. Γ_α is given as 72 keV.

At $E(^{6}\text{Li}) = 23.8$ MeV angular distributions are reported to ^{13}C*(0, 3.1, 3.6, 6.9, 7.5, 9.9, 10.8, 12.0, 13.3). There is some indication of the population of ^{13}C*(9.5, 13.9, 14.5, 15.2, 16.7, 18.5) (1971GO24). See also (1970OG1A, 1973OG1A).

10. ^{9}Be(^{7}Li, t)^{13}C $\qquad Q_m = 8.181$

At $E(^{7}\text{Li}) = 5.6$ to 6.2 MeV, angular distributions are reported for t_0, t_1, t_{2+3}, t_4 (1969SN02). The t_0 angular distribution has been measured for $E(^{7}\text{Li}) = 1.7$ to 1.9 MeV (1969KA1C). Many of the states populated in reaction 9 are also strongly populated in this reaction (1971GO24: $E(^{7}\text{Li}) = 30.3$ MeV). See also (1970OG1A, 1972GA1E).

11. ^{9}Be(^{12}C, ^{8}Be)^{13}C $\qquad Q_m = 3.281$

Angular distributions have been measured at $E(^{12}\text{C}) = 12$ and 15 MeV involving the transitions to ^{13}C*(0, 3.09, 3.85): the extracted neutron spectroscopic factors for these three states are 0.80, 1.02 and 0.89, respectively (1970BA49, 1971BA68).

12. ^{9}Be(^{14}N, ^{10}B)^{13}C $\quad Q_m = -0.965$

See (1970AJ04).

13. (a) ^{10}B(t, p)^{12}B $\quad Q_m = 6.343 \quad E_b = 23.877$

(b) ^{10}B(t, d)^{11}B $\quad Q_m = 5.198$

(c) ^{10}B(t, α)^{9}Be $\quad Q_m = 13.229$

The p_0 and p_1 yields from reaction (a), the d_0 yield from reaction (b) and the α_0 yield from reaction (c) have been determined for $E_t = 0.8$ to 2.0 MeV. There is no evidence of resonance behavior (1963HO19).

14. ^{10}B(α, p)^{13}C $\quad Q_m = 4.0627$

Proton groups have been observed to the first four states of ^{13}C: see (1959AJ76) and (1975WI04). Angular distributions of ground state protons have been measured at many energies up to $E_\alpha = 30.4$ MeV: see (1970AJ04) and ^{14}N.

The τ_m of ^{13}C*(3.85) is $9.0^{+2.5}_{-1.5}$ psec (1968RI16), 10.7 ± 1 psec (1969HE22), 9.9 ± 0.9 psec (1970GA01). The intensity ratio for the transitions $(3.85 \rightarrow 3.68)/(3.85 \rightarrow 0)$ is 0.55 ± 0.03. The cascade decay via ^{13}C*(3.09), relative to the g.s. decay, is $(2.5 \pm 0.5) \times 10^{-2}$. $E_\gamma = 3854 \pm 1$ keV (1969LI07). Studies of this reaction lead to $J^\pi = \frac{3}{2}^-$ and $\frac{5}{2}^+$ for ^{13}C*(3.68, 3.85): see (1970AJ04) for a summary of the evidence and (1971HIZF). See also (1967SP09) and (1971BU1K; theor.).

15. ^{10}B(^{6}Li, ^{3}He)^{13}C $\quad Q_m = 8.083$

Comparisons of the relative intensities of the ^{3}He groups in this reaction and of the triton groups in the mirror reaction (see reaction 11 in ^{13}N) at $E(^6\text{Li}) = 18$ MeV suggest that the following states are analogs: $6.86 - 6.36$, $7.49 - 7.16$, $9.50 - 9.00$, $9.90 - 9.48$, $(10.82 + 10.75) - (10.36 + 10.36)$ [the first (set of) E_x is in ^{13}C, the second in ^{13}N]. An angular distribution is also reported for ^{13}C*(9.50) and the widths for ^{13}C*(7.55, 7.68, 9.50) are determined to be < 30, 60 ± 30 and < 30 keV, respectively (1974HO06).

16. ^{10}B(^{7}Li, α)^{13}C $\quad Q_m = 21.411$

Angular distributions have been measured at $E(^7\text{Li}) = 5.20$ MeV for the α_0, α_1, α_{2+3} and α_4 groups (1966MC05).

17. ^{10}B(^{14}N, ^{11}C)^{13}C $Q_{\rm m} = 1.141$

At $E(^{10}\text{B}) = 100$ MeV angular distributions are reported for the transitions to ^{13}C*(0, 3.68, 7.5, 11.8) (1975NA15). See also (1970GO1B).

18. ^{11}B(d, γ)^{13}C $Q_{\rm m} = 18.6790$

The 90° γ_0 excitation curve measured for $E_{\rm d} = 1.0$ to 4.2 MeV shows a resonance at $E_{\rm d} = 2.0 \pm 0.1$ MeV (^{13}C*(20.4)) with $\Gamma_{\rm lab} \approx 0.6$ MeV: the peak cross section is ≈ 1.1 μb/sr. The angular distributions of γ_0 are isotropic to within 10% on and off ($E_{\rm d} = 3.6$ MeV) resonance, consistent with E1 radiation (1973WE12).

19. ^{11}B(d, n)^{12}C $Q_{\rm m} = 13.7325$ $E_{\rm b} = 18.6790$

The yield of neutrons and γ-rays has been measured for $E_{\rm d} = 0.2$ to 11 MeV; observed resonances are displayed in Table 13.10 (1958KA31, 1964KU09, 1965AL17, 1967DI01, 1972TH14). The yields of 4.4 and 15.1 MeV γ-rays have been measured by (1972TH14) for $E_{\rm d} = 2.7$ to 5.0 and 4.0 to 4.8 MeV, respectively. Angular correlations for these two γ-rays are reported at $E_{\rm d} = 4.0$, 4.5 and 4.8 MeV (1972TH14). For a listing of polarization measurements, see Table 13.11: measurements at $E_{\rm d} = 11.8$ MeV show that the transition to ^{12}C*(4.4) predominantly involves $j = \frac{1}{2}$ for the transferred proton (1971HI09). See also (1970AJ04), (1970MI1G, 1975SE07; theor.) and ^{12}C in (1975AJ02).

20. ^{11}B(d, p)^{12}B $Q_{\rm m} = 1.145$ $E_{\rm b} = 18.6790$

Some measurements show that the thin-target yield rises smoothly from $E_{\rm d} = 0.3$ to 3.1 MeV with no evidence of resonance: see (1970AJ04). However, (1964BR1A) and (1968CH05) report a resonance in the yields of p_0, p_1 and p_2, and of γ_1 and γ_2: see Table 13.10. Polarization measurements at $E_{\rm d} = 10$ and 12 MeV show that $p_{j=\frac{1}{2}}$ for both the p_0 and p_1 transitions are 0.85 ± 0.15 (1970FI07, 1972FI1E, 1973FI1C). See also (1970VO09, 1974DA13, 1975HU1H) and ^{12}B in (1975AJ02).

21. ^{11}B(d, d)^{11}B $E_{\rm b} = 18.6790$

A polarization measurement has been reported at $E_{\rm d} = 12.6$ MeV (1971ZA04). See also (1970VE06) and ^{11}B in (1975AJ02).

Table 13.10: Resonant structure in ^{11}B + d

Resonant structure in yield of (MeV ± keV)									Γ_{cm} (keV)	E_x (MeV)
γ_0 [a]	n_0 [b]	n_1 [b]	n_2 [b]	n_3 [b]	$\gamma_{15.1}$ [c]	p	$\gamma_{0.9}, \gamma_{1.7}$ [d]	α [e]		
		1.2								19.7 [i]
	1.45					1.5 [g]			≈ 600	19.90
	1.6	1.8 [f]						1.85	≈ 200	20.24
2.0 ± 100										
		2.2 [f]			2.180 ± 10	2.2 [g,h]	≈ 2.1		116 ± 10	20.52
					3.080 ± 15	3.0 [g]			159 ± 15	21.28
	3.6				3.71 ± 20				114 ± 21	21.81
	4.23	4.0	4.1		4.4				broad	22.23
		(5.2)								(23.1)
	9.6	9.6	9.6	9.6						26.8
	10.4		10.4	10.4						27.5

[a] (1973WE12): $\Gamma_{lab} \approx 600$ keV.
[b] (1965AL17, 1967DI01, 1972TH14).
[c] (1958KA31, 1964KU09).
[d] Broad resonance in yields of $\gamma_{0.95}$ and $\gamma_{1.67}$ (1968CH05).
[e] Yield of α_0, α_1, α_2, α_3 (1969FR03).
[f] (1965AL17) report a resonance at 1.8 MeV while (1967DI01) report one at 2.2 MeV, in addition to a sharper structure at 1.2 MeV.
[g] Resonance in polarization of ^{12}B recoils (1967PF02).
[h] Yield of p_0, p_1 and p_2 (1964BR1A).
[i] (1971RI19, 1972SE09) suggest $J^\pi = \frac{5}{2}^-$.

Table 13.11: Polarization measurements in ^{11}B(d, n)^{12}C [a]

E_d (MeV)	Neutron groups	Refs.
0.9	n_0	(1971RI19, 1972SE09)
2.40 – 4.00	n_0, n_1, n_{2+3}	(1972ME06)
3.0 – 5.5	n_0, n_1, n_2, n_3, n_6, n_7	(1974TH02)
5.5	n_0, n_1	(1970BU15)
7.6, 9.6, 11.7	n_0, n_1	(1970TA1B, 1971TA1D, 1971TAZN)
10.0, 11.8	n_0, n_1	(1971HI09)

[a] See also the previous measurements listed in reaction 17 of (1970AJ04).

22. (a) ^{11}B(d, t)^{10}B $\qquad Q_{\rm m} = -5.1984 \qquad E_{\rm b} = 18.6790$

(b) ^{11}B(d, ^{3}He)^{10}Be $\qquad Q_{\rm m} = -5.7356$

For polarization measurements of $t_0 \rightarrow t_3$ at $E_{\rm d} = 27.8$ MeV see (1974VAZO). See also (1974AJ01).

23. ^{11}B(d, α)^{9}Be $\qquad Q_{\rm m} = 8.031 \qquad E_{\rm b} = 18.6790$

At low energies the excitation functions for α_0 and α_1 increase monotonically: see (1970AJ04). Then at $E_{\rm d} = 1.85$ MeV a pronounced resonance is observed in the α_0, α_1, α_2 and α_3 yields (1969FR03). Some gross structure is also observed in these yields for $E_{\rm d} = 1.0$ to 3.2 MeV (1964BR1A, 1969FR03). See also ^{9}Be in (1974AJ01).

24. ^{11}B(t, n)^{13}C $\qquad Q_{\rm m} = 12.4214$

See ^{14}C.

25. ^{11}B(^{3}He, p)^{13}C $\qquad Q_{\rm m} = 13.1852$

Levels derived from proton groups are displayed in Table 13.12. The gamma, neutron and α-widths of the first $T = \frac{3}{2}$ state at $E_{\rm x} = 15.11$ MeV are displayed in Table 13.7 where they are compared with corresponding quantities for ^{13}N*(15.07) (1973AD02, 1975MA21). The particle decays of the $T = \frac{3}{2}$ states show strong charge asymmetries indicating that the isovector and isotensor mixing amplitudes have similar magnitudes (1973AD02). See (1970AJ04) for the earlier work on this state.

Angular distributions have been measured at many energies, see (1970AJ04) for the earlier work and (1970ME1N, 1970ME24, 1971ME01: $E(^{3}{\rm He}) = 3$ MeV; Table 13.12) and (1973WU01, 1971WU1A: $E(^{3}{\rm He}) = 4$, 6, 8, 10, 12 MeV; most states below $E_{\rm x} = 10$ MeV). For ^{13}C*(7.49, 7.55) $\Gamma_\gamma/\Gamma = 0.3 \pm 0.1\%$, $< 0.1\%$ (1971HIZF). See also (1970MA38, 1974GU1D; theor.).

26. ^{11}B(α, d)^{13}C $\qquad Q_{\rm m} = -5.1686$

Angular distributions for the d_0 group have been measured at $E_\alpha = 23$ and 25 MeV (1967AL16). See also (1971BU1K; theor.).

Table 13.12: Levels of ^{13}C from ^{11}B(^{3}He, p)^{13}C [a]

E_x (MeV ± keV)	$\Gamma_{c.m.}$ (keV)	Refs.
0		(1955BI26, 1958MO99, 1963GA03)
3.09		(1955BI26, 1958MO99, 1963GA03, 1971ME01)
3.68	< 5	(1955BI26, 1958MO99, 1963GA03, 1971ME01)
3.85	< 5	(1958MO99, 1963GA03, 1971ME01)
6.871 ± 12 [b]	< 10	(1959YO25, 1963GA03, 1971ME01)
7.500 ± 12	< 5	(1959YO25, 1963GA03, 1971ME01)
7.554 ± 12	< 5	(1959YO25, 1963GA03, 1971ME01)
7.694 ± 14	70 ± 10	(1959YO25, 1963GA03, 1971ME01)
8.869 ± 36	150 ± 30	(1959YO25, 1971ME01)
9.509 ± 12	< 10	(1959YO25, 1971ME01)
9.896 ± 12 [c]	< 10	(1959YO25, 1971ME01)
10.76 ± 10		(1971ME01)
10.82 ± 10		(1971ME01)
11.01 ± 10		(1971ME01)
11.09 ± 10		(1971ME01)
(11.72) [d]		(1973AD02)
15.11		(1973AD02)

[a] A number of higher states were reported in Table 13.7 in (1970AJ04): however, the references for these levels have not been published.

[b] Decay is by n-emission to $^{12}C_{g.s.}$: branching ratio $= 0.99 \pm 0.09$ (1973AD02).

[c] Branching ratios for neutron decay to ^{12}C*(0, 4.4) $= 1.0 \pm 0.2$ and < 0.15, respectively (1973AD02).

[d] For this state these branching ratios are 0.67 ± 0.16 and 0.33 ± 0.08, respectively (1973AD02).

Table 13.13: Neutron capture γ-rays in ^{13}C

E_γ (MeV $\pm$ keV)	Transition	Intensities [a]	
		(1967TH05)	(1968SP01)
4.9458 ± 0.6	capt. $\rightarrow$ g.s.		68 ± 1
4.94546 ± 0.17 [b]	capt. $\rightarrow$ g.s.		
4.946	capt. $\rightarrow$ g.s.	66 ± 3	
3.68428 ± 0.14	$3.68 \rightarrow$ g.s.		32 ± 1
3.68394 ± 0.17 [b]	$3.68 \rightarrow$ g.s.		
3.684	$3.68 \rightarrow$ g.s.	34 ± 2	
1.26176 ± 0.07	capt. $\rightarrow 3.68$		32 ± 1
1.26192 ± 0.06 [b]	capt. $\rightarrow 3.68$		
1.2619 ± 0.4 [c]	capt. $\rightarrow 3.68$		
1.267	capt. $\rightarrow 3.68$	34 ± 2	

[a] Gamma rays per 100 captures. See also (1970AJ04).
[b] (1967PR10).
[c] (1972OP01).

27. ^{11}B(^{6}Li, α)^{13}C $\qquad$ $Q_{\rm m} = 17.205$

Angular distributions are reported at $E(^6{\rm Li}) = 4.72$ MeV for α_0, α_1, α_{2+3}, α_4 and α_{5+6+7} (1966MC05).

28. ^{11}B(^{14}N, ^{12}C)^{13}C $\qquad$ $Q_{\rm m} = 8.4065$

Angular distributions involving the ground state transitions have been measured at $E(^{14}{\rm N}) = 41, 77$ and 113 MeV (1971LI11). See also (1970JA1B) and (1973DE35; theor.).

29. ^{11}B(^{16}O, ^{14}N)^{13}C $\qquad$ $Q_{\rm m} = -2.058$

See (1968OK06) and (1972KU1H; theor.).

Table 13.14: $^{12}C + n$ total cross section measurements [a]

E_n (MeV)	Refs.
$0.001 - 15$	(1975HE02)
$0.07 - 7$	(1970UT1A)
$0.1 - 1.50$	(1970ME1C)
$0.1 - 5.0$	(1975HO1N)
$0.2 - 20$	(1972PEYR)
$2.1 - 4.7$	(1973FA06)
$2.5 - 15$	(1971FO1P, 1971FO24)
$3.03 - 6.94$	(1972GA13)
$4.04 - 5.61$	(1971BO07)
$4.60 - 8.56$ [b]	(1969PE1C)
$5.3 - 6.3$	(1968YA1A)
$6.01 - 8.56$ [c]	(1969PE1C)
7.73, 8.20, 9.00	(1973VE03)
8.0 to 14.5	(1975HA1Z, 1975HA2D)
14.1	(1969GR30)
14.5	(1970AN1F)
$17 - 20.5$	(1970DE14)
$21.0 - 44.2$	(1974BU05)
$24.63 - 58.90$	(1972AU01)
0.9 to 2.5 GeV/c	(1973SC01)
$26 - 54$ GeV	(1974BA52, 1974BA62)
$34 - 273$ GeV/c	(1974JO13, 1975MU1B)

[a] For earlier references see Table 13.11 in (1970AJ04).

[b] Elastic scattering.

[c] Inelastic scattering.

Table 13.15: ^{12}C(n, n)^{12}C polarization studies [a]

E_n (MeV)	Neutron groups	Refs.
1.9 – 5.0	n_0	(1972HO01, 1973HO39)
1.9 – 5.2	n_0	(1972DR03)
2.3	n_0	(1967RO1C)
2.63	n_0	(1973KN06)
2.72 – 2.92	n_0	(1971HA16)
4.55, 4.79., 5.15	n_0	(1974WE1Q)
14.1	n_0, n_1	(1971SE1D)
14.2	n_0, n_1	(1975CA1V)
15.85	n_0, n_1	(1971MA1M)

[a] See Table 13.12 in (1970AJ04) for earlier references. See also (1972BU20).

30. ^{12}C(n, γ)^{13}C

$Q_m = 4.9464$
$Q_0 = 4.94603 \pm 0.00015$ (1968SP01);
$Q_0 = 4.94647 \pm 0.00017$ (1967PR10);
$Q_0 = 4.94643 \pm 0.00003$ (1975SM02).

The thermal capture cross section is 3.4 ± 0.3 mb (1973MU14). Reported γ-transitions are displayed in Table 13.13. See also (1967MO05, 1967RA24, 1975LA1K, 1975SH18), (1970CL1C, 1973CL1E; astrophys.) and (1974MA10; theor.). At $E_n = 14$ MeV, there is some indication that γ_0 peaks backwards (1975AR19).

31. ^{12}C(n, n)^{12}C

$E_b = 4.9464$

The coherent scattering length $a_{coh} = 6.6572 \pm 0.0013$ fm (1971KO1F, 1975KO29). (1973MU14) had adopted 6.65 ± 0.01 fm. A listing of recent σ_t measurements is displayed in Table 13.14, and the recent polarization measurements are shown in Table 13.15. See also (1972BU20, 1973FA06) and (1970GA1A) for a review of earlier angular distributions.

A number of resonances have been observed for $E_n = 2$ to 20 MeV: see Table 13.16. The parameters of the resonances with $E_n > 6.3$ MeV are poorly known.

See also (1969BE1F, 1969FA1B, 1970AH1B, 1971CR06, 1974HE1E, 1976HO1B), (1971PL1C, 1972LA1F, 1973BR1C, 1975HA2C, 1975LA1K, 1975RO1G), (1970CO1J, 1970ER1A, 1970GN1A, 1970SH14, 1970YO1C, 1971CH01, 1971DO15, 1971GR48, 1971MI07, 1971WE08, 1972AD02,

Table 13.16: Resonances in ^{12}C(n, n)^{12}C [a]

E_{res} (MeV ± keV)	Γ_{cm} (keV)	^{13}C* (MeV)	l_n	J^π		Refs.
		3.09	0	$\frac{1}{2}^+$	$\theta^2 = 0.185$ [b]	(1970ME1C)
2.079 ± 3 [c]	6	6.864	2	$\frac{5}{2}^+$	[f]	(1961LA1A, 1963PI03, 1968DA1F, 1973HO39, 1975HE02)
2.819 ± 3 [d]	1.2 ± 0.3	7.547				(1968CI1A, 1975HE02)
2.94 ± 10 [c]	124 ± 7	7.66	2	$\frac{3}{2}^+$		(1973FA06, 1973HO39, 1975HU01)
3.472 ± 15 [c]	1000 ± 50	8.149	2	$\frac{3}{2}^+$	$\theta^2 = 0.35$ [f]	(1961FO07, 1973FA06, 1973HO39, 1975HU01)
4.259 ± 15 [c]	210 ± 15	8.875	1	$\frac{1}{2}^-$	$\Gamma_{el}/\Gamma = 1.00$ [f]	(1961FO07, 1972GA13, 1973FA06, 1973HO39)
4.935 ± 4	5	9.498	1	$(\frac{1}{2}^-, \frac{3}{2}^-)$	1.00 [f]	(1961FO07, 1969DA13, 1972GA13, 1975HE02)
5.368 ± 5	26 ± 3	9.897	1	$\frac{3}{2}^-$	0.70 ± 0.10 [f]	(1961FO07, 1969DA13, 1972GA13, 1975HE02)
6.294 ± 5	53 ± 4	10.751	3	$\frac{7}{2}^-$	0.70 ± 0.10	(1961FO07, 1969DA13, 1972GA13, 1975HE02)
6.5		10.9				(1961FO07)
6.558 ± 8	37 ± 4	10.994	(0)	$(\frac{1}{2}^+)$	0.40 ± 0.10	(1961FO07, 1972GA13)
6.7		11.1				(1961FO07)
(7.4)	(250)	(11.8)		$(\geq \frac{5}{2})$		(1961FO07)
7.759 ± 8	(200)	12.102		$(> \frac{7}{2})$		(1961FO07, 1969DA13)
(8.1)	(150)	(12.4)				(1961FO07)
9.3	370	13.5				(1961FO07)
11.1	450	15.2		$(\geq \frac{3}{2})$		(1961FO07)
12.1	230	16.1				(1961FO07)
15.8 [e]	≈ 460	19.5	1	$(\frac{1}{2}, \frac{3}{2})^-$		(1968BO34)
19.6 ± 200	≈ 1000	23.0				(1965HA21, 1968BO34, 1970DE14)

[a] See Table 13.10 in (1970AJ04) for earlier references. See also (1973MU14).
[b] $\gamma_n^2 = 540$ keV, radius = 4.80 fm (1970ME1C: single bound state + hard sphere scattering). See also (1970UT1A).
[c] See also (1973AB07).
[d] See also (1973KN06).
[e] Resonance in elastic scattering: see also Table 13.17.
[f] See also Table 13.18 and Table I in (1973DA17).

1972FR09, 1972JO11, 1972PE11, 1972PE1H, 1972RO07, 1972RO08, 1973AD01, 1973CO27, 1973LE02, 1973MO1F, 1973WE06, 1974OL1D, 1974PH03, 1974ZA04, 1975CA05, 1976AH02; theor.), ^{12}C in (1975AJ02) and (1970AJ04).

32. (a) ^{12}C(n, n′)^{12}C* $E_b = 4.9464$
(b) ^{12}C(n, n′)^{4}He^{4}He^{4}He $Q_m = -7.2748$

From threshold to $E_n = 19$ MeV, twelve resonances are observed in the yield of 4.4 MeV γ-rays: see Table 13.17 (1959HA13, 1968BO34). Cross sections for production of 4.4 MeV γ-rays have been reported at $E_n = 5.8$ to 7.5 MeV (1970DR11) and for the n_0 and n_1 groups at $E_n = 8$ to 14.5 MeV (1975HA1Z, 1975HA2D). Other inelastic cross sections to individual ^{12}C states have been measured by (1973VE03: $E_n = 7.7$, 8.2, 9.0 MeV) and by (1969GR30: $E_n = 14.1$ MeV). Earlier work is displayed in (1959AJ76, 1970AJ04). For reaction (b) see ^{12}C in (1975AJ02) and (1969GR30, 1975AN01). See also (1969RO1F, 1973VE03, 1974ROXP, 1975HA2C, 1975LA1K), (1970CA13; theor.) and (1974CR1E; applied).

Table 13.17: Resonances in ^{12}C(n, n′$\gamma_{4.4}$)^{12}C [a]

E_n (MeV)	$\Gamma_{c.m.}$ (keV)	E_x in ^{13}C (MeV)
4.96	< 80	9.52
5.42	< 80	9.95
5.98	200	10.46
6.35	120	10.80
6.57	< 80	11.01
6.65	< 80	11.08
7.50	260	11.86
7.81	180	12.15
8.14	220	12.45
9.31	500	13.53
15.8	≈ 450	19.5
≈ 19		22.5 [b]

[a] The first ten resonances are from (1959HA13), the two highest are reported by (1968BO34).
[b] See, however, (1970DE14).

33. ^{12}C(n, 2n)^{11}C $Q_m = -18.722$ $E_b = 4.9464$

See (1969BR1F, 1975BI1K) and (1970AJ04).

34. ^{12}C(n, p)^{12}B $Q_m = -12.588$ $E_b = 4.9464$

The cross section exhibits a weak resonance corresponding to $E_x \approx 20.5$ MeV (1968RI02, 1972BO73) and stronger structures at $E_x \approx 21.5$ MeV (1968RI02, 1970BA1L), 22.8 and 23.6 MeV (1970BA1L; abstract). See also (1971CU1B, 1972ED01, 1975LA1K, 1975MC19) and (1974OL03; theor.).

35. ^{12}C(n, d)^{11}B $Q_m = -13.7325$ $E_b = 4.9464$

See (1974PO03, 1975LA1K, 1975MC19).

36. ^{12}C(n, α)^{9}Be $Q_m = -5.702$ $E_b = 4.9464$

The cross section for the α_0 group shows a broad structure at $E_n \approx 8$ MeV (1963DA12). See also (1971SA31, 1973VE03, 1974ROXP). (1975HA2C, 1975LA1K) and ^{9}Be in (1974AJ01).

37. ^{12}C(p, π^+)^{13}C $Q_m = -135.405$

At $E_p = 185$ MeV, angular distributions have been observed for the π^+ groups to the ground state of ^{13}C and to $E_x = 3.08 \pm 0.09$, 3.80 ± 0.12, 6.87 ± 0.18, 7.57 ± 0.16 and 9.51 ± 0.22 MeV. The shape of the distributions and the differential cross sections to the various states are quite different: several kinds of reaction processes appear to be involved (1973DA24). See also (1972RH1A, 1973EI1B), (1973KE02, 1974GR1Q, 1975EI1B, 1975NO05, 1976LE02; theor.) and "*Pion capture and reactions*" section in the "GENERAL" section here.

38. (a) ^{12}C(d, p)^{13}C $Q_m = 2.7218$

(b) ^{12}C(d, np)^{12}C $Q_m = -2.2246$

$Q_0 = 2721.9 \pm 0.8$ keV (1974JO14).

Measurements on the proton groups are summarized in Table 13.18. Angular distributions have been studied at many energies: recent experiments are listed in Table 13.19. For earlier work see (1959AJ76, 1970AJ04). Observed γ-rays are listed in Table 13.16 of (1970AJ04): ground state decays have been observed for ^{13}C*(3.09, 3.68, 3.85). ^{13}C*(3.68) decays via ^{13}C*(3.09) with a $1.6 \pm 0.3\%$ branch (1975TR07). ^{13}C*(3.85) also decays via ^{13}C*(3.68) with a $37 \pm 4\%$ branch (1966GO15), $36.0 \pm 0.7\%$ (1975TR07), with $E_\gamma = 169.25 \pm 0.04$ keV (1969AL17) and via ^{13}C*(3.09) with a $0.6 \pm 0.2\%$ branch (1975TR07). Mixing ratios are given in (1970AJ04). Lifetimes of the first three excited states are displayed in Table 13.5. Recent measurements give $\tau_{\rm m} = 12.4 \pm 0.8$ psec (1974BE48), 13.0 ± 0.4 psec (1975RA29) for ^{13}C*(3.85): its nuclear g-factor is 0.59 ± 0.05 (1974BE48).

Reaction (b) has been studied in a kinematically complete experiment at $E_{\rm d} = 5.00$ to 9.85 MeV: there is some evidence for p-n final state interaction (1973SA03). See also (1969PH1B, 1972GE1G).

See also (1967SP09, 1970BO20, 1970HO37, 1973MU1H, 1975ZA06, 1976SC1G), (1974FO1J), (1969ST1D, 1970DO10, 1970EL01, 1970KU1B, 1970OH06, 1970OH1C, 1970PE1B, 1971BR1H, 1971BU02, 1971PE10, 1972DZ06, 1972GO27, 1973CO23, 1973CO27, 1973DO02, 1974GO02, 1974OR1A, 1975GR12, 1975HU01, 1975IS03; theor.) and ^{14}N.

39. ^{12}C(t, d)^{13}C $\qquad Q_{\rm m} = -1.3112$

At $E_{\rm t} = 12$ MeV angular distributions have been studied by (1966GL01: $\rm d_0 \rightarrow d_3$). See also (1969AR1B).

40. ^{12}C(^{3}He, 2p)^{13}C $\qquad Q_{\rm m} = -2.7720$

The angular distributions for the transitions to ^{13}C*(0, 3.85) have been studied at $E(^3{\rm He}) =$ 40 MeV (1971ST21). The proton decay of various ^{14}N states to $^{13}{\rm C}_{\rm g.s.}$ has been studied by (1974NO01): see ^{14}N. See also (1970AJ04).

41. ^{12}C(α, ^{3}He)^{13}C $\qquad Q_{\rm m} = -15.6321$

Angular distributions of the ^{3}He particles have been measured at $E_\alpha = 56$ MeV (1969GA11: to ^{13}C*(0, $3.68 + 3.85$)), 104 MeV (1972HA08: to ^{13}C(0)) and 139 MeV (1973SM03: to ^{13}C*(0, 3.85)). A detailed comparison has been made between the angular distributions of the ground state ^{3}He particles and of the tritons from the mirror reaction ^{12}C(α, t)^{13}N (1969GA11, 1972HA08). See also (1974HA32; theor.).

Table 13.18: Levels of ^{13}C from ^{12}C(d, p)^{13}C

E_x (MeV ± keV)			Γ_{cm} (keV)	l_n [b]	J^π [b]	S
A	(1955MC75)	(1973GO03, 1975TR07)				
0	0			1	$\frac{1}{2}^-$	0.58 ± 0.04 [c]
						1.1 [d]
3.087 ± 5	3.09	3.0884 ± 0.2 [g]		0	$\frac{1}{2}^+$	0.36 ± 0.02 [c]
						1.1 [d]
3.685 ± 7	3.68	$\equiv 3.6841$		1	$\frac{3}{2}^-$	0.10 [d]
3.855 ± 7	3.85	3.8535 ± 0.2 [g]		2	$\frac{5}{2}^+$	1.1 [d]
	6.86			2	$\frac{5}{2}^+$	0.04 [d]
	7.470 ± 20					
	7.533 ± 20					
	7.641 ± 20		70 ± 15			
	8.4 ± 300	8.25 [f]	1100 ± 300	2	$\frac{3}{2}^+$	1.0 [d,e]
		8.86 [f]		1	$\frac{1}{2}^-$	0.5 [d,e]
	9.500 ± 20			(1)	$(\frac{3}{2}^-)$	
	9.897 ± 20			1	$\frac{3}{2}^-$	0.1 [d,e]
	10.759 ± 20	10.755 ± 5	56 ± 2			
		10.818 ± 5	24 ± 3			
		10.997 ± 8	82 ± 15			
		11.080 ± 5	< 8			
		11.748 ± 10	107 ± 14			
		11.851 ± 5	68 ± 4			
		11.97 ± 40 [a]	≈ 260			
		12.108 ± 5	81 ± 8			

A: (1951ST19, 1951VA1A, 1954SP01).

[a] May correspond to unresolved states.

[b] See (1970AJ04, 1973DA17).

[c] (1972PE11).

[d] (1973DA17) [HD parameters]. See also (1974GM01, 1975HU01) and Table 13.14 in (1970AJ04).

[e] $\Gamma_{d,p}/\Gamma_n = 0.68$, 0.91 and 2.2 for ^{13}C*(8.25, 8.86, 9.90), respectively (1973DA17).

[f] Nominal energies (1973DA17).

[g] From E_γ measurements: E_x relative to adopted energy of ^{13}C*(3.68) (Table 13.4) (1975TR07).

Table 13.19: ^{12}C(d, p)^{13}C angular distribution studies [a]

E_d (MeV)	Proton groups	Refs.
0.39 – 1.36	p_0	(1972HU13)
0.41, 0.51	p_0	(1971PU01)
1.14, 1.18	p_0	(1973LE26)
1.39 – 2.28	p_0	(1970AL26)
1.44 – 1.46	p_1	(1973TR02)
1.82 – 2.50	p_0	(1974GM01)
2.26	p_1, p_2	(1974GM01)
2.46 – 2.80	$p_0 \rightarrow p_3$	(1973BE25)
2.64 – 2.82	$p_0 \rightarrow p_3$	(1974DA06)
2.71 – 3.07	p_0, p_1	(1972BO56)
3.31 – 3.69	p_0	(1970LE20)
4.5	p_0	(1969GU02)
9.2 – 13.9	p_0, p_1	(1969GU1C)
9.3, 13.3	$p_0 \rightarrow p_4$, $p_8 \rightarrow p_{11}$	(1973DA17)
51.0, 51.5	p_0	(1969BR1E, 1971FE1D)
80.2	p_0, p_1, p_3	(1971DU09)

[a] For earlier measurements see Table 13.15 in (1970AJ04).

42. ^{12}C(^{7}Li, ^{6}Li)^{13}C $\qquad Q_m = -2.304$

Angular distributions have been obtained at $E(^{7}\text{Li}) = 36$ MeV to ^{13}C*(0, 3.09, 3.85) (1973SC26). See also (1973KU12; theor.).

43. ^{12}C(^{11}B, ^{10}B)^{13}C $\qquad Q_m = -6.510$

See (1974AN36) and (1972MO1E, 1973SC1J). See also (1970AJ04).

44. (a) ^{12}C(^{12}C, ^{11}C)^{13}C $\qquad Q_m = -13.7755$

(b) ^{12}C(^{13}C, ^{12}C)^{13}C

For reaction (a) see (1974AN36). See also (1972BR21; theor.). For (b) see reaction 60.

45. ^{12}C(^{14}N, ^{13}N)^{13}C $Q_{\rm m} = -5.607$

Angular distributions have been reported at $E(^{14}\rm N) = 78$ MeV (1970VO02; transitions to both g.s., and also ^{13}N(0) + ^{13}C*(3.85)), 100 MeV (1974DE03: to ^{13}C*(0, 3.09, $3.68 + 3.85$, 7.3 ± 0.3 [may be due to $6.86 + 7.50 + 7.55 + 7.68$]) and 154.8 MeV (1975NA15, 1975VO05, 1976NAZZ: to g.s. and 3.85). The ratio of the differential cross section to $^{13}\rm C_{g.s.}$ and that to $^{13}\rm N_{g.s.}$ (observed via ^{12}C(^{14}N, ^{13}C)^{13}N), as a function of θ, is approximately 1 as expected if mirror symmetry holds (1969VO01, 1970VO02, 1975VO05). See also (1970JA1B, 1973BR1C, 1973SC1J, 1973VO1E, 1974AN36, 1974SC1M, 1975HA1P) and (1970AN1D, 1973DE02, 1973DE35, 1974BR18, 1974BR37, 1975RE04; theor.).

46. (a) ^{12}C(^{17}O, ^{16}O)^{13}C $Q_{\rm m} = 0.804$
(b) ^{12}C(^{18}O, ^{17}O)^{13}C $Q_{\rm m} = -3.100$

See (1974CH1Q).

47. ^{12}C(^{19}F, ^{18}F)^{13}C $Q_{\rm m} = -5.484$

See (1970AJ04).

48. ^{13}B(β^-)^{13}C $Q_{\rm m} = 13.437$

^{13}B decays to a number of states of ^{13}C: see Table 13.2.

49. ^{13}C(γ, γ)^{13}C

For $\tau_{\rm m}$ studied by resonant scattering see Table 13.5.

50. (a) ^{13}C(γ, n)^{12}C $Q_{\rm m} = -4.9464$
(b) ^{13}C(γ, 2n)^{11}C $Q_{\rm m} = -23.668$

The cross section exhibits structure at 13.3 ± 1 [$\Gamma = 5 \pm 1$ MeV] and at ≈ 22 MeV [$\Gamma \approx 7$ MeV] (1957CO57, 1975PA09, 1976MC1L). Indications of structures at other E_x are reported by (1965BE1A, 1970FU09, 1976JU1A, 1976MC1L). ^{12}C*(15.11) [$J^\pi = 1^+$; $T = 1$] is populated to a large extent by neutrons emitted from the $T = \frac{3}{2}$ component of the giant resonance in ^{13}C (1971MU11). ^{12}C*(4.4) is populated most strongly at ^{13}C*(13.3) (1975PA09). See also (1973AR1L), (1974KI03, 1974MA10; theor.) and (1973FR1F; applied). For reaction (b) see (1975PA09, 1976MC1L).

51. ^{13}C(γ, p)^{12}B $\qquad Q_m = -17.534$

(1964DE12) report structures at $E_\gamma = 18.5$, 20.0, 23.5, 26.0 and 29.0 MeV. The main part of the cross section is in the 23.5 MeV peak which has $\Gamma \approx 3$ MeV. A broad maximum near 25.5 MeV has been reported by (1956CO72, 1957CO57). The cross section to ^{12}B*(0.95) shows a broad maximum at $E_\gamma = 25$ MeV (1975PA09). See also (1974KI03; theor.).

52. ^{13}C(γ, α)^{9}Be $\qquad Q_m = -10.648$

See (1970AJ04).

53. (a) ^{13}C(e, e)^{13}C
(b) ^{13}C(e, ep)^{12}B $\qquad Q_m = -17.534$

The radius of ^{13}C, $r_{rms} = 2.452 \pm 0.047$ [relative to r_{rms} of ^{12}C $= 2.462 \pm 0.022$ fm] (1973FE13). See also (1967CR1C, 1970HE24, 1971BE25, 1971YA02) and (1970BR1C). The rms radius of the magnetization distribution of ^{13}C $= 3.3 \pm 0.3$ fm (1975LA23). The elastic scattering has been studied for $E_e = 120$ to 750 MeV (1970HE24). A number of inelastic groups are seen: see Tables 13.20 and 13.21 (1970WI04, 1971BE51, 1971YA02). A distinct splitting of the giant resonance into two large peaks near $E_x = 20.5$ and 24.5 MeV, with widths of ≈ 3 and ≈ 4 MeV, respectively, is observed. It is suggested that these are groupings of narrower peaks [see Table 13.21]. The $E_x = 20.5$ and 24.5 MeV resonances are probably $T = \frac{1}{2}$ and $T = \frac{3}{2}$, although the 4 MeV splitting is somewhat smaller than expected (1971BE51). See also reactions 50 and 51. See also (1970BR1C, 1972THZF, 1974DE1E, 1975BE1T, 1975SI1H) and (1970BE1G, 1970TI1C, 1973GA19, 1974BE10; theor.).

At $E_e = 43$ MeV the energy and angular distributions of the protons emitted in reaction (b) suggest the involvement of ^{13}C*(21.8?. 24.2, 25.5, 27.5, 31.5) (1970WO1E, 1971SH09). See also (1973DO1L).

Table 13.20: Electromagnetic transitions [a] in ^{13}C from ^{13}C(e, e$'$)^{13}C [b]

E_x (MeV ± keV)	J^π	Mult.	Γ_{γ_0} (eV)	$\Gamma_{\gamma_0}/\Gamma_W$ (W.u.)
3.08 ± 30	$\frac{1}{2}^+$	E1	0.68 ± 0.23	0.62
3.69 ± 20	$\frac{3}{2}^-$	E2	$(3.61 \pm 0.40) \times 10^{-3}$	3.52
		M1	0.358 ± 0.047	0.339
6.85 ± 60	$\frac{5}{2}^+$	M2	$(6.9 \pm 3.6) \times 10^{-5}$	0.055
7.54 ± 20	$\frac{5}{2}^-$	M3	(1.01×10^{-5})	(35)
		E2	0.115 ± 0.007	3.15
8.86 ± 20 [d]	$\frac{1}{2}^-$	M1	3.36 ± 0.47	0.230
		E0	2.09 [c]	
9.90 ± 30	$\frac{3}{2}^-$	E2	$(6.3 \pm 1.1) \times 10^{-3}$	0.045
		M1	0.324 ± 0.038	0.0159
11.07 ± 20	$\frac{1}{2}^-$	M1	1.02 ± 0.12	0.0359
		E0	2.62 [c]	
	$\frac{3}{2}^-$	E2	0.256 ± 0.047	1.03
		M1	0.172 ± 0.020	0.006
11.80	$\frac{3}{2}^-$	M1	3.45 ± 0.86	0.100
15.11 ± 20	$\frac{3}{2}^-$	E2	0.59 ± 0.11	0.50
		M1	22.7 ± 2.7	0.313

[a] See also Tables 13.6 and 13.7.

[b] (1969WI22, 1970WI04). See also (1970YA1C, 1971YA02, 1975LU1B) and (1975FA1A).

[c] Monopole matrix element in fm^2.

[d] $\Gamma = 190 \pm 35$ keV.

Table 13.21: States of ^{13}C from ^{13}C(e, e′)^{13}C* (1971BE51) [a]

E_x (MeV)	Γ_{cm} (keV)	E_x (MeV)	Γ_{cm} (keV)
11.1		20.1	700
11.8		20.5	400
(12.3)		21.3	400
15.1		22.2	1100
16.2	300	24.7	600
(16.9)		25.5	500
17.7	300	27.3	600
18.3	400	28.1	500
18.7	1200	(29.4)	1200
19.3	500		

[a] See also Tables 13.4 and 13.20 and (1970YA1C, 1971YA02, 1973FI1F).

54. ^{13}C(n, n)^{13}C

See ^{14}C.

55. (a) ^{13}C(p, p)^{13}C

(b) ^{13}C(p, pn)^{12}C $\qquad Q_m = -4.9464$

Angular distributions have been studied at $E_p = 1.37$ to 2.38 MeV (1966GE03; p_0), 6.36 and 6.48 MeV (1971VA29; p_1), 7 MeV (1969GU02) and 30.4 MeV (1972GR02; p_0, p_1). Angular distributions of the 3.09 MeV γ-rays are isotropic for E_p up to 5 MeV consistent with the assignment $J = \frac{1}{2}$ for the ground state (1960BA35). For τ_m measurements see (1968RI16) and Table 13.5. See also (1970OH1C, 1973KA04, 1974GU1D; theor.).

Reaction (b) has been studied at $E_p = 7.9$ to 12 MeV (1970OT1A, 1971OT02) and at $E_p = 46$ MeV (1974MI05). One or more ^{13}C states at $E_x = 7.5$ MeV seem to be involved in the sequential decay (1971OT02). See also (1974AV02; theor.), ^{13}N and ^{14}N.

56. ^{13}C(d, d)^{13}C

Angular distributions have been measured at $E_\mathrm{d} = 0.71$ MeV (1971PU01; d_0), 4.7, 5.0 and 5.3 MeV (1968CO04; d_0), 12.8 MeV (1973VA07; d_1), 13.7 MeV (1970GU01; d_0, d_1, d_{2+3}) and 15 MeV (1974BU06). See also (1970LI1E), (1974GU1D; theor.) and ^{15}N.

57. ^{13}C(^{3}He, ^{3}He)^{13}C

Angular distributions of elastically scattered ^{3}He have been studied at $E(^3\mathrm{He}) = 12$, 15 and 18 MeV (1966KE08), 14 MeV (1970NU02), 35.7 MeV (1969AR08) and at 40 MeV (1969BA06). Angular distributions at $E(^3\mathrm{He}) = 40$ MeV have also been reported to ^{13}C states at $E_\mathrm{x} = 3.09$, 3.68, 3.85, 6.86, 7.55 ± 0.03, 8.86 ± 0.03 and 11.84 ± 0.03 MeV. ^{3}He groups to ^{13}C*(9.50 ± 0.03) and (15.11) are also reported: the latter is weak (1969BA06). See also (1974CH58; theor.).

58. ^{13}C(α, α)^{13}C

Elastic angular distributions have been measured at $E_\alpha = 15$, 18 and 20 MeV (1971CO14), 18 to 24 MeV (1973KU18), 18.3 MeV (1973LE28), 24 MeV (1974FE08), 26.6 MeV (1972KU19), 28.4 MeV (1965KO1A), 33.4 MeV (1967AR17) and 40.5 MeV (1966HA19). In addition, (1967AR17) report distributions to ^{13}C*(3.68, 7.5), (1966HA19) to ^{13}C*(3.09, 3.68+3.85, 7.5) and (1965KO1A, 1974FE08) to ^{13}C*(3.09, $3.68 + 3.85$, 6.85, 7.5). See also (1974CH58, 1974KU15; theor.).

59. (a) ^{13}C(^{6}Li, ^{6}Li)^{13}C
(b) ^{13}C(^{7}Li, ^{7}Li)^{13}C

Angular distributions of elastically scattered Li ions have been studied at $E(\mathrm{Li}) = 4.5$, 5.8, 9.0 and 13 MeV (1976PO02; ^{6}Li and ^{7}Li [not 4.5]), 20 MeV (1969BE90; ^{6}Li and ^{7}Li), 28 MeV (1972BA52; ^{6}Li) and 34 MeV (1973SC26; ^{6}Li and ^{7}Li). The inelastic scattering to ^{13}C*(3.09) in reaction (a) has also been studied (1973SC26). See also (1971BA2V, 1972WA31; theor.).

60. (a) ^{13}C(^{12}C, ^{12}C)^{13}C
(b) ^{13}C(^{13}C, ^{13}C)^{13}C
(c) ^{13}C(^{14}C, ^{14}C)^{13}C

Angular distributions for reaction (a) have been studied at $E(^{12}\mathrm{C}) = 10$ to 30 MeV (1968GO1H; elastic), 15 and 19 MeV (1971BO52, 1972BO68; elastic), 20 to 36 MeV (1973CH1L: to ^{13}C*(0, 3.09, 3.68+3.85)) and 87 MeV (1971LI11; elastic). See also (1971WI1J, 1972CH1H, 1974CR03),

(1970GO1B, 1973BR1C, 1973SC1B, 1974GO1L), (1970VO1D, 1973BA2K, 1973DE35, 1973MC1J, 1973SA1K, 1973VO04, 1974GA1L, 1974IM1B, 1975DE09, 1975VO1B; theor.) and ^{12}C in (1975AJ02).

For reaction (b), elastic angular distributions have been measured at $E(^{13}\mathrm{C}) = 15$ to 24 MeV (1973HE12), while for reaction (c) the elastic distribution has been measured at $E(^{13}\mathrm{C}) = 15$ MeV (1972BO68). See also (1972HA2B), (1974GO1L) and (1973MC1J, 1973VO04, 1975DE09, 1975VO1B; theor.).

61. ^{13}C(^{14}N, ^{14}N)^{13}C

The elastic angular distribution has been studied at $E(^{14}\mathrm{N}) = 19.3$ MeV (1971VO01). See also (1973MC1J, 1973VO04, 1975DE09; theor.).

62. (a) ^{13}C(^{16}O, ^{16}O)^{13}C
(b) ^{13}C(^{17}O, ^{17}O)^{13}C
(c) ^{13}C(^{18}O, ^{18}O)^{13}C

Elastic angular distributions have been measured for reaction (a) at $E(^{16}\mathrm{O}) = 10$ to 30 MeV (1968GO1H) and 14, 17 and 20 MeV (1970BA49) and at $E(^{13}\mathrm{C}) = 36$ MeV (1975WE1D, 1975RA33), and, for reaction (c), at $E(^{18}\mathrm{O}) = 15$, 20 and 24 MeV (1971KN05). See also (1974CH1Q). For reaction (b) see (1974CH1Q). See also (1974BE1J; theor.).

63. ^{13}N(β^+)^{13}C $\qquad$ $Q_\mathrm{m} = 2.221$

See ^{13}N.

64. ^{14}C(p, d)^{13}C $\qquad$ $Q_\mathrm{m} = -5.9524$

Angular distributions have been measured at $E_\mathrm{p} = 12$ MeV (1966GL01; d_0), 14.5 MeV (1971CU01; d_0, partial d_2), 18.5 MeV (1963LE03; d_1, d_2, d_3) and 27 MeV (1975CE04; $\mathrm{d}_0 \rightarrow \mathrm{d}_3$). The spectroscopic factors for ^{13}C*(0, 3.09, 3.68, 3.85) are 1.4, 0.02, 1.8 and 0.13, respectively (1975CE04).

65. ^{14}C(d, t)^{13}C $\qquad$ $Q_\mathrm{m} = -1.9194$

Angular distributions have been studied at $E_d = 12$ MeV (1966GL01; $t_0 \rightarrow t_3$) and 14 MeV (1976WE01; $t_0 \rightarrow t_3$; polarized deuterons). The spectroscopic factors for ^{13}C*(0, 3.09, 3.68, 3.85) are 1.00, 0.06, 1.0 and 0.08, respectively (1976WE01). See also ^{16}N in (1977AJ02).

66. ^{14}C(^{3}He, α)^{13}C $\qquad$ $Q_m = 12.4015$

Angular distributions have been measured at $E(^3\text{He}) = 6$, 8 and 10 MeV (1971CO14; α_0) and 44.8 MeV (1966BA13; α_0, α_2 and α to ^{13}C*(15.11)).

67. ^{14}C(^{11}B, ^{12}B)^{13}C $\qquad$ $Q_m = -4.808$

See (1972KU1H; theor.).

68. ^{14}C(^{12}C, ^{13}C)^{13}C $\qquad$ $Q_m = -3.2306$

See (1972BO68).

69. ^{14}C(^{14}N, ^{13}C)^{15}N $\qquad$ $Q_m = 2.657$

See (1975VO1B).

70. ^{14}C(^{16}O, ^{17}O)^{13}C $\qquad$ $Q_m = -4.035$

Angular distributions have been measured at $E(^{16}\text{O}) = 20$, 25 and 30 MeV (1975SC35, 1975SC42): they are well described by DWBA (fixed range approximation). See also (1973BR1C).

71. ^{14}C(^{18}O, ^{19}O)^{13}C $\qquad$ $Q_m = -4.220$

See (1972EY01).

72. ^{14}N(γ, p)^{13}C $\qquad$ $Q_m = -7.5507$

For $E_{bs} = 15.5$ to 29.5 MeV a large fraction of the neutron yield appears to be associated with sequential decay to ^{12}C via ^{13}C*(7.75, 8.86, 11.80) (1970SH06, 1972GE11). Angular distributions measured in the giant resonance region of ^{14}N are consistent with the proton decay of $(p_{1/2})^{-1}$ (2s1d) giant dipole states to $^{13}C_{g.s.}$ and of $(p_{3/2})^{-1}$ (2s1d) states to ^{13}C*(3.68) (1974BA37). The population of ^{13}C*(3.09, 3.85) has also been reported (1970TH01: $E_{bs} = 29$ MeV). See also ^{14}N and (1973KI05; theor.).

73. ^{14}N(n, d)^{13}C $\qquad Q_m = -5.3260$

Angular distributions of d_0 have been determined at $E_n = 14.1$ to 14.7 MeV: see (1970AJ04). See also (1971MI12). Gamma rays with energies of 3.686 and 3.853 MeV are reported by (1971NY03: ±3 keV). Differential cross sections for formation of ^{13}C*(3.09, 3.68) have been measured for $E_n = 10.1$ to 11.0 MeV by (1970DI1A). See also ^{15}N and (1970BO1K; theor.).

74. (a) ^{14}N(e, ep)^{13}C $\qquad Q_m = -7.5507$
(b) ^{14}N(p, 2p)^{13}C $\qquad Q_m = -7.5507$

For reaction (a) see (1969BA1F). At $E_p = 46$ MeV, the summed proton spectrum shows transitions to ^{13}C*(0, 3.68, 7.5, 11.9) (1970WE09, 1970WE1J). At $E_p = 460$ MeV ^{13}C*(0, 7.8, 12.3) are populated: the two excited states are formed by ejection of $p_{3/2}$ protons. There is also some indication of other structure (1966TY01). See also (1972CH21, 1973DE1T; theor.).

75. ^{14}N(d, ^{3}He)^{13}C $\qquad Q_m = -2.0569$

At $E_d = 52$ MeV, angular distributions have been measured for the ^{3}He particles to ^{13}C*(0, 3.09, 3.68, 6.86, 7.5, 8.86, 9.50, 11.9 ± 0.15) and analyzed by DWBA: $J^\pi = \frac{5}{2}^-, \frac{1}{2}^-, \frac{3}{2}^-$ and $\frac{3}{2}^-$, respectively, are assigned to ^{13}C*(7.5, 8.86, 9.50, 11.9) (1968HI01). As expected, angular distributions of ^{3}He and of tritons (from ^{14}N(d, t)^{13}N) to analog states are closely the same: this has been shown for the ground state ^{3}He and triton groups (1966DE1C, 1968GA13: $E_d = 28.5$ MeV; (1974LU06): $E_d = 15$ MeV) and for the groups to ^{13}C*(8.9+9.5) and ^{13}N*(9.2) (1968HI01: $E_d = 52$ MeV). See also ^{16}O in (1977AJ02) and (1974DA1D; theor.).

76. ^{14}N(t, α)^{13}C $\qquad Q_m = 12.2640$

Observed particle groups at $E_t = 2.6$ MeV are displayed in Table 13.22 (1962SI04). See also ^{16}O in (1977AJ02).

Table 13.22: Energy levels of ^{13}C from ^{14}N(t, α)^{13}C (1962SI04) and from ^{15}N(p, ^{3}He)^{13}C (1968FL03)

E_x in ^{13}C [a] (MeV ± keV)	$\Gamma_{c.m.}$ (keV)	E_x in ^{13}C [b] (MeV ± keV)	J^π
0		0	$\frac{1}{2}^-$
3.09 [c]		3.08 ± 20	$\frac{1}{2}^+$
3.68 [c]		3.68 [c]	$\frac{3}{2}^-$
3.85 [c]			
6.86 [c]		6.87 [c]	$\frac{5}{2}^+$
7.5 [c]		7.55 ± 20	$\frac{5}{2}^-$
7.68 [c]			
8.860 ± 20	145 ± 20	8.86 ± 60	$\frac{1}{2}^-$
9.509 [d]		9.52 ± 30	$(\frac{3}{2}^-)$
9.897 [d]			
10.736 ± 20	< 30		
10.809 ± 20	< 30		
11.000 ± 20	< 30		
11.078 ± 20	< 30	11.09 ± 50	$(\frac{1}{2}^-)$
11.721 ± 30	125 ± 20	11.80 ± 30	$(\frac{3}{2}^-)$
12.131 ± 30	125 ± 30		
		12.40 ± 50	$\frac{7}{2}^-$
		15.103 ± 45 [e]	$\frac{3}{2}^-$

[a] From ^{14}N(t, α)^{13}C (1962SI04).
[b] From ^{15}N(p, ^{3}He)^{13}C (1968FL03).
[c] Observed but E_x not determined.
[d] E_x values of other levels given in terms of E_x of these two levels. [See, however, Table 13.4.]
[e] (1966CE02).

77. ^{14}N(α, pα)^{13}C $\qquad Q_m = -7.5507$

This sequential reaction has been studied at $E_\alpha = 22.9$ MeV (1969BA17).

78. ^{14}N(^{6}Li, ^{7}Be)^{13}C $\qquad Q_m = -1.944$

An angular distribution has been obtained at $E(^6\text{Li}) = 32$ MeV for the transition to ^{13}C$_{\text{g.s.}}$ and ^{7}Be*(0, 0.43) [for the mirror reaction see reaction 38 in ^{13}N]: the relative cross sections show a deviation from isospin symmetry which is attributed to Coulomb effects. ^{13}C*(3.09) was also populated (1971GR44, 1971ZE1C).

79. ^{14}N(^{14}N, ^{15}O)^{13}C $\qquad Q_m = -0.259$

See (1966GA04).

80. ^{15}N(γ, d)^{13}C $\qquad Q_m = -16.1597$

See (1973DE30) and ^{15}N.

81. ^{15}N(n, t)^{13}C $\qquad Q_m = -9.9021$

Not reported.

82. ^{15}N(p, ^{3}He)^{13}C $\qquad Q_m = -10.6659$

At $E_p = 43.7$ MeV, ^{3}He groups have been observed to eleven states of ^{13}C: see Table 13.22 (1966CE02, 1968FL03). Angular distributions of the ^{3}He particles to these states are generally found to be in agreement with DWBA predictions, using intermediate coupling wave functions to obtain the two-nucleon structure factors (1968FL03). Detailed comparisons are made with the results of the mirror reaction ^{15}N(p, t)^{13}N: the (p, t) transitions are generally stronger than expected relative to the mirror (p, ^{3}He) transitions. This may arise from interference effect terms due to a spin-orbit interaction in the optical potential, or to interference terms between direct-reaction and core excitation (1968FL02, 1968FL03). A study of both angular distributions and analyzing powers in this reaction and in the mirror (p, t) reaction shows that DWBA generally fails to predict the analyzing powers (1974MA12: $E_p = 43.8$ MeV; pol. protons). Angular distributions have also been measured for the ^{3}He groups to ^{13}C*(0, 3.68, 7.55) at several energies in the range $E_p = 24.0$ to 43.5 MeV (1974PI05, 1975MI01). See also (1969TE1A, 1972HA1X) and ^{16}O in (1977AJ02).

83. ^{15}N(d, α)^{13}C $\qquad Q_m = 7.6879$

Alpha-particle groups have been observed to excited states at $E_x = 3.083$ and 3.677 MeV (1951MA08: ± 5 keV) and 8.80 ± 0.04 MeV (1957WA01: other states were excited but their E_x were not determined). Angular distributions of α_0 have been measured at $E_d \approx 1$ MeV and ≈ 21 MeV: see (1970AJ04). See also (1967SP09).

84. ^{15}N(α, ^{6}Li)^{13}C $\qquad Q_m = -14.686$

At $E_\alpha = 42$ MeV, the angular distribution of the ^{6}Li particles to ^{13}C$_{g.s.}$ has been measured (1968MI05).

85. ^{15}N(^{11}B, ^{13}C)^{13}C $\qquad Q_m = 2.519$

See (1972KU1H; theor.).

86. ^{16}O(n, α)^{13}C $\qquad Q_m = -2.2152$

Angular distributions have been measured at many energies. The earlier results are listed in (1970AJ04). Recent measurements have been carried out at $E_n = 4.9$ MeV (1972KI12; α_0), 13.9 MeV (1971BR33; α_0, α_1, α_{2+3}) and 14.1 MeV (1970AJ03; α_{1+2+3}; (1973BO26); α_0, α_{1+2+3}). Excitation energies derived from γ-ray measurements are 3685 ± 3 and 3854 ± 3 keV (1971NY03). See also (1970DI1C) and ^{17}O in (1977AJ02).

See also (1969KA1D, 1970BR17) and (1973CL1E; astrophys. questions).

87. ^{16}O(α, ^{7}Be)^{13}C $\qquad Q_m = -10.496$

At $E_\alpha = 42$ MeV the angular distribution of the reaction involving ^{13}C(0) and ^{7}Be*($0 + 0.43$) has been measured by (1972RU03).

88. ^{16}O(^{14}N, ^{17}F)^{13}C $\qquad Q_m = -6.950$

This reaction has been studied at $E(^{14}\mathrm{N}) = 79$ MeV (1976MO03) and 155 MeV (1975NA15).

89. ^{17}O(d, ^{6}Li)^{13}C $\qquad Q_{\rm m} = -4.884$

See (1966DE09).

90. ^{18}O(d, ^{7}Li)^{13}C $\qquad Q_{\rm m} = -5.680$

See (1967DE03).

91. ^{20}Ne(n, 2α)^{13}C $\qquad Q_{\rm m} = -6.945$

$$Q_0 = -7.00 \pm 0.02 \text{ (1971KA18).}$$

At $E_{\rm n} = 14.3$ MeV the cross section is 42 ± 8 mb (1971KA18). See also (1966PE08).

^{13}N

(Figs. 3 and 4)

GENERAL (See also (1970AJ04).):

Model calculations: (1971AR1R, 1972DE1H, 1972EL1C, 1972LE1L, 1973DE13, 1973HA49, 1973SA30, 1974PH1D, 1975ME24).

Speacial levels: (1970PE18, 1971AR03, 1971AR1R, 1971JA13, 1971SE1C, 1972BE1E, 1972DE1H, 1973JO1G, 1973SA30, 1974HA1G, 1974PH1D, 1974VA24, 1975KU21, 1975ME24).

Electromagnetic transitions: (1971JA13, 1972NA05, 1973HA1Q, 1973LE06, 1973MA1K, 1973SA25, 1973SA30, 1974AD1B, 1974CH46, 1974RO1R, 1974RO1T, 1975FO1L, 1975KU21, 1975ME24).

Special reactions: (1969GA18, 1969HI1A, 1969KR21, 1970KR1C, 1970LE1D, 1971AR02, 1971BI22, 1974HA61, 1974WO1F, 1975HU14, 1975KU01).

Astrophysical questions: (1973BA1H, 1975EN1A).

Pion reactions: (1971KA62, 1973AL1D, 1973AU06, 1973CH20, 1973NA1H, 1973NA14, 1974RE1E, 1975AL1K, 1975EI1D, 1975GI1B, 1975KA1R).

Applied work: (1973PH1B, 1973WE1N, 1975AL1B, 1975AU1F, 1975VA1J).

Other topics: (1969WA1C, 1970PE18, 1971AR03, 1971AU1G, 1971JA13, 1971SE1C, 1971NG01, 1972AN05, 1972CA37, 1972CH16, 1972LE1L, 1973DE13, 1973GO1H, 1973KA1H, 1973SA25, 1974VA24, 1975GR03, 1975KU01, 1975SH20).

Ground state: (1971AU02, 1971TA1A, 1972LE1L, 1972VA36, 1973MA1K, 1973RO1R, 1973SA25, 1973SA30, 1974HA27, 1975BE31, 1975ME24).

$$\mu = -0.32212 \pm 0.00035 \text{ nm (1964BE24).}$$

See also (1971SH26, 1974SHYR).

1. $^{13}N(\beta^+)^{13}C$ $\qquad Q_m = 2.221$

Measured values of the half-life are displayed in Table 13.22 of (1970AJ04): the weighted mean value of $\tau_{1/2} = 9.961 \pm 0.004$ min. The decay is entirely to $^{13}C_{g.s.}$: $\log ft = 3.643 \pm 0.001$ (1974WI1M). The positrons are completely polarized: see (1970AJ04). See (1969BA1M, 1972KO1A, 1974UL1B) for astrophys. considerations. See also (1972CH1G) and (1970DA21, 1970KO41, 1970PA23, 1970ST04, 1971BL12, 1971LI1H, 1971VA1C, 1971WI18, 1972WI28, 1972WI1C, 1973EM1B, 1973MU1D, 1973SA25, 1973WI04, 1973WI11, 1974LE1G, 1975KR14, 1975ME24, 1975WI1E; theor.).

Table 13.23: Energy levels of ^{13}N

E_x (MeV ± keV)	$J^\pi; T$	Γ_{cm} (keV)	Decay	Reactions
g.s.	$\frac{1}{2}^-$	$\tau_{1/2} = 9.961 \pm 0.004$ min	β^+	1, 2, 3, 10, 12, 13, 14, 15, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47
2.3653 ± 1.1	$\frac{1}{2}^+$	$\Gamma = 33.7 \pm 2$ kev [b]	γ, p	10, 13, 15, 16, 21, 22, 25, 28, 29, 30, 35, 37, 38, 43
3.511 ± 2	$\frac{3}{2}^-$	66 ± 4	γ, p	3, 10, 12, 13, 15, 16, 21, 22, 24, 25, 28, 29, 30, 31, 33, 35, 36, 37, 41, 43
3.547 ± 4	$\frac{5}{2}^+$	47 ± 7	p	3, 10, 12, 13, 16, 21, 22, 24, 25, 28, 29, 30, 31, 35, 37
6.364 ± 9	$\frac{5}{2}^+$	11	p	11, 13, 16, 22, 30, 37, 41
6.885 ± 8	$\frac{3}{2}^+$	115 ± 5	p	11, 13, 16, 22, 35
7.155 ± 5	$\frac{7}{2}^+$	9 ± 0.5	p	3, 11, 13, 16, 22, 30, 37
7.376 ± 9	$\frac{5}{2}^-$	75 ± 5	p	3, 11, 12, 13, 16, 22, 30, 33, 35, 36, 37, 41, 43
8.0	$\frac{3}{2}^+$	≈ 1500	p	13, 16, 37
8.918 ± 11	$\frac{1}{2}^-$	230	p	13, 16, 30, 33, 35, 36, 37, 41
9.00		280 ± 30		11
9.476 ± 8	$\frac{3}{2}^-$	30	p	3, 11, 13, 16, 30, 33, 36
10.25 ± 150	$(\frac{1}{2}, \frac{3}{2})^+$	270 ± 65	γ, p	15
10.36	$\frac{5}{2}^-$	30	p	11, 13, 16, 33
10.36	$\frac{7}{2}^-$	76	p	11, 16
10.833 ± 9	$(\frac{1}{2}^-)$			11, 13, 30, 41
11.530 ± 12	$\frac{5}{2}^+$	430 ± 35	p	11, 13, 16
11.70 ± 30	$\frac{5}{2}^-$	115 ± 30	p	16
11.74 ± 40	$\frac{3}{2}^+$	250 ± 30	γ, p	15, 16
11.74 ± 50	$\frac{3}{2}^-$	530 ± 80	p	16
11.878 ± 12	$(\frac{3}{2}^-)$	380 ± 50	p	12, 13, 16, 30, 35, 36, 37, 41
12.13 ± 50	$\frac{7}{2}^-$	250 ± 30	p	16, 43
12.558 ± 23		> 400		13
12.937 ± 24		> 400		13
13.5 ± 200	$\frac{3}{2}^+$	≈ 6500	γ, p	15
14.04 ± 90	$\frac{3}{2}^+; \frac{1}{2}$	155 ± 20	γ, p, α	15, 16, 19
14.1		≈ 500	p	16

Table 13.23: Energy levels of ^{13}N (continued)

E_x (MeV ± keV)	$J^\pi; T$	Γ_{cm} (keV)	Decay	Reactions
14.7		≈ 500	p	16
15.0651 ± 0.9 [a]	$\frac{3}{2}^-; \frac{3}{2}$	1.10 ± 0.09	γ, p, α	13, 15, 16, 19, 30, 41
15.3 ± 200	$(\frac{3}{2}^+)$	350 ± 150	γ, p	15
15.7		≈ 500	p	16
16.0		≈ 500	p	16
16.02 ± 30	$\frac{7}{2}^+; \frac{1}{2}$	130 ± 30	p	16, 30
16.3		≈ 500	p	16
17.2		≈ 500	p	16
18.23	$\frac{1}{2}^-; \frac{1}{2}$	300	p, α	16, 19
18.4		≈ 500	p	16
18.406 ± 5	$\frac{3}{2}^+; \frac{3}{2}$	66 ± 8	p, α	13, 16, 19
18.7		≈ 500	p	16
18.961 ± 10	$\frac{3}{2}^-$ or $\frac{7}{2}^+; \frac{3}{2}$	23 ± 5	p, α	13, 16, 19
19.3		≈ 500	p	16
19.83	$\frac{5}{2}^-; \frac{1}{2}$	1000	p, α	16, 19
19.88	$\frac{3}{2}^+; \frac{1}{2}$	520	p, α	16, 19
20.9 ± 300	$(\frac{5}{2}^+)$	≈ 1100	n, p	16, 17
21.68			p	16
21.97			p	16
22.4 ± 500	$(\frac{5}{2}^-)$	≈ 2000	p	16
23.3		400	p, ^{3}He	5
23.83 ± 50		350 ± 50	n, p, ^{3}He	5, 16, 17
24.5		$\lesssim 500$	γ, p, ^{3}He	5, 15
25.4	$(\frac{3}{2})^-$		p, ^{3}He	5, 16
25.9	$\geq \frac{3}{2}$	≈ 1000	p, ^{3}He	5, 6, 9
26.84			p	16
28	$\geq \frac{7}{2}$		p, ^{3}He	5
31.9	$T = \frac{1}{2}$	≈ 2000	γ, p, d, ^{3}He, α	6, 9, 15

[a] See also Table 13.7.

[b] See reaction 15 (1974BL06).

2. ^{9}Be(^{6}Li, 2n)^{13}N $\qquad Q_m = 3.947$

See (1957NO17).

3. ^{10}B(^{3}He, γ)^{13}N $\qquad Q_m = 21.638$

The 90° γ_0 cross section has been measured for $E(^3\text{He}) = 4.8$ to 14 MeV: it is typically 40 nb/sr and does not show any pronounced structure. In the same energy interval to 90° cross section for $\gamma_{3.5}$ decreases monotonically from ≈ 500 nb/sr to ≈ 100 nb/sr. Capture transitions to ^{13}N*(7.25 ± 0.15, 9.8 ± 0.3) may also have been observed (1972BE05).

4. ^{10}B(^{3}He, n)^{12}N $\qquad Q_m = 1.569 \qquad E_b = 21.638$

The activation cross section has been measured for $E(^3\text{He}) = 1$ to 6.3 MeV (1963PE10) and 6 to 30.6 MeV (1970SI16). See also (1971ADZZ). There is some evidence of broad structures. See also ^{12}N in (1975AJ02).

5. ^{10}B(^{3}He, p)^{12}C $\qquad Q_m = 19.6948 \qquad E_b = 21.638$

Observed resonances in the yields of proton groups and γ-rays are displayed in Table 13.24. Recent measurements have been carried out at $E(^3\text{He}) = 11.6$ to 18.6 MeV (1972BE56; p_0, p_1) [no indication of resonances] and $E(^3\text{He}) = 4$ to 17 MeV ($\gamma_{15.1}$) and 5 to 12 MeV ($\gamma_{12.7}$) (1972BE05) [some indication in the 90° yield of both γ for the population of ^{13}N*(26., 28.)]. See also (1970BE1F), (1970AJ04) and ^{12}C in (1975AJ02).

6. ^{10}B(^{3}He, d)^{11}C $\qquad Q_m = 3.198 \qquad E_b = 21.638$

Excitation functions have been measured for $E(^3\text{He}) = 3.5$ to 10 MeV (1965PA10; d_0) and 11 to 19 MeV (1972BE56; $d_0 \rightarrow d_3$, d_{4+5}). Resonances are reported in the d_0 yield at $E(^3\text{He}) = 5.8$ MeV and in the 150° d_{4+5} yield at 13.6 MeV [^{13}N*(26, 32)]: see Table 13.24. See also (1970BE1F) and ^{11}C in (1975AJ02).

7. ^{10}B(^{3}He, t)^{10}C $\qquad Q_m = -3.669 \qquad E_b = 21.638$

The excitation function for ^{10}C production has been measured from threshold to $E(^3\text{He}) = 10.5$ MeV: no detailed structure is observed (1964OS1A).

8. ^{10}B(^{3}He, ^{3}He)^{10}B $\qquad E_b = 21.638$

Table 13.24: Structure in $^{10}B + {}^{3}He$

E_{res} (MeV ± keV)	Γ (keV)	Res. in	$^{13}N^*$ (MeV)	Refs.
2.1 [a,b]	500	p_0, (p_1)	23.3	(1956SC01, 1966PA10)
2.85 ± 50	450 ± 50	$\gamma_{15.1}$	23.83 [g]	(1964KU09)
3.6 [a]	700	p_0, p_1	24.4 [g]	(1956SC01, 1966PA10)
3.9	120	p_0	24.6	(1956SC01, 1966PA10)
4.6 [a]	150	p_0, (p_1)	25.2	(1956SC01)
5.2 ± 100 [c]	240 ± 80	p_0, $\gamma_{15.1}$, p_2, p_3	25.6	(1964KU09)
5.6	1000 [d]	(n), p_0, p_2, p_3, $\gamma_{12.7}$, $\gamma_{15.1}$, d_0, α_0	25.9 [g]	(1965PA05, 1972BE05, 1972BE56)
8.5	[e]	(γ_0), p_0, $\gamma_{12.7}$, $\gamma_{15.1}$, (α_0)	28 [g]	(1972BE05, 1972BE56)
13.5 [f]	≈ 2000	(γ_0), d_{4+5}, α_1	32	(1972BE05, 1972BE56)

[a] See, however, (1964KU09).
[b] See also (1967SI05).
[c] See, however, (1966BA01, 1966PA10).
[d] $J \geq \frac{3}{2}$ (1965PA10, 1966PA10).
[e] $J \geq \frac{7}{2}$ (1966PA10).
[f] This may correspond to more than one state (1972BE56).
[g] See also (1970GI04).

See (1970DU07) and ^{10}B in (1974AJ01).

9. $^{10}B(^{3}He, \alpha)^{9}B$ $\quad Q_m = 12.143 \quad E_b = 21.638$

Excitation functions for α_0 and α_1 have been measured for $E(^3He) = 2$ to 10 MeV (1965PA05) and 9 to 19 MeV (1972BE56). Strong resonances are observed at $E(^3He) = 5.8$ MeV (α_0) and ≈ 13.3 MeV (α_1 at 150°): see Table 13.24. See also (1970BE1F, 1970GI04) and ^9B in (1974AJ01).

10. $^{10}B(\alpha, n)^{13}N$ $\quad Q_m = 1.060$

Angular distributions have been measured for $E_\alpha = 1.5$ to 4.6 MeV (n_0) and at ≈ 4.6 MeV (n_1, n_{2+3}) (1973VA25). See also ^{14}N, (1975WI04) and (1970AJ04).

11. $^{10}B(^{6}Li, t)^{13}N$ $\quad Q_m = 5.844$

At $E(^6\text{Li}) = 18$ MeV the known states of ^{13}N with $6.3 < E_x < 11.7$ MeV are observed, with the exception of ^{13}N*(8.0, 8.92). In addition, evidence is presented for a new ^{13}N state at $E_x = 9.00$ MeV with $\Gamma_{cm} = 280 \pm 30$ keV: it is very strongly excited and its angular distribution is similar to that for ^{13}C*(9.50) in the mirror reaction (^{6}Li, ^{3}He) suggesting that these two states are analogs. Other analog assignments made on the basis of corresponding intensities in the mirror reaction are given in reaction 15 of ^{13}C. The widths of ^{13}N*(6.89, 7.38) are, respectively, 120 ± 30 and 70 ± 30 keV (1974HO06). See also (1970AJ04).

12. ^{10}B(^{14}N, ^{11}B)^{13}N $\quad\quad Q_m = 0.902$

At $E(^{10}\text{B}) = 100$ MeV, angular distributions are reported for the transitions to ^{13}N*(0, 3.5, 7.4, 11.9) (1975NA15). See also (1970GO1B) and (1970SC1G, 1972AN25, 1973MC17, 1973OS03, 1975OS01; theor.).

13. ^{11}B(^{3}He, n)^{13}N $\quad\quad Q_m = 10.182$

Neutron groups have been observed to a number of states in ^{13}N: see Table 13.25 (1969AD02, 1971HS03). The gamma, proton and α-widths of the first $T = \frac{3}{2}$ state at $E_x = 15.07$ MeV are displayed in Table 13.7 where they are compared with the corresponding quantities for ^{13}C*(15.11) (1973AD02, 1975MA21). Branching ratios of 0.096 ± 0.014 and 0.164 ± 0.036 are obtained for the proton decay of ^{13}N*(15.07) to ^{12}C*(9.6, 10.8), respectively: these values suggest the importance of 2s-1d shell isospin admixtures in ^{13}N*(15.07) (1974AD1D). [See ^{13}N, reaction 11 in (1970AJ04) for the earlier work.] See also (1974GO23).

14. ^{11}B(^{11}B, ^{9}Li)^{13}N $\quad\quad Q_m = -12.976$

See (1974AN36).

15. (a) ^{12}C(p, γ)^{13}N $\quad\quad Q_m = 1.944$
(b) ^{12}C(p, p$'\gamma$)^{12}C

Resonances for capture radiation are displayed in Table 13.26. [See also Table 13.6 for a summary of the total raditation widths of the low-lying levels of ^{13}C–^{13}N.] No resonance is observed at $E_p = 1.73$ MeV corresponding to ^{13}N*(3.55): $\omega\Gamma_\gamma < 0.006$ eV (1963YO06).

Excitation functions have been measured for $E_p = 150$ to 2500 keV. In addition to the two resonances at $E_p = 0.46$ and 1.70 MeV, direct radiative capture is observed. From the cross

Table 13.25: States of ^{13}N from ^{11}B(^{3}He, n)^{13}N

E_x [a] (MeV $\pm$ keV)	$\Gamma_{c.m.}$ (keV)	L [a]	J^{π} [a]
0		2	$\frac{1}{2}^-$
2.358 ± 10		1	$\frac{1}{2}^+$
3.502 ± 10		0, 2	$\frac{3}{2}^-$
3.55 ± 18			
6.353 ± 9		1, 3	$\frac{5}{2}^+$
6.875 ± 10		1, 3	$\frac{3}{2}^+$
7.145 ± 9		3, 5	$\frac{7}{2}^+$
7.363 ± 8		2, 4	$\frac{5}{2}^-$
8.2 ± 22			
8.918 ± 11			
9.476 ± 8		0, 2	$\frac{3}{2}^-$
10.381 ± 8		2, 4	$\frac{5}{2}^-$
10.833 ± 9			
11.530 ± 12			
11.878 ± 12		0, 2	$\frac{3}{2}^-$
12.558 ± 23	> 400		
12.937 ± 24	> 400		
15.068 ± 8 [b,c]	< 15		$\frac{3}{2}^-; T = \frac{3}{2}$
18.44 ± 40 [b]			$T = \frac{3}{2}$
18.98 ± 20 [b]	40 ± 20		$T = \frac{3}{2}$

[a] (1971HS03) except for those states labeled [b]; $E(^{3}\text{He}) = 4.7$, 6.1 and 6.49 MeV.
[b] (1969AD02): $E(^{3}\text{He}) = 7.0$ to 13.5 MeV.
[c] See also Table 13.7.

Table 13.26: Resonances in ^{12}C(p, γ)^{13}N [a]

$E_{\rm p}$ (MeV $\pm$ keV)	$\Gamma_{\rm lab}$ (keV)	Γ_{γ_0} (eV)	^{13}N* (MeV)	Res. in yield of	J^π	Refs.
0.4568 ± 0.5	39.5 ± 1.0	0.67	2.3649 ± 0.0011	γ_0	$\frac{1}{2}^+$	(1951SE67, 1953HU18)
	36.7 ± 1.0	0.45 ± 0.05 [k]				(1968RI16)
	39 ± 2					(1974RO29)
	36 ± 2 [b]					(1974BL06)
1.699 ± 2 [g]	67 ± 4	0.53	3.511	γ_0	$\frac{3}{2}^-$	(1963YO06, 1974RO29)
9.01 ± 150	280 ± 100	≥ 0.6	10.25	γ_0	$\frac{3}{2}^+$	(1973ME12) [j]
	300 ± 100	≥ 6 [c]			$\frac{1}{2}^+$	
10.62 ± 120	220 ± 50	≈ 4.2 [d]	11.74	γ_0	$\frac{3}{2}^+$	(1973ME12) [j]
12.5 ± 200	7000	≥ 1100	13.5	γ_0	$\frac{3}{2}^+$	(1973ME12) [h,j]
13.12 ± 90	170 ± 20	3.7 ± 1.0 [e]	14.04	γ_0	$\frac{3}{2}^+$	(1973ME12) [j]
14.2	[see text and Table 13.7]		15.0	γ_0, , γ_2	$\frac{3}{2}^-$; $T = \frac{3}{2}$	(1968DI04, 1975MA21)
14.5 ± 200 [f]	380 ± 150	≥ 0.5	15.3	γ_1	$(\frac{3}{2}^+)$	(1973ME12) [j]
20 [i]			20	γ_0		(1963FI07)
24.5			24.5	γ_2		(1963FI07)
32.5 [i]			31.9	γ_0		(1963FI07)

[a] See also Table 13.24 in (1970AJ04).
[b] See text: $\Gamma_{\rm cm} = 33.3 \pm 1.8$ keV (1974BL06).
[c] Assuming interfering background.
[d] A value of 0.30 ± 0.05 is assumed for $\Gamma_{\rm p_0}/\Gamma$: see Table 13.27.
[e] A value of 126 keV is taken for $\Gamma_{\rm p_0}$ (1969LE18).
[f] This peak may be due to an unresolved doublet.
[g] See also (1972JO1B) for possible additional resonances.
[h] See also (1972JO1B).
[i] $T = \frac{1}{2}$ dipole states (1963FI07, 1964TA05).
[j] See also (1972HA32).
[k] 0.64 ± 0.07 eV: see (1975FO1L).

section for that process C^2S $(l = 1)$ is determined to be 0.49 ± 0.15 for the $\frac{1}{2}^-$ $^{13}N_{g.s.}$. In reaction (b), studied for $E_p = 610$ to 2700 keV the capture γ-ray yield is dominated by a direct capture process to ^{13}N*(2.37): C^2S $(l = 0) = 1.02 \pm 0.15$. The cascade decay ^{13}N*($3.51 \rightarrow 2.37$) has an intensity of 8 ± 1% (1974RO29). Extrapolating the cross section to $E_{cm} = 25$ keV yeilds a cross section factor $S = 1.45 \pm 0.20$ keV $\cdot$ b (1974RO29). For other discussions of astrophysical questions see (1971BA1A, 1972CA1N, 1973CL1E, 1973SM1D, 1973TR1E, 1973TR1B).

There have been a number of measurements of the width of ^{13}N*(2.37) in this and in other reactions and suggestions have been made that the width may be reaction dependent: we refer the reader to p.1327 of (1974BL06) for an excellent discussion of this question. It appears that there is no reaction dependence and that the apparent discrepancies arise from questions of detector efficiency, background subtraction and penetrability variations. For the values for Γ reported in this reaction see Table 13.26.

At $E_p = 14.2$ MeV, capture radiation from the first $T = \frac{3}{2}$ state, ^{13}N*(15.07), is reported: $\Gamma_p\Gamma_{\gamma 0}/\Gamma = 5.79 \pm 0.20$ eV which, combined with $\Gamma_p/\Gamma = 0.20 \pm 0.025$ from (1969AD01) yields $\Gamma_\gamma = 24.5 \pm 1.5$ eV. The amplitude ratio of E2/M1 $= 0.013 \pm 0.005$. For the transitions to ^{13}N*(2.37, $3.51 + 3.55$), $\Gamma_\gamma < 2.8 \pm 0.3$ and 19.6 ± 1.4 eV, respectively (1975MA21). The angular distributions of the γ-rays determine $J = \frac{3}{2}$ for ^{13}N*(15.07) (1968DI04): see Table 13.7.

See also (1973RO1U, 1975CR06, 1975NA1C, 1975SW1C), (1973SU1E), (1968SE1A, 1973EI1B, 1974KI03, 1974RO1T; theor.), (1974LO1G; applied) and (1970AJ04).

16. (a) ^{12}C(p, p)^{12}C $E_b = 1.944$
(b) ^{12}C(p, 2p)^{11}B $Q_m = -15.9572$
(c) ^{12}C(p, pα)^{8}Be $Q_m = -7.367$

Yield curves for elastic protons, protons inelastically scattered to ^{12}C*(4.4, 7.7, 9.6, 12.7, 15.1), and for γ-rays from ^{12}C*(12.7, 15.1) have been studied at many energies up to $E_p = 48.5$ MeV: see Table 13.27 for a display of the characteristics of the observed structure. The excitation functions of p_0, p_1 and α_0 have been measured in the region of the $T = \frac{3}{2}$ state at $E_x = 15.07$ MeV: $\Gamma = 1.10 \pm 0.09$ keV, $\Gamma_p = 210 \pm 11$ eV, $\Gamma_p/\Gamma = 0.191 \pm 0.017$ (1975HI07): see Table 13.7.

Total reaction cross section measurements have been made at $E_p = 9.88$ to 19.46 MeV (1970DI08), 22 to 35 MeV (1975SL02), 23.2 to 47.7 MeV (1969MC1A, 1974MC19), 30, 40, 49.5 and 60.8 MeV (1971ME09), 180 to 560 MeV (1972SC1M) and 231, 345, 464 and 552 MeV (1972RE06). The nuclear absorption cross section for p to $\overline{p}$ has been studied at 6 to 60 GeV/c (1973GO41). See (1970AJ04) for a listing of the earlier measurements in the range 10 MeV to 1 GeV. See also ^{12}C in (1975AJ02).

See also (1975CA1L, 1975JA1A, 1975RI1A), (1969TE1A, 1970SL1B, 1971SA1E, 1972BE23) and (1969AB1A, 1969SO1A, 1970CA13, 1970SH01, 1970SH14, 1970SH1J, 1971MI07, 1971IN05, 1971JA13, 1972DA1J, 1972ER1A, 1972JO11, 1972PE11, 1973AD01, 1973CL01, 1973VA1L, 1974IN06, 1974IN07, 1974RE1B, 1974RO1T, 1975BA05, 1975CA05, 1975VI09; theor.).

Spin-flip measurements have been carried out at $E_p = 5.2$ to 6 MeV (1973SA1N), 7.0 to 8.0 MeV

Table 13.27: ^{13}N levels from ^{12}C(p, p), ^{12}C(p, p′) and ^{12}C(p, α) [a]

$E_{\rm res}$ (MeV ± keV)	^{13}N* (MeV)	$\Gamma_{\rm cm}$ (keV)	$l_{\rm p}$	J^π		Refs.
0.461 ± 3	2.369	31 [h]	0	$\frac{1}{2}^+$	$\theta^2 = 0.54$	(1953JA1B, 1954MI05)
1.686 ± 6	3.499	63	1	$\frac{3}{2}^-$	0.031	(1953JA1B, 1966AR03, 1973AN07)
1.734 ± 6 [i]	3.543	74	2	$\frac{5}{2}^+$	0.21	(1953JA1B, 1966AR03, 1973AN07)
4.808 ± 10	6.378	11	2	$\frac{5}{2}^+$	0.0031	(1956RE39, 1967BA1C)
5.370 ± 10	6.896	115 ± 5	2	$\frac{3}{2}^+$	0.13	A
5.65 ± 10	7.15	9 ± 0.5	4	$\frac{7}{2}^+$	0.016	(1963BA36, 1963BA43, 1963NI05)
5.891	7.38	75 ± 5	3	$\frac{5}{2}^-$	0.069	B
6.5	7.9	≈ 1500	2	$\frac{3}{2}^+$	0.14	C
7.54	8.90 [b]	230	1	$\frac{1}{2}^-$	0.02	D, (1973BE37)
8.18	9.49 [c]	30	1	$\frac{3}{2}^-$	0.001	D, (1966SW04, 1972BE15, 1976SO02)
9.13 [d]	10.36	30	3	$\frac{5}{2}^-$		E
9.13 [d]	10.36	76	3	$\frac{7}{2}^-$		E
					$\Gamma_{\rm p}/\Gamma =$	
10.35 ± 50	11.49	430 ± 35	2	$\frac{5}{2}^+$	0.70 ± 0.05	(1972WI26, 1973ME03)
10.58 ± 30	11.70	115 ± 30	3	$\frac{5}{2}^-$	0.60 ± 0.04	(1972WI26, 1973ME03)
10.62 ± 40	11.74	250 ± 30	2	$\frac{3}{2}^+$	0.30 ± 0.05	(1973ME03) [e]
10.62 ± 50	11.74	530 ± 80	1	$\frac{3}{2}^-$	0.55 ± 0.05	(1973ME03) [e]
10.75 ± 40	11.86	380 ± 50	0	$\frac{1}{2}^+$	0.35 ± 0.05	(1973ME03) [e]
11.05 ± 50	12.13	250 ± 30	3	$\frac{7}{2}^-$	0.30 ± 0.05	(1973ME03)
12.5	13.5	≈ 500				(1961NA02)
13.035	13.96	140	2	$\frac{3}{2}^+; T = \frac{1}{2}$		(1969LE18)
13.2	14.1	≈ 500				(1961NA02, 1969FA04)

Table 13.27: ^{13}N levels from ^{12}C(p, p), ^{12}C(p, p$'$) and ^{12}C(p, α) [a] (continued)

$E_{\rm res}$ (MeV $\pm$ keV)	^{13}N* (MeV)	$\Gamma_{\rm cm}$ (keV)	$l_{\rm p}$	J^π		Refs.
13.8	14.7	≈ 500				(1961NA02, 1964DA03)
14.23075 ± 0.2	15.06	1.10 ± 0.09	1	$\frac{3}{2}^-; T = \frac{3}{2}$		F, Table 13.7
14.9	15.7	≈ 500				(1964DA03)
15.2	16.0	≈ 500				(1961NA02, 1964DA03, 1967KU02)
15.27 ± 30	16.02	130 ± 30	4	$\frac{7}{2}^+; T = \frac{1}{2}$		(1969LE18, 1973ME12)
15.6	16.3	≈ 500				(1964DA03)
16.5	17.2	≈ 500				(1964DA03)
17.670	18.23	300	1	$\frac{1}{2}^-; T = \frac{1}{2}$		(1964DA03, 1967KU02, 1969LE18)
17.857 ± 5	18.406	66 ± 8	2	$\frac{3}{2}^+; T = \frac{3}{2}$		(1967KU02, 1969LE18, 1969LE1C)
17.9	18.4	≈ 500				(1964DA03)
18.2	18.7	≈ 500				(1964DA03)
18.460 ± 10	18.961	23 ± 5		$\frac{3}{2}^-$ or $\frac{7}{2}^+; T = \frac{3}{2}$		(1967KU02, 1969LE18, 1969LE1C)
18.8	19.3	≈ 500				(1964DA03)
19.40	19.83	1000	3	$\frac{5}{2}^-; T = \frac{1}{2}$		(1964DA03, 1969LE18) [f,g]
19.46	19.88	520	2	$\frac{3}{2}^+; T = \frac{1}{2}$		(1963ME04, 1965MA26, 1966LO16, 1967SC11) [f,g]
20.55 ± 300	20.9	≈ 1100		$(\frac{5}{2})^+$		(1973ME12) [f]
21.41	21.68					(1963DI16, 1966CR04)
21.73	21.97					(1963DI16, 1966CR04)
22.2 ± 500	22.4	≈ 2000		$(\frac{5}{2}^-)$		(1963ME04, 1966LO16, 1967SC11, 1973ME12) [f]
24.0	24.0	$\lesssim 500$				(1963ME04, 1966LO16, 1975SL02) [f]
25.7	25.6			$(\frac{3}{2})^-$		(1967SC11, 1975SL02) [f]
27.02	26.84					(1963DI16, 1966CR04)

A: (1956RE39, 1961AD04, 1962SH22, 1963BA36, 1963BA43, 1963NI05, 1966BA35, 1967BA1C, 1967DU1A, 1968BE31). See also (1973SA1N).

B: (1956BR27, 1961AD04, 1962SH22, 1963BA36, 1963BA43, 1963NI05, 1966BA35, 1966SH10, 1968BE31).

C: (1956SC29, 1961NA02, 1962SH22, 1966BA35).

D: (1961AD04, 1962SH22, 1966BA35).

E: (1961AD04, 1962SH22, 1966BA35, 1966SW04, 1967SW1A, 1968BE31, 1970DA1G, 1974MU1G, 1976SO02).

F: (1967KU02, 1969LE18, 1969LE1C, 1973HU07, 1975GO03, 1975HI07). See also (1972BA14, 1973SZ1B).

[a] See also Table 13.25 in (1970AJ04).

[b] Decays predominantly by $f_{5/2}$ waves: the reduced width for $f_{5/2}$ emission is $\approx$ the single particle limit (1973BE37).

[c] More than $\approx 90\%$ of inelastic width is in the $p_{1/2}$ channel (1972BE15).

[d] The resonant energies probably do not differ by more than 2 keV (1968BE31).

[e] See also (1972WI26) and (1970AJ04).

[f] See also (1970GI04).

[g] See also (1973ME12).

[h] See reaction 15.

[i] See also (1975CR06).

(1973BE37), 8.0 to 8.3 and 8.9 to 9.4 MeV (1972BE15, 1974MU1G, 1976SO02), 12 to 14 MeV (1970KO15), 12 to 15 MeV and at 20 MeV (1969KO07) and 15.9 to 35.3 MeV (1975DE32): the absolute values of the spin-flip probabilities show pronounced structure at ≈ 20 and 29 MeV, suggesting giant resonance effects. See also ^{12}C in (1968AJ02). Polarization measurements have been carried out for $E_{\rm p} = 0.5$ MeV to 3.6 GeV: see Table 13.26 in (1970AJ04) and Table 13.28 here.

See also (1969RE1A, 1970TS03, 1971CR1A, 1973BI1H), (1971PL1C), (1975ME1E; astrophys.) and (1970SH01, 1971CH01, 1972DE13, 1972SI19, 1973ME1J, 1973MO1E, 1974IN04; theor.).

For reaction (b) see (1970AJ04), ^{11}B in (1975AJ02) and (1975ME1E; astrophys.). For reaction (c) see (1972MA62) and ^{8}Be in (1974AJ01).

For spallation studies see (1969DA1D, 1969EP1B, 1969AZ03, 1970DA30, 1970JU05, 1971FO06, 1972AL1K, 1973BA81, 1973BE36, 1973KR09, 1974BE65, 1975RA14, 1976EDZZ, 1976KO03). See also (1968ED1A, 1970KO25, 1973BA1M, 1973RO1V, 1974CL1G, 1974KO1V) and (1970SC1F; theor.).

17. (a) ^{12}C(p, n)^{12}N $\quad Q_{\rm m} = -18.126 \quad E_{\rm b} = 1.944$
(b) ^{12}C(p, pn)^{11}C $\quad Q_{\rm m} = -18.722$

The cross section for reaction (a) has been measured from threshold to $E_{\rm p} = 50$ MeV. Resonant structure is observed corresponding to $E_{\rm x} = 21$, 24 and, possibly ≈ 27 MeV (1968RI01). See also (1970AM1A, 1971JU05), (1974RE1B; theor.) and ^{12}N in (1975AJ02).

Cross sections for reaction (b) have been measured to $E_{\rm p} = 385$ MeV (see (1970AJ04)), at 450 MeV (1972WA30), at 7.6 GeV (1972BU31) and at 300 GeV (1976KA01). See also (1970DA26, 1970VA1K, 1971DE18, 1973SK1B, 1973WA1G) and (1972DA09; theor.).

18. (a) ^{12}C(p, d)^{11}C $\quad Q_{\rm m} = -16.497 \quad E_{\rm b} = 1.944$
(b) ^{12}C(p, t)^{10}C $\quad Q_{\rm m} = -23.364$
(c) ^{12}C(p, ^{3}He)^{10}B $\quad Q_{\rm m} = -19.6948$

For polarization measurements (reaction (a)) see (1970AJ04). See also (1973TA27, 1974IN07, 1974RE1B; theor.) and ^{11}C in (1975AJ02).

Polarization measurments involving the t_0 and t_1 groups have been carried out at $E_{\rm p} = 49.5$ MeV (1970NE17). See also ^{10}B and ^{10}C in (1974AJ01) and (1974RE1B; theor.).

19. ^{12}C(p, α)^{9}B $\quad Q_{\rm m} = -7.551 \quad E_{\rm b} = 1.944$

Table 13.28: Summary of $^{12}C(p, p)^{12}C$ polarization measurements [a]

E_p (MeV)	Groups	Refs.
≈ 0.5	p_0	(1973DI1F)
1.3 – 2.2	p_0	(1971KL03)
2.0 – 4.5	p_0	(1973HA59)
2.4 – 3.9	p_0	(1965BL02)
4.5 – 6.0	p_0	(1974AL31)
4.7 – 4.9	p_0	(1971NA29)
4.8 – 6.2	p_0	(1974RO42)
5.8 – 6.3	p_0	(1974GU04)
6 – 15	$\gamma_{4.4}$	(1975GL1C)
9.5 – 11.5	p_0, p_1	(1973ME03)
9.95 – 10.90	p_0	(1972WI26)
12 – 18	p_0	(1975ME1H)
≈ 20, 24.5	p_1, p_2	(1974PL02, 1974PL05)
20.3	p_0, p_1, p_2	(1970BL03)
22.3, 26.7, 30.5	p to all states up to $^{12}C^*(14.1)$	(1974PEZU)
22.3, 26.7, 30.5	p to $^{12}C^*(12.7)$	(1974AM05, 1974GEZL)
30.4	p_0, p_1, p_2, p_3	(1972GR02)
40.5	p_0, p_1, p_2, p_3	(1971BE1D)
49.4	p_0, p_1	(1970CL10)
51.8	p_1	(1973HA2F)
180 – 270	p	(1970RE1C)
185	p_0, p_3, p to $^{12}C^*(15.1)$	(1973IN09, 1974IN01, 1974IN06)
399 – 576	p	(1974AE01, 1975AE1A)
990	p	(1972VO20)
2.1 GeV/c	p	(1974ZH1B)

[a] For a listing of earlier polarization measurements [E_p = 1 MeV to 3.6 GeV] see Table 13.26 in (1970AJ04).

Yield curves for α_0 have been measured over the 14.2 MeV resonance, corresponding to the first $T = \frac{3}{2}$ state at $E_x = 15.07$ MeV, and from $E_p = 17$ to 20 MeV. The yield for the α_1 group has been determined for $E_p = 17$ to 21.5 MeV. Parameters of observed resonances are displayed in Table 13.27 (1969LE18, 1975HI07). Excitation functions for α_0 have also been measured for $E_p = 18.5$ to 44 MeV at a number of angles: they exhibit structures which are typically 1 MeV broad (1971GU23). See also (1969KO1D), (1974RE1B; theor.) and ^{9}B in (1974AJ01).

20. ^{12}C(p, ^{6}Li)^{7}Be $\quad$ $Q_m = -22.569$ $\quad$ $E_b = 1.944$

Excitation functions have been measured for $E_p = 36$ to 43 MeV: no structure is apparent (1971HO25). See also (1975FU01) and (1974RE1B; theor.).

21. (a) ^{12}C(d, n)^{13}N $\quad$ $Q_m = -0.281$
(b) ^{12}C(d, pn)^{12}C $\quad$ $Q_m = -2.2246$

Measurements of angular distributions of neutrons are tabulated in Table 13.27 of (1970AJ04). Recent measurements are by (1972DA02: $7.0 \rightarrow 12.0$ MeV; n_0), (1971MU18: 11.8 MeV; n_0, n_1 n_{2+3}) and (1970GA07: 12, 15, 17 MeV; angular distributions of recoils in coincidence with n_0). Forward differential cross sections have been measured by (1972DU01) at 1.69 GeV/c. The cm width of ^{13}N*(2.37) is reported by (1973CL04) as 36.15 ± 0.54 keV: see, however, the discussion in (1974BL06, 1975BO32) and in reaction 15 here; the neutron group to ^{13}N*(2.37) shows a pronounced asymmetry (1975BO32). See also ^{14}N, (1974MA1T, 1975BO35), (1969PH1B), (1970BO1K, 1972PE11, 1974BO53, 1975BO1W; theor.) and (1970DA1F, 1973WE19; applied).

Reaction (b) is dominated at $E_d = 5.0$ to 6.5 MeV and at 9.20 and 9.85 MeV by sequential decay via ^{13}N*(3.51 + 3.55). At lower energies ^{13}N*(2.37) participates also: see (1972VA10, 1972LA03, 1970SA1K, 1972GE1G, 1973SA03, 1973SH04). See also (1972BE54; theor.) and (1970AJ04).

22. (a) ^{12}C(^{3}He, d)^{13}N $\quad$ $Q_m = -3.550$
(b) ^{12}C(^{3}He, pd)^{12}C $\quad$ $Q_m = -5.4938$

Angular distributions have been studied to the first eight states of ^{13}N at $E(^3\text{He})$ up to 29 MeV: see (1970AJ04) for a listing of the earlier work and (1971CO07: 21 MeV; d_0), (1971ST21: 40 MeV; d_0, d_{2+3}). The energies and widths of the first three excited states are $E_x = 2368.2 \pm 2.8$, 3507.8 ± 7.6 and 3549.1 ± 5.0 keV, with $\Gamma_{cm} = 36.1 \pm 2.8$, 54.8 ± 11.5 and 46.5 ± 7.1 keV, respectively (1974BL06). See also (1970BO1K; theor.).

23. ^{12}C(α, t)^{13}N $\qquad Q_m = -17.871$

Angular distributions of the ground state tritons have been measured at $E_\alpha = 56$ MeV (1969GA11) and 104 MeV (1972HA08). See also reaction 41 in ^{13}C.

24. ^{13}C(^{7}Li, ^{6}He)^{13}N $\qquad Q_m = -8.034$

Angular distributions have been obtained at $E(^{7}\text{Li}) = 36$ MeV for the ^{6}He ions to ^{13}N*(0, $3.51 + 3.55$) (1973SC26).

25. ^{12}C(^{10}B, ^{9}Be)^{13}N $\qquad Q_m = -4.642$

Angular distributions have been measured at $E(^{10}\text{B}) = 100$ MeV for the transitions to ^{13}N*(0, 2.37, $3.51 + 3.55$) (1975NA1M). See also (1973YO1D) and (1975RA13; theor.).

26. ^{12}C(^{11}B, ^{10}Be)^{13}N $\qquad Q_m = -9.286$

See (1973SC1J, 1974AN36). See also (1970AJ04).

27. ^{12}C(^{12}C, ^{11}B)^{13}N $\qquad Q_m = -14.014$

See (1971SC1F, 1972SC21, 1974AN36).

28. ^{12}C(^{14}N, ^{13}C)^{13}N $\qquad Q_m = -5.607$

Angular distributions involving $^{13}\text{N}_{\text{g.s.}}$ and various ^{13}C states (see reaction 45 in ^{13}C) have been studied at $E(^{14}\text{N}) = 78$ MeV (1970VO02), 100 MeV (1974DE03) and 155 MeV (1975NA15, 1976NAZZ; also ^{13}N*(2.37, $3.51 + 3.55$)). For a symmetry test at 155 MeV, see reaction 45 in ^{13}C (1975VO05) and (1969VO01). See also (1974AN36), (1970JA1B, 1973BR1C, 1973SC1J, 1973VO1E, 1974SC1M, 1975HA1P) and (1970AN1D, 1973DE02, 1973DE1R, 1973DE35, 1974BR18, 1974BR37, 1975RE04; theor.).

29. (a) ^{12}C(p, n)^{13}N $\qquad Q_m = -3.003$

(b) ^{13}C(p, pn)^{12}C $\qquad Q_m = -4.9464$

Angular distributions of ground state neutrons have been measured at $E_p = 3.1$ to 18.5 MeV [see (1970AJ04)] and at 30 and 50 MeV (1970CL01; also (n_1), n_2), at $E_p = 16.3$ and 22.8 MeV (1975LI11; also n_1, $n_2 + n_3$). Neutron thresholds have been observed to ^{13}N*(0, 3.51) (1966RI09). ^{13}N*(2.37) is weakly populated in this reaction: see e.g., (1961DA09, 1970CL01). See also (1969MO32), (1973CL1E; astrophys. questions), (1970AT1A, 1970DA1E, 1970LA1B, 1970LO1B, 1971GE12; theor.), (1975AU1F, 1975DO1J, 1975LI11; applied work).

In sequential decay of reaction (b) at $E_p = 7.9$ to 12 MeV one or more of the ^{13}N states at $E_x = 3.5$ MeV appear to be involved (1970OT1A, 1971OT02).

30. ^{13}C(^{3}He, t)^{13}N $Q_m = -2.239$

At $E(^3\text{He}) = 39.6$ MeV, angular distributions have been obtained for the tritons corresponding to the ground state of ^{13}N and to the excited states at 2.37, 3.53 ± 0.03 (unresolved), 6.36, 7.16, 7.38, 8.92 ± 0.04, 11.85 ± 0.04 and 15.07 MeV. States at $E_x = 9.5$, 10.78 ± 0.04 and 15.98 ± 0.05 MeV were also populated, the first of these weakly. The transitions to ^{13}N*(7.38, 8.92, 11.85, 15.07) are $L = 2$ [$J^\pi = \frac{5}{2}^-, \frac{1}{2}^-, \frac{3}{2}^-, \frac{3}{2}^-$, respectively] (1969BA06). Angular distributions have also been reported at $E(^3\text{He}) = 14$ MeV (1970NU02; t_0, t_1).

31. ^{13}C(^{6}Li, ^{6}He)^{13}N $Q_m = -5.730$

At $E(^6\text{Li}) = 31.8$ MeV, angular distributions have been measured for the transitions to ^{13}N*(0, $3.51 + 3.55$ (1970CH19, 1971CH1B). See also (1975DI1J; theor.).

32. ^{13}C(^{14}N, ^{14}C)^{13}N $Q_m = -2.377$

See (1971GA05) and (1973TO05; theor.).

33. ^{13}O(β^+)^{13}N $\rightarrow$ ^{12}C + p $Q_m = 15.816$

See ^{13}O.

34. ^{14}N(γ, n)^{13}N $Q_m = -10.554$

See (1973KI05; theor.) and ^{14}N.

35. ^{14}N(p, d)^{13}N $\qquad Q_m = -8.329$

Angular distributions have been measured for the deuterons to ^{13}N*(0, 2.37, $3.51 + 3.55$, 7.38, 8.92, 11.87) at many energies up to $E_p = 155.6$ MeV: see (1970AJ04) for a listing of the earlier work and (1971CU01: $E_p = 14.5$ MeV; d_0) and (1975RO27: $E_p = 65$ MeV; to states listed above; spectroscopic factors). The speparation energy spectrum has been measured at $E_p = 185$ MeV (1973FA10). See also (1971MC15; theor.).

36. ^{14}N(d, t)^{13}N $\qquad Q_m = -4.296$

Angular distributions of the tritons to ^{13}N*(0, 3.51, 7.38, $8.93 + (9.00) + 9.48$, 11.8) have been obtained at $E_d = 52$ MeV and analyzed by DWBA. The spectroscopic factors for the ^{13}N states [and the mirror states reached in the ^{14}N(d, ^{3}He)^{13}C reaction] are in good agreement with theory and are additional evidence for the J^π assignments of $\frac{1}{2}^-$, $\frac{3}{2}^-$, $\frac{5}{2}^-$, $\frac{1}{2}^-$, $\frac{3}{2}^-$ and $\frac{3}{2}^-$ to these states (1968HI01). Comparisons of (d, t) and (d, ^{3}He) angular distributions are also reported by (1966DE1C, 1968GA13) and by (1974LU06: $E_d = 15$ MeV): see reaction 75 in ^{13}C. See also ^{16}O in (1977AJ02) and (1971BO50, 1974DA1D; theor.).

37. (a) ^{14}N(^{3}He, α)^{13}N $\qquad Q_m = 10.025$
(b) ^{14}N(^{3}He, pα)^{12}C $\qquad Q_m = 8.081$

Alpha-particle groups have been observed to the first seven excited states of ^{13}N, including two at $E_x = 7.166$ and 7.388 MeV (1962CL12: ± 8 keV). Angular distributions have been studied at many energies up to $E(^3\text{He}) = 45$ MeV: see (1970AJ04) for a listing of the earlier work and (1972MO39: $3.60 \rightarrow 6.24$ MeV; α_0) and (1970KN01: 4.5, 5.5, 7.0 MeV; α_0, α_1, α_{2+3}). Reaction (b), studied at $E(^3\text{He}) = 8$ MeV, appears to involve some excited states of ^{13}N, possibly ^{13}N*(7.93, 8.92, 11.87) (1969HO13).

38. ^{14}N(^{6}Li, ^{7}Li)^{13}N $\qquad Q_m = -3.303$

An angular distribution has been measured at $E(^6\text{Li}) = 32$ MeV for the transition to $^{13}\text{N}_{\text{g.s.}}$ and ^{7}Li*(0, 0.48). ^{13}N*(2.37) was also populated (1971GR44, 1971ZE1C). See also (1973OG1A), (1974FL1A; theor.) and reaction 77 in ^{13}C.

39. ^{14}N(^{9}Be, ^{10}Be)^{13}N $\qquad Q_m = -3.742$

See (1973TO05; theor.).

40. ^{14}N(^{14}N, ^{15}N)^{13}N $\quad Q_{\rm m} = 0.280$

See (1970GO1B), (1970AN1D, 1970KA41, 1970TR1B, 1971AL1D, 1971AN12, 1973OS03, 1974OS1A, 1975OS01; theor.) and (1970AJ04).

41. ^{15}N(p, t)^{13}N $\quad Q_{\rm m} = -12.905$

At $E_{\rm p} = 43.7$ MeV, angular distributions have been obtained for the tritons corresponding to the ground state of ^{13}N and the excited states at 3.51 ($\frac{3}{2}^-$), 6.38 ± 0.03 ($\frac{5}{2}^+$), 7.38 ($\frac{5}{2}^-$), 8.93 ± 0.05 ($\frac{1}{2}^-$), 10.78 ± 0.06 ($\frac{1}{2}^-$), 11.88 ± 0.04 ($\frac{3}{2}^-$) and 15.07 ($\frac{3}{2}^-$; $T = \frac{3}{2}$) MeV states [J^π values in parentheses, as determined by DWBA analyses using intermediate-coupling wave functions to obtain the two-nucleon structure factors] (1968FL03). Detailed comparisons have been made with the (p, ^{3}He) reaction to the mirror states in ^{13}C (1968FL02, 1968FL03, 1974MA12): see reaction 82 in ^{13}C. Angular distributions have also been measured for the triton groups to ^{13}N*(0, $3.51 + 3.55$, 7.39) at several energies in the range $E_{\rm p} = 24.0$ to 43.5 MeV (1974PI05, 1975MI01). See also (1970HA23, 1972HA1X), (1969TE1A), (1971KA04; theor.) and ^{16}O in (1977AJ02).

42. ^{16}O(γ, t)^{13}N $\quad Q_{\rm m} = -25.033$

See ^{16}O in (1977AJ02).

43. (a) ^{16}O(p, α)^{13}N $\quad Q_{\rm m} = -5.218$

(b) ^{16}O(p, pα)^{12}C $\quad Q_{\rm m} = -7.1616$

Measurements of angular distributions have been reported at $E_{\rm p} = 19$ to 44 MeV (1970GU06, 1971GU23; α_0, α_1) and at 54.1 MeV (1972MA21; α_0, α_2 and α to ^{13}N*(7.38, 12.13)). The parameters of the latter state are: $E_{\rm x} = 12.13 \pm 0.06$ MeV, $\Gamma_{\rm cm} \approx 300$ keV, $J^\pi = \frac{7}{2}^-$ (1972MA21). For earlier work on angular distributions to $E_{\rm p} = 38$ MeV see (1970AJ04). See also (1967SP09) and (1973CL1E; astrophys. questions). For reaction (b) see (1967CH04, 1972BO71). See also ^{17}F in (1977AJ02).

44. ^{16}O(^{3}He, ^{6}Li)^{13}N $\quad Q_{\rm m} = -9.238$

Angular distributions have been studied at $E(^3\text{He}) = 30$ and 40.7 MeV for the ^{6}Li ions corresponding to $^{13}\text{N}_{\text{g.s.}}$ (1972OH01). See also (1966CE02).

45. ^{16}O(α, ^{7}Li)^{13}N $\qquad Q_{\text{m}} = -22.566$

The angular distribution for the transition to $^{13}\text{N}_{\text{g.s.}} + {}^7\text{Li}_{\text{g.s.}+0.48}$ has been measured at $E_\alpha = 42$ MeV (1972RU03).

46. ^{16}O(^{14}N, ^{17}O)^{13}N $\qquad Q_{\text{m}} = -6.411$

This reaction has been studied at $E(^{14}\text{N}) = 79$ MeV (1976MO03) and 155 MeV (1975NA15).

47. ^{18}O(d, ^{7}Li)^{13}N $\qquad Q_{\text{m}} = -7.901$

See (1970AJ04).

^{13}O

(Fig. 4)

GENERAL (See also (1970AJ04)):

Theoretical papers: (1973HA49, 1973RO1R, 1973SP1A, 1975GR03, 1975BE31, 1975HU14).

Review papers: (1972CE1A, 1972WA07, 1973HA77).

Mass of ^{13}O:

From the Q-value of the ^{16}O(^{3}He, ^{6}He)^{13}O reaction [$Q_0 = -30.508 \pm 0.010$ MeV] the atomic mass excess of ^{13}O is determined to be 23.105 ± 0.010 MeV (1971TR03). ^{13}O is then bound with respect to ^{12}N + p and ^{11}C + 2p by 1.528 and 2.123 MeV, respectively.

1. ^{13}O(β^+)^{13}N → ^{12}C + p $\qquad Q_m = 15.816$

The half-life of the delayed proton emitter ^{13}O is 8.7 ± 0.4 msec (1965MC09), 8.95 ± 0.20 msec (1970ES03): we adopt $\tau_{1/2} = 8.90 \pm 0.20$ msec as suggested by (1970ES03). ^{13}O decays to a number of states of ^{13}N some of which subsequently decay to ^{12}C*(0, 4.4): see Table 13.30 (1970ES03). See also (1973TO14, 1974CH46; theor.).

Table 13.29: Energy levels of ^{13}O

E_x (MeV)	$J^\pi; T$	$\tau_{1/2}$ (msec)	Decay	Reactions
g.s.	$(\frac{3}{2}^-); \frac{3}{2}$	8.90 ± 0.20	β^+	1, 2, 3

2. ^{14}N(p, 2n)^{13}O $\qquad Q_m = -29.095$

See (1965MC09, 1970ES03).

3. ^{16}O(^{3}He, ^{6}He)^{13}O $\qquad Q_m = -30.508$

Table 13.30: Beta decay of ^{13}O [a]

Decay to		E_p(cm) (MeV) to		Relative intensity	% of all β-decays	log ft
^{13}N* (MeV)	J^π	^{12}C*(g.s.)	^{12}C*(4.4)			
g.s.	$\frac{1}{2}^-$				88.1 ± 3.4 [b]	4.10 ± 0.02 [b]
3.51	$\frac{3}{2}^-$	observed		100	10.7 ± 3.1	4.52 ± 0.13
7.38	$\frac{5}{2}^-$	5.48 ± 0.05	not seen	0.33 ± 0.10	0.40 ± 0.19	5.22 ± 0.23
8.92	$\frac{1}{2}^-$	observed		3.5 ± 0.3		
					0.54 ± 0.16	4.73 ± 0.14
			2.56 ± 0.05	1.5 ± 0.3		
9.48	$\frac{3}{2}^-$	observed		0.8 ± 0.1		
					0.13 ± 0.04	5.18 ± 0.14
			3.12 ± 0.05	0.43 ± 0.15		
10.36	$\frac{5}{2}^-$	observed		0.05 ± 0.03 [c]		
					0.019 ± 0.012	5.8 ± 0.3
			3.97 ± 0.05	0.13 ± 0.07		

[a] (1970ES03). In addition there is some evidence for weak proton groups with $E_p = 3.44$ and 6.38 MeV (± 0.05 MeV). See also (1965MC09).
[b] The ground state ft was taken to be 1.15 times that for ^{13}B (1970ES03). (1971WI07) find $(ft)^+/(ft)^- = 1.17 \pm 0.03$: see reaction 1 in ^{13}B.
[c] Calculated value from the known ratio of the elastic and inelastic widths.

$$Q_0 = -30.506 \pm 0.013 \text{ (1971TR03)};$$

$$Q_0 = -30.511 \pm 0.015 \text{ (1970ME11: recalculated on basis of } ^{9}\text{C mass excess of 28.908 MeV (see (1974AJ01)).}$$

The ground state of ^{13}O has been populated at $E(^3\text{He}) = 62.6$ and 66.3 MeV (1970ME11) and at 68.2 to 68.6 MeV (1970TR05, 1970TR1F, 1971TR03).

^{13}F, ^{13}Ne

(Not illusrtated)

^{13}F and ^{13}Ne have not been observed. See (1975BE31; theor.).

References

(Closed 31 January 1976)

References are arranged and designated by the year of publication followed by the first two letters of the first-mentioned author's name and then by two additional characters. Most of the references appear in the National Nuclear Data Center files (Nuclear Science References Database) and have NNDC key numbers. Otherwise, TUNL key numbers were assigned with the last two characters of the form 1A, 1B, etc. In response to many requests for more informative citations, we have, when possible, included up to ten authors per paper and added the authors' initials.

1951MA08 R. Malm and W.W. Buechner, Phys. Rev. 81 (1951) 519

1951SE67 J.D. Seagrave, Phys. Rev. 84 (1951) 1219

1951ST19 E.N. Strait, D.M. Van Patter, W.W. Buechner and A. Sperduto, Phys. Rev. 81 (1951) 747

1951VA1A Van Patter, Buechner and Sperduto, Phys. Rev. 82 (1951) 248

1953HU18 S.E. Hunt and W.M. Jones, Phys. Rev. 89 (1953) 1283

1953JA1B Jackson and Galonsky, Phys. Rev. 89 (1953) 370

1953TA06 F.L. Talbott and N.P. Heydenburg, Phys. Rev. 90 (1953) 186

1954BE08 W.E. Bennett, P.A. Roys and B.J. Toppel, Phys. Rev. 93 (1954) 924, K4

1954MI05 E.A. Milne, Phys. Rev. 93 (1954) 762

1954SP01 A. Sperduto, W.W. Buechner, C.K. Bockelman and C.P. Browne, Phys. Rev. 96 (1954) 1316

1955BI26 C.B. Bigham, K.W. Allen and E. Almqvist, Phys. Rev. 99 (1955) 631A

1955MC75 J.N. McGruer, E.K. Warburton and R.S. Bender, Phys. Rev. 100 (1955) 235

1955TA28 N.W. Tanner, Proc. Phys. Soc. A68 (1955) 1195

1956BO61 T.W. Bonner, A.A. Kraus, Jr., J.B. Marion and J.P. Schiffer, Phys. Rev. 102 (1956) 1348

1956BR27 C.P. Browne and J.R. Lamarsh, Phys. Rev. 104 (1956) 1099

1956CO72 B.C. Cook, A.S. Penfold and V.L. Telegdi, Phys. Rev. 104 (1956) 554

1956JA28 D.B. James, G.A. Jones and D.H. Wilkinson, Phil. Mag. 1 (1956) 949

1956RE39 C.W. Reich, G.C. Phillips and J.L. Russell, Jr., Phys. Rev. 104 (1956) 143

1956SC01 J.P. Schiffer, T.W. Bonner, R.H. Davis and F.W. Prosser, Jr., Phys. Rev. 104 (1956) 1064

1956SC29 H. Schneider, Helv. Phys. Acta 29 (1956) 55

1957CO57 B.C. Cook, Phys. Rev. 106 (1957) 300

1957NO17 E. Norbeck, Jr. and C.S. Littlejohn, Phys. Rev. 108 (1957) 754

1957RI38 J.R. Risser, J.E. Price and C.M. Class, Phys. Rev. 105 (1957) 1288

1957WA01 E.K. Warburton and J.N. McGruer, Phys. Rev. 105 (1957) 639

1958KA31 R.W. Kavanagh and C.A. Barnes, Phys. Rev. 112 (1958) 503

1958MO99 C.D. Moak, A. Galonsky, R.L. Traughber and C.M. Jones, Phys. Rev. 110 (1958) 1369

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

1959GI47 J.H. Gibbons and R.L. Macklin, Phys. Rev. 114 (1959) 571

1959HA13 H.E. Hall and T.W. Bonner, Nucl. Phys. 14 (1959) 295

1959MO12 G.C. Morrison and J.A. Galey, Phys. Rev. 116 (1959) 1583

1959YO25 T.E. Young, G.C. Phillips, R.R. Spencer and D.A.A.S.N. Rao, Phys. Rev. 116 (1959) 962

1960BA35 J.K. Bair, H.O. Cohn and H.B. Willard, Phys. Rev. 119 (1960) 2026

1961AD04 H.S. Adams, J.D. Fox, N.P. Heydenburg and G.M. Temmer, Phys. Rev. 124 (1961) 1899

1961DA09 P. Dagley, W. Haeberli and J.X. Saladin, Nucl. Phys. 24 (1961) 353

1961FO07 D.B. Fossan, R.L. Walter, W.E. Wilson and H.H. Barschall, Phys. Rev. 123 (1961) 209

1961LA1A Lane, Langsdorf, Monahan and Elwyn, Ann. Phys. 12 (1961) 135

1961NA02 Y. Nagahara, J. Phys. Soc. Jpn. 16 (1961) 133

1961NO05 E. Norbeck, Phys. Rev. 121 (1961) 824

1962CL12 D.D. Clayton, Phys. Rev. 128 (1962) 2254

1962MA19 A. Marques, A.J.P.L. Policarpo and W.R. Phillips, Nucl. Phys. 36 (1962) 45.

1962SH22 G.G. Shute, D. Robson, V.R. McKenna and A.T. Berztiss, Nucl. Phys. 37 (1962) 535

1962SI04 M.G. Silbert, Phys. Rev. 127 (1962) 2113

1962SI08 J.J. Simpson, M.A. Clark and A.E. Litherland, Can. J. Phys. 40 (1962) 769

1963BA36 F.C. Barker, G.B. Symons, N.W. Tanner and P.B. Treacy, Nucl. Phys. 45 (1963) 449

1963BA43 F.C. Barker, Nucl. Phys. 45 (1963) 467

1963CA09 R.R. Carlson and E. Norbeck, Phys. Rev. 131 (1963) 1204

1963DA12 E.A. Davis, T.W. Bonner, D.W. Worley, Jr. and R. Bass, Nucl. Phys. 48 (1963) 169

1963DI16 J.K. Dickens, D.A. Haner and C.N. Waddell, Phys. Rev. 132 (1963) 2159

1963FI07 P.S. Fisher, D.F. Measday, F.A. Nikolaev, A. Kalmykov and A.B. Clegg, Nucl. Phys. 45 (1963) 113

1963GA03 A. Gallmann, D.E. Alburger, D.H. Wilkinson and F. Hibou, Phys. Rev. 129 (1963) 1765

1963HO19 H.D. Holmgren, L.M. Cameron and R.L. Johnston, Nucl. Phys. 48 (1963) 1

1963LE03 J.C. Legg, Phys. Rev. 129 (1963) 272

1963ME04 D.F. Measday, P.S. Fisher, A. Kalmykov, F.A. Nikolaev and A.B. Clegg, Nucl. Phys. 45 (1963) 98

1963NI05 N. Nikolic, L.J. Lidofsky and T.H. Kruse, Phys. Rev. 132 (1963) 2212

1963PE10 R.W. Peterson and N.W. Glass, Phys. Rev. 130 (1963) 292

1963PI03 G. Pisent and A.M. Saruis, Nuovo Cim. 28 (1963) 600

1963SE04 J.B. Seaborn, G.E. Mitchell, N.R. Fletcher and R.H. Davis, Phys. Rev. 129 (1963) 2217

1963YO06 F.C. Young, J.C. Armstrong and J.B. Marion, Nucl. Phys. 44 (1963) 486; Erratum Nucl. Phys. 49 (1963) 695

1964BE24 A.M. Bernstein, R.A. Haberstroh, D.R. Hamilton, M. Posner and J.L. Snider, Phys. Rev. 136 (1964) B27

1964BR1A Breuer, Z. Phys. 178 (1964) 268

1964DA03 W.W. Daehnick and R. Sherr, Phys. Rev. 133 (1964) B934

1964DE12 V.P. Denisov, A.V. Kulikov and L.A. Kulchitskii, Zh. Eksp. Teor. Fiz. 46 (1964) 1488; Sov. Phys. JETP 19 (1964) 1007

1964KU09 H.-M. Kuan, P.R. Almond, G.U. Din and T.W. Bonner, Nucl. Phys. 60 (1964) 509

1964LI14 I. Lindgren, Perturbed Angular Correlations; Eds., E. Karlsson, E. Matthias and K. Siegbahn (1964) 379

1964MI04 R. Middleton and D.J. Pullen, Nucl. Phys. 51 (1964) 50

1964OS1A Osgood, Patterson and Titterton, Phys. Lett. 10 (1964) 75

1964TA05 N.W. Tanner, G.C. Thomas and E.D. Earle, Nucl. Phys. 52 (1964) 29

1965AL17 P.R. Almond and J.R. Risser, Nucl. Phys. 72 (1965) 436

1965BE1A Bertozzi et al., Nucl. Instrum. Meth. 33 (1965) 199

1965BL02 R.A. Blue and W. Haeberli, Phys. Rev. 137 (1965) B284

1965GI02 J.H. Gibbons and R.L. Macklin, Phys. Rev. 137 (1965) B1508

1965GR22 D.E. Groce and B.D. Sowerby, Nature 206 (1965) 494

1965HA21 M.V. Harlow, Jr., R.L. Robinson and B.B. Kinsey, Nucl. Phys. 67 (1965) 249

1965KO1A Kokame, Fukunaga, Nakamura and Inoue, Suppl. Bull. Inst. Chem. Res. Kyoto Univ. (1965) 26

1965LI09 G.P. Lietz, S.F. Trevino, A.F. Behof and S.E. Darden, Nucl. Phys. 67 (1965) 193

1965MA26 M.Q. Makino, C.N. Waddell and R.M. Eisberg, Nucl. Phys. 68 (1965) 378

1965MC09 R. McPherson, R.A. Esterlund, A.M. Poskanzer and P.L. Reeder, Phys. Rev. 140 (1965) B1513

1965PA05 J.R. Patterson, J.M. Poate and E.W. Titterton, Proc. Phys. Soc. 85 (1965) 1085

1965PA10 J.R. Patterson, J.M. Poate, E.W. Titterton and B.A. Robson, Proc. Phys. Soc. 86 (1965) 1297

1965PO03 A.M. Poskanzer, P.L. Reeder and I. Dostrovsky, Phys. Rev. 138 (1965) B18

1965TA04 R.B. Taylor, N.R. Fletcher and R.H. Davis, Nucl. Phys. 65 (1965) 318

1966AR03 J.C. Armstrong, M.J. Baggett, W.R. Harris and V.A. Latorre, Phys. Rev. 144 (1966) 823

1966BA01 F.C. Barker, J.R. Patterson, J.M. Poate and E.W. Titterton, Phys. Lett. 21 (1966) 318

1966BA13 G.C. Ball and J. Cerny, Phys. Lett. 21 (1966) 551

1966BA35 A.C.L. Barnard, J.B. Swint and T.B. Clegg, Nucl. Phys. 86 (1966) 130

1966CE02 J. Cerny, R.H. Pehl, G. Butler, D.G. Fleming, C. Maples and C. Detraz, Phys. Lett. 20 (1966) 35

1966CR04 R.M. Craig, J.C. Dore, G.W. Greenlees, J. Lowe and D.L. Watson, Nucl. Phys. 79 (1966) 177

1966DE09 L.J. Denes, W.W. Daehnick and R.M. Drisko, Phys. Rev. 148 (1966) 1097

1966DE1C Detraz et al., Phys. Lett. 22 (1966) 638

1966GA04 R.M. Gaedke, K.S. Toth and I.R. Williams, Phys. Rev. 141 (1966) 996

1966GE03 D.G. Gerke, D.R. Tilley, N.R. Fletcher and R.M. Williamson, Nucl. Phys. 75 (1966) 609

1966GL01 R.N. Glover and A.D.W. Jones, Nucl. Phys. 84 (1966) 673

1966GO15 S. Gorodetzky, R.M. Freeman, A. Gallman and F. Hass, Phys. Rev. 149 (1966) 801

1966HA19 B.G. Harvey, J.R. Meriwether, J. Mahoney, A. Bussiere de Nercy and D.J. Horen, Phys. Rev. 146 (1966) 712

1966KE08 E.M. Kellogg and R.W. Zurmuhle, Phys. Rev. 152 (1966) 890

1966LO16 J. Lowe and D.L. Watson, Phys. Lett. 23 (1966) 261

1966MC05 R.L. McGrath, Phys. Rev. 145 (1966) 802

1966MI12 R.G. Miller and R.W. Kavanagh, Nucl. Phys. 88 (1966) 492

1966PA10 J.R. Patterson, J.M. Poate and E.W. Titterton, Proc. Phys. Soc. 88 (1966) 641

1966PE08 S. Petralia, G. Di Caporiacco, M. Mando and G. Parrini, Nuovo Cim. B44 (1966) 225

1966PO11 A.R. Poletti, J.W. Olness and E.K. Warburton, Phys. Rev. 151 (1966) 812

1966RI09 G. Rickards, B.E. Bonner and G.C. Phillips, Nucl. Phys. 86 (1966) 167

1966SH10 G.G. Shute and A.M. Baxter, Nucl. Phys. 83 (1966) 460

1966SW04 J.B. Swint, A.C.L. Barnard, T.B. Clegg and J.L. Weil, Nucl. Phys. 86 (1966) 119

1966TY01 H. Tyren, S. Kullander, O. Sundberg, R. Ramachandran, P. Isacsson and T. Berggren, Nucl. Phys. 79 (1966) 321; Erratum Nucl. Phys. A119 (1968) 692

1967AL16 A.U. Aldzhauakhiri, A.V. Spasskii, I.B. Teplov and L.N. Fateeva, Yad. Fiz. 6 (1967) 248; Sov. J. Nucl. Phys. 6 (1968) 180

1967AR17 K.P. Artemov, V.Z. Goldberg, V.P. Rudakov and I.N. Serikov, Yad. Fiz. 6 (1967) 13; Sov. J. Nucl. Phys. 6 (1968) 9

1967BA1C A.C. Barnard, Phys. Rev. 155 (1967) 1135

1967CH04 R. Chapman and A.M. Macleod, Nucl. Phys. A94 (1967) 324

1967CR1C H. Crannell, L.R. Suelzle, F.J. Uhrhane and M.R. Yearian, Nucl. Phys. A103 (1967) 677

1967DE03 L.J. Denes and W.W. Daehnick, Phys. Rev. 154 (1967) 928

1967DI01 G.U. Din, M.A. Nagarajan and R. Pollard, Nucl. Phys. A93 (1967) 190

1967DU1A J.S. Duval, Jr. , A.C.L. Barnard and J.B. Swint, Nucl. Phys. A93 (1967) 164

1967KI03 K.G. Kibler, Phys. Rev. 155 (1967) 1110

1967KU02 H.M. Kuan and S.S. Hanna, Phys. Lett. B24 (1967) 566

1967MO05 H.T. Motz, E.T. Jurney, O.W.B. Schult, H.R. Koch, U. Gruber, B.P. Maier, H. Baader, G.L. Struble, J. Kern, R.K. Sheline et al., Phys. Rev. 155 (1967) 1265

1967PF02 L. Pfeiffer and L. Madansky, Phys. Rev. 163 (1967) 999

1967PR10 W.V. Prestwich, R.E. Cote and G.E. Thomas, Phys. Rev. 161 (1967) 1080

1967RA24 N.C. Rasmussen, V.J. Orphan and Y. Hukai, Proc. 3rd Int. Conf. on At. Masses, Winnipeg, Canada 1967 (1967) 278

1967RO1C Rogers, Thesis, Case Western Reserve Univ. (1967)

1967SC11 D.K. Scott, P.S. Fisher and N.S. Chant, Nucl. Phys. A99 (1967) 177

1967SI05 D.G. Simons, Phys. Rev. 155 (1967) 1132

1967SP09 A. Sperduto, Proc. 3rd Int. Conf. on At. Masses, Winnipeg, Canada ,1967 (1967) 657

1967SW1A J.B. Swint, J.S. Duval, Jr. , A.C.L. Barnard and T.B. Clegg, Nucl. Phys. A93 (1967) 177

1967TH05 G.E. Thomas, D.E. Blatchley and L.M. Bollinger, Nucl. Instrum. Meth. 56 (1967) 325

1968AJ02 F. Ajzenberg-Selove and T. Lauritsen, Nucl. Phys. A114 (1968) 1

1968AL03 K.W. Allen, P.G. Lawson and D.H. Wilkinson, Phys. Lett. B26 (1968) 138

1968BE31 E.M. Bernstein and G.E. Terrell, Phys. Rev. 173 (1968) 937

1968BO34 F. Boreli, B.B. Kinsey and P.N. Shrivastava, Phys. Rev. 174 (1968) 1147

1968CH05 L.F. Chase, Jr., R.E. McDonald, W.W. True and E.K. Warburton, Phys. Rev. 166 (1968) 997

1968CH28 R. Chiba, N. Nakamura, K. Ebisawa, M. Ikeda, N. Kawai and T. Murata, Phys. Lett. B28 (1968) 173.

1968CI1A Cierjacks et al., Neutron Cross Sections Tech., NBS Special Pub. 299 (1968) 743

1968CO04 R.L.A. Cottrell, J.C. Lisle and J.O. Newton, Nucl. Phys. A109 (1968) 288

1968DA05 C.N. Davids, Nucl. Phys. A110 (1968) 619

1968DA1D Davids, Astrophys. J. 151 (1968) 775

1968DA1F J.C. Davis and H.H. Barschall, Phys. Lett. B27 (1968) 636

1968DI04 F.S. Dietrich, M. Suffert, A.V. Nero and S.S. Hanna, Phys. Rev. 168 (1968) 1169

1968ED1A Edge, Darden, Lankford and Orr, Bull. Amer. Phys. Soc. 13 (1968) 237

1968FL02 D.G. Fleming, J. Cerny and N.K. Glendenning, Phys. Rev. 165 (1968) 1153

1968FL03 D.G. Fleming, J. Cerny, C.C. Maples and N.K. Glendenning, Phys. Rev. 166 (1968) 1012

1968GA13 M. Gaillard, R. Bouche, L. Feuvrais, P. Gaillard, A. Guichard, M. Gusakow, J.L. Leonhardt and J.-R. Pizzi, Nucl. Phys. A119 (1968) 161

1968GO1H A. Gobbi, U. Matter, J.-L. Perrenoud and P. Marmier, Nucl. Phys. A112 (1968) 537

1968HI01 F. Hinterberger, G. Mairle, U. Schmidt-Rohr, P. Turek and G.J. Wagner, Nucl. Phys. A106 (1968) 161

1968MI05 P.F. Mizera and J.B. Gerhart, Phys. Rev. 170 (1968) 839

1968OK06 Y. Okuma, J. Phys. Soc. Jpn. 25 (1968) 1

1968PO04 A.M. Poskanzer, G.W. Butler, E.K. Hyde, J. Cerny, D.A. Landis and F.S. Goulding, Phys. Lett. B27 (1968) 414

1968RI01 E.M. Rimmer and P.S. Fisher, Nucl. Phys. A108 (1968) 561

1968RI02 E.M. Rimmer and P.S. Fisher, Nucl. Phys. A108 (1968) 567

1968RI16 F. Riess, P. Paul, J.B. Thomas and S.S. Hanna, Phys. Rev. 176 (1968) 1140

1968RO02 S.W. Robinson, C.P. Swann and V.K. Rasmussen, Phys. Lett. B26 (1968) 298

1968SE1A Sergeev, Geradin, Wery and Magnac-Valette, Compt. Rend. 261 (1965) 291

1968SP01 P. Spilling, H. Gruppelaar, H.F. De vries and A.M.J. Spits, Nucl. Phys. A113 (1968) 395

1968YA1A Yang et al., Chin. J. Phys. (Taiwan) 6 (1968) 74

1969AB1A Abdinov and Barashenkov, Joint Inst. Nucl. Res., Lab. Theor. Phys., USSR, Rept. P2 4788 (1969)

1969AD01 E.G. Adelberger, C.L. Cocke, C.N. Davids and A.B. McDonald, Phys. Rev. Lett. 22 (1969) 352

1969AD02 E.G. Adelberger, A.B. McDonald and C.A. Barnes, Nucl. Phys. A124 (1969) 49

1969AL17 D.E. Alburger, E.K. Warburton, A. Gallmann and D.H. Wilkinson, Phys. Rev. 185 (1969) 1242

1969AR08 K.P. Artemov, V.Z. Goldberg and V.P. Rudakov, Yad. Fiz. 9 (1969) 1173; Sov. J. Nucl. Phys. 9 (1969) 686

1969AR1B Armstrong, Beery, Keaton and Veeser, LA 4177 (1969)

1969AZ03 S.A. Azimov, R. Aripov, E.V. Beter, U.G. Gulyamov, K. Igamberdiev and O.V. Lozhkin, Yad. Fiz. 10 (1969) 1145; Sov. J. Nucl. Phys. 10 (1970) 652

1969BA06 G.C. Ball and J. Cerny, Phys. Rev. 177 (1969) 1466

1969BA17 K. Bahr, T. Becker, R. Jahr and W.R. Kuhlmann, Nucl. Phys. A129 (1969) 388

1969BA1F V.V. Balashov, N.M. Kabachnik and V.I. Markov, Nucl. Phys. A129 (1969) 369

1969BA1J Balashov, Bochum Conf. STI/PUB/232 IAEA (1969) 59

1969BA1M Bahcall, Bahcall and Ulrich, Astrophys. J. 156 (1969) 559

1969BE1F Bertin et al., France Comm. L'energie Atom. Rept. CEA 3808 (1969)

1969BE90 K. Bethge, C.M. Fou and R.W. Zurmu, Nucl. Phys. A123 (1969) 521

1969BR1E Bruckmann, Kluge and Schanzler, Z. Phys. 221 (1969) 379

1969BR1F Bruninx and Crombeen, Int. J. Appl. Rad. Isotopes 20 (1969) 255

1969CA1A R.R. Carlson and H.W. Wyborny, Phys. Rev. 178 (1969) 1529

1969DA13 J.C. Davis and F.T. Noda, Nucl. Phys. A134 (1969) 361

1969DA1D C.N. Davids, H. Laumer and S.M. Austin, Phys. Rev. Lett. 22 (1969) 1388

1969EP1B M. Epherre, E. Gradsztajn, R. Klapisch and H. Reeves, Nucl. Phys. A139 (1969) 545

1969FA04 J.C. Faivre, D. Garreta, J. Jungerman, A. Papineau, J. Sura and A. Tarrats, Nucl. Phys. A127 (1969) 169

1969FA1B Fasoli, Scotoni, Toniolo and Zago, RC Acad. Naz. Lincei Cl. Sci. Fis. 46 (1969) 725

1969FR03 E. Friedland and H. Verleger, Z. Phys. 222 (1969) 138

1969GA11 P. Gaillard, R. Bouche, L. Feuvrais, M. Gaillard, A. Guichard, M. Gusakow, J.L. Leonhardt and J.R. Pizzi, Nucl. Phys. A131 (1969) 353

1969GA18 J. Galin, B. Gatty, M. Lefort, J. Peter, X. Tarrago and R. Basile, Phys. Rev. 182 (1969) 1267

1969GR30 G.A. Grin, B. Vaucher, J.C. Alder and C. Joseph, Helv. Phys. Acta 42 (1969) 990

1969GU02 H. Guratzsch, G. Hofmann, H. Muller and G. Stiller, Nucl. Phys. A129 (1969) 405

1969GU1C Guratzsch and Stiller, Zentral. Kernf. Rossendorf Dresden. Rept. No. Zfk 189 (1969)

1969HE22 S.H. Henson, D.B. Fossan, P. Paul and K.W. Jones, Phys. Rev. 188 (1969) 1967

1969HI1A Higgins, AD 703259, Naval Postgrad. School, Monterey, CA (1969)

1969HO13 K. Hofmann, W. Mausberg, M. Raabe, E. Rossle and M. Tauber, Z. Phys. 221 (1969) 417

1969JO21 K.W. Jones, W.R. Harris, M.T. McEllistrem and D.E. Alburger, Phys. Rev. 186 (1969) 978.

1969KA1C Kaschlik and Koch, Wiss. Z. Friedrich. Schiller U. Jena. Math. Naturwiss. Reihe (Germany) 18 (1969) 37

1969KA1D Karge, Wiss. Z. Friedrich. Schiller U. Jena. Math. Naturwiss. Reihe (Germany) 18 (1969) 51

1969KA1E Kaschlik, Koch and Treff, Wiss. Z. Friedrich. Schiller U. Jena. Math. Naturwiss. Reihe (Germany) 18 (1969) 11

1969KL09 H.O. Klages and H. Scholermann, Z. Phys. 227 (1969) 344

1969KO07 W.A. Kolasinski, J. Eenmaa, F.H. Schmidt, H. Sherif and J.R. Tesmer, Phys. Rev. 180 (1969) 1006

1969KO1D Konig and Staudi, Bochum Conf. STI/PUB/232 IAEA (1969) 216

1969KR21 N.N. Krasnov, P.P. Dmitriev, Z.P. Dmitrieva, I.O. Konstantinov and G.A. Molin, Atomn. Energ. (USSR) 27 (1969) 125

1969LE18 M.J. LeVine and P.D. Parker, Phys. Rev. 186 (1969) 1021

1969LE1B Leonardi, Cargese Lecture in Phys.; Ed., M. Jean, Vol. 3 (1969) 97

1969LE1C Levine, Thesis, Yale Univ. (1969)

1969LI07 A.E. Litherland, T.K. Alexander and A.T. Jeffs, Can. J. Phys. 47 (1969) 1061

1969MC1A McGill, UCLA P-83 (1969)

1969MO32 J.M. Morris and T.R. Ophel, Nucl. Instrum. Meth. 68 (1969) 344

1969PE1C Perey and Kinney, ORNL-4441 (1969)

1969PH1B Phillips, Bochum Conf. STI/PUB/232 IAEA (1969) 73

1969RA20 V.K. Rasmussen and C.P. Swann, Phys. Rev. 183 (1969) 918

1969RE1A Renevey and Heer, Helv. Phys. Acta 42 (1969) 903

1969RO1F Roturier, Ann. Phys. 4 (1969) 289

1969SN02 F.D. Snyder and M.A. Waggoner, Phys. Rev. 186 (1969) 999

1969SO1A Soroka and Pucherov, Ukr. Fiz. Zh. 14 (1969) 688

1969ST1D Stieglitz, Thesis, Case Western Reserve Univ. (1969)

1969TE1A Temmer, Isospin in Nucl. Phys.; Ed., D.H. Wilkinson (1969) 693

1969TH01 M.J. Throop, Phys. Rev. 179 (1969) 1011

1969VO01 W. Von Oertzen, J.C. Jacmart, M. Liu, F. Pougheon, J.C. Roynette and M. Riou, Phys. Lett. B28 (1969) 482

1969WA1C Warburton and Weneser, Isospin in Nucl. Phys.; Ed., D.H. Wilkinson (1969) 173

1969WI22 G. Wittwer, H.-G. Clerc and G.A. Beer, Phys. Lett. B30 (1969) 634

1969WO03 G. Wolber, H. Figger, R.A. Haberstroh and S. Penselin, Phys. Lett. A29 (1969) 461

1970AH1B Ahmed, Coppola and Knitter, 2nd Int. Conf. on Nucl. Data for Reactors, Helsinki (1970)

1970AJ03 V. Ajdacic, M.L. Chatterjee, N. Cindro and M. Jurcevic, Nucl. Instrum. Meth. 79 (1970) 77

1970AJ04 F. Ajzenberg-Selove, Nucl. Phys. A152 (1970) 1

1970AL1E Albert, Wagner, Uberall and Werntz, Proc. 3rd Int. Conf. on High Energy Phys. and Nucl. Struct., New York, 1969 (1970) 89

1970AL26 M. Allab, M. Amiel, A. Amokrane, H. Beaumevielle, A. Henni and M. Lambert, J. Phys. 31 (1970) 919

1970AM1A Amos, Galonsky and Jolly, Bull. Amer. Phys. Soc. 15 (1970) 1692

1970AN1D Anni and Taffara, Rivista Nuovo Cim. 2 (1970) 1

1970AN1F Angeli, Csikai and Hunyadi, Acta Phys. Acad. Sci. Hung. 28 (1970) 629

1970AR27 A.G. Artukh, V.V. Avdeichikov, J. Ero, G.F. Gridnev, V.L. Mikheev, V.V. Volkov and J. Wilczynski, Phys. Lett. B33 (1970) 407

1970AT1A J. Atkinson and V.A. Madsen, Phys. Rev. C1 (1970) 1377

1970BA1L Baumann, Huck and Walter, Bull. Amer. Phys. Soc. 15 (1970) 567

1970BA49 P.H. Barker, A. Huber, H. Knoth, U. Matter, A. Gobbi and P. Marmier, Nucl. Phys. A155 (1970) 401

1970BE1F Bennett, Thesis, Washington State Univ. (1970)

1970BE1G Beck, Grunbaum and Tomaselli, Proc. 3rd Int. Conf. on High Energy Phys. and Nucl. Struct., New York, 1969 (1970) 63

1970BJ1A Bjornenak, Finjord, Osland and Reitan, Phys. Norvegica 4 (1970) 252

1970BL03 A.G. Blair, C. Glashausser, R. de Swiniarski, J. Goudergues, R. Lombard, B. Mayer, J. Thirion and P. Vaganov, Phys. Rev. C1 (1970) 444

1970BO1K Borbei and Dolinski, Sov. J. Nucl. Phys. 10 (1970) 173

1970BO20 I.I. Bondouk, F. Machali and Z.A. Saleh, Z. Phys. 236 (1970) 170

1970BR17 M. Brendle, M. Morike, G. Staudt and G. Steidle, Nucl. Instrum. Meth. 81 (1970) 141

1970BR1C Brix, Private Communication (1970)

1970BU15 W. Busse, B. Efken, D. Hilscher, J.A. Scheer and W. Wenning, Nucl. Phys. A152 (1970) 354

1970CA13 J. Carcabal, J. Phys. 31 (1970) 151

1970CH19 V.I. Chuev, V.V. Davydov, V.I. Manko, B.G. Novatsky, S.B. Sakuta and D.N.Stepanov, Phys. Lett. B31 (1970) 624

1970CL01 A.S. Clough, C.J. Batty, B.E. Bonner and L.E. Williams, Nucl. Phys. A143 (1970) 385

1970CL10 N.M. Clarke, E.J. Burge, D.A. Smith and J.C. Dore, Nucl. Phys. A157 (1970) 145

1970CL1C Clayton, 2nd Int. Conf. on Nucl. Data for Reactors, Helsinki (1970) 35

1970CO1H Cohen and Kurath, Nucl. Phys. A141 (1970) 145

1970CO1J Conn, Nucl. Sci. Eng. 40 (1970) 17

1970DA1E Danielopoulos and Park, Bull. Amer. Phys. Soc. 15 (1970) 503

1970DA1F Dandl et al., Plasma Phys. 12 (1970) 235

1970DA1G Davids and Donner, Bull. Amer. Phys. Soc. 15 (1970) 1662

1970DA21 A. D'Andrea and M. Scalia, Nuovo Cim. A69 (1970) 702

1970DA26 V.K. Daruga and E.S. Matusevich, Attomn. Energ. (USSR) 29 (1970) 456; Sov. J. At. Energy 29 (1970) 1233

1970DA30 C.N. Davids, H. Laumer and S.M. Austin, Phys. Rev. C1 (1970) 270

1970DE14 G. Deconninck and J.-P. Meulders, Phys. Rev. C1 (1970) 1326

1970DI08 J.F. Dicello and G. Igo, Phys. Rev. C2 (1970) 488

1970DI1A Dickens and Perey, Nucl. Sci. Eng. 40 (1970) 346

1970DI1C Dickens and Perey, Nucl. Sci. Eng. 40 (1970) 283

1970DO04 J.J. Domingo, B.W. Allardyce, C.H.Q. Ingram, S. Rohlin, N.W. Tanner, J. Rohlin, E.M. Rimmer, G. Jones and J.P. Girardeau-Montaut, Phys. Lett. B32 (1970) 309

1970DO10 J. Dobes, Nucl. Phys. A157 (1970) 661

1970DR11 D.M. Drake, J.C. Hopkins, C.S. Young and H. Conde, Nucl. Sci. Eng. 40 (1970) 294

1970DU07 J.L. Duggan, J.Y. Park, S.D. Danielopoulos, P.D. Miller, J. Lin, M.M. Duncan and R.L. Dangle, Nucl. Phys. A151 (1970) 107

1970EL01 M. El-Nadi and O. Zohni, Nucl. Phys. A142 (1970) 87

1970ER1A Ericson and Locher, Nucl. Phys. A148 (1970) 1

1970ES03 J.E. Esterl, J.C. Hardy, R.G. Sextro and J. Cerny, Phys. Lett. B33 (1970) 287.

1970FI07 D. Fick, R. Kankowsky, K. Kilian and E. Salzborn, Phys. Rev. Lett. 24 (1970) 1503

1970FR1C Frahn, Theory of Nucl. Struct., Trieste, 1969, IAEA STI/PUB/249 (1970) 297

1970FU09 K. Fukuda, Nucl. Phys. A156 (1970) 10

1970GA01 A. Gallmann, G. Frick, B. Heusch, F. Haas and E.K. Warburton, Nucl. Phys. A143 (1970) 326

1970GA07 S. Gangadharan and R.L. Wolke, Phys. Rev. C1 (1970) 1333

1970GA1A Garber et al., BNL 400, 3rd Edition, Vol. 1 (1970)

1970GI04 M. Girod, Nguyen Van Sen, J.P. Longequeue and Tsan Ung Chan, J. Phys. (Paris) 31 (1970) 125

1970GN1A Gnedin, Dolginov, Silantyev and Shibanov, Yad. Fiz. 12 (1970) 815

1970GO1B Goldfarb, Nucl. Reactions Induced by Heavy Ions, Heidelberg, 1969 (1970) 115

1970GO1G Goss, Thesis, Ohio State Univ. (1970)

1970GU01 H. Guratzsch, J. Slotta and G. Stiller, Nucl. Phys. A140 (1970) 129

1970GU06 P. Guazzoni, I. Iori, S. Micheletti, N. Molho, M. Pignanelli and G. Tagliaferri, Nuovo Cim. A67 (1970) 407

1970HA23 J.C. Hardy, A.D. Bacher, G.R. Plattner, J.A. Macdonald and R.G. Sextro, Phys. Rev. Lett. 25 (1970) 298

1970HE24 J. Heisenberg, J.S. McCarthy and I. Sick, Nucl. Phys. A157 (1970) 435

1970HO37 K. Hosono, S. Kakigi, H. Nakamura, N. Fujiwara, D.C. Nguyen and T. Yanabu, Bull. Inst. Chem. Res. Kyoto Univ. 48 (1970) 269

1970HS02 S.T. Hsieh and H. Horie, Nucl. Phys. A151 (1970) 243

1970JA1B Jacmart et al., Nucl. Reactions Induced by Heavy ions, Heidelberg, 1969 (1970) 128

1970JU05 M. Jung, C. Jacquot, C. Baixeras-Aiguabella, R. Schmitt and H. Braun, Phys. Rev. C1 (1970) 435

1970KA41 T. Kaneko, Prog. Theor. Phys. 44 (1970) 292

1970KN01 A.R. Knudson and F.C. Young, Nucl. Phys. A149 (1970) 323

1970KO15 S. Kobayashi, S. Motonaga, Y. Chiba, K. Katori, A. Stricker, T. Fujisawa and T. Wada, J. Phys. Soc. Jpn. 29 (1970) 1

1970KO25 V.I. Komarov, G.E. Kosarev and O.V. Savchenko, Yad. Fiz. 11 (1970) 711; Sov. J. Nucl. Phys. 11 (1970) 399

1970KO41 S.-I. Koyama, K. Takahashi and M. Yamada, Prog. Theor. Phys. 44 (1970) 663

1970KR09 N.N. Krasnov, P.P. Dmitriev, Z.P. Dmitrieva, I.O. Konstantinov and G.A. Molin, Atomn. Energ. (USSR) 28 (1970) 258; Sov. J. At. Energy 28 (1970) 335

1970KR1C Krasnov et al., Atomn. Energ. (USSR) 28 (1970) 503

1970KU1B Kubo, Prog. Theor. Phys. 44 (1970) 929

1970LA1B Laird, Bull. Amer. Phys. Soc. 15 (1970) 544

1970LE1D Lefort et al., Nucl. Reactions Induced by Heavy Ions, Heidelberg, 1969 (1970) 181

1970LE20 J.W. Leonard and D.O. Wells, Nucl. Phys. A153 (1970) 657

1970LI1E Liebenauer, Silverstein, Kibler and Koral, Bull. Amer. Phys. Soc. 15 (1970) 521

1970LO1B W.G. Love, L.J. Parish and A. Richter, Phys. Lett. B31 (1970) 167

1970MA38 E.Z. Magzumov, V.G. Neudachin and M.S. Belkin, Yad. Fiz. 11 (1970) 589; Sov. J. Nusl. Phys. 11 (1970) 331

1970ME11 R. Mendelson, G.J. Wozniak, A.D. Bacher, J.M. Loiseaux and J. Cerny, Phys. Rev. Lett. 25 (1970) 533

1970ME1C Meadows and Whalen, Nucl. Sci. Eng. 41 (1970) 351

1970ME1N Meynadier, NP 18862 (1970)

1970ME24 C. Meynadier, Y. Chanut and D. Drain, Lett. Nuovo Cim. 4 (1970) 1063

1970MI1G Miller, Morrison and Westley, Bull. Amer. Phys. Soc. 15 (1970) 1315

1970NE17 J.M. Nelson, N.S. Chant and P.S. Fisher, Nucl. Phys. A156 (1970) 406

1970NU02 F. Nusslin and P. Braun-Munzinger, Z. Phys. 240 (1970) 217

1970OG1A Ogloblin, Nucl. Reactions Induced by Heavy Ions, Heidelberg, 1969 (1970) 231

1970OH06 T. Ohmura, B. Imanishi, M. Ichimura and M. Kawai, Prog. Theor. Phys. 43 (1970) 347

1970OH1C Ohmura, Imanishi, Ichimura and Kawai, Prog. Theor. Phys. 44 (1970) 1242

1970OT1A Otte, Thesis, Rice Univ. (1970)

1970PA23 H. Paul, Nucl. Phys. A154 (1970) 160

1970PE18 A.K. Petrauskas and L.Y. Sabalyauskas, Yad. Fiz. 12 (1970) 492; Sov. J. Nucl. Phys. 12 (1970) 269

1970PE1B Pearson, Rickel and Zissermann, Nucl. Phys. A148 (1970) 273

1970RE1C Renevey et al., Arch. Sci. (Switzerland) 23 (1970) 5

1970SA1K Sandler, Thesis, Rice Univ. (1970)

1970SC1F Schmitt and Shen, Bull. Amer. Phys. Soc. 15 (1970) 520

1970SC1G F. Schmittroth, W. Tobocman and A.A. Golestaneh, Phys. Rev. C1 (1970) 377

1970SH01 H. Sherif and J.S. Blair, Nucl. Phys. A140 (1970) 33

1970SH06 N.K. Sherman, R.W. Gellie, K.H. Lokan and R.G. Johnson, Phys. Rev. Lett. 25 (1970) 114

1970SH14 R. Shanta and R.K. Satpathy, Phys. Rev. C2 (1970) 1279

1970SH1C Sherwood and Goswami, Bull. Amer. Phys. Soc. 15 (1970) 527

1970SH1J Shima and Alsmiller, Nucl. Sci. Eng. 41 (1970) 47

1970SI16 J. Singh, Nucl. Phys. A155 (1970) 453

1970SL1B Slaus, Theory of Nucl. Struct., Trieste 1969, IAEA STI/PUB/249 (1970) 17

1970ST04 H.J. Strubbe and D.K. Callebaut, Nucl. Phys. A143 (1970) 537

1970ST15 T. Stammbach, J. Taylor, G. Spalek and R.L. Walter, Phys. Rev. C2 (1970) 434

1970ST16 T. Stammbach, G. Spalek, J. Taylor and R.L. Walter, Nucl. Instrum. Meth. 80 (1970) 304

1970SU1B Sukhoruchkin, Sov. J. Nucl. Phys. 10 (1970) 144

1970TA06 J. Taylor, G. Spalek, T. Stammbach, R.A. Hardekopf and R.L. Walter, Phys. Rev. C1 (1970) 803

1970TA1B Taylor et al., Bull. Amer. Phys. Soc. 15 (1970) 483

1970TA1J Talmi, Theory of Nucl. Struct., Trieste 1969, IAEA STI/PUB/249 (1970) 455

1970TH01 M.N. Thompson, R.J.J. Stewart and J.E.M. Thompson, Phys. Lett. B31 (1970) 211

1970TI1C Tishchenko and Kresnin, Sov. J. Nucl. Phys. 10 (1970) 442

1970TR05 G.F. Trentelman, B.M. Preedom and E. Kashy, Phys. Rev. Lett. 25 (1970) 530

1970TR1B Trautmann and Alder, Helv. Phys. Acta 43 (1970) 363

1970TR1F Trentelman, Thesis, Michigan State Univ. (1970)

1970TS03 C. Tschalar, C.J. Batty and A.I. Kilvington, Nucl. Instrum. Meth. 78 (1970) 141

1970UT1A Uttley and Diment, 2nd Int. Conf. on Nucl. Data for Reactors, Helsinki (1970)

1970VA1K J.F. Valley, J. Lang, R. Muller and P. Marmier, Helv. Phys. Acta 43 (1970) 438

1970VA23 L. van der Zwan and K.W. Geiger, Nucl. Phys. A152 (1970) 481

1970VE06 A.N. Vereshchagin, I.N. Korostova and I.P. Chernov, Izv. Vys. Ucheb. Zav. Fiz. 8 (1970) 105; Sov. Phys. J. 13 (1973) 1071

1970VO02 W. Von Oertzen, M. Liu, C. Caverzasio, J.C. Jacmart, F. Pougheon, M. Riou, J.C. Roynette and C. Stephan, Nucl. Phys. A143 (1970) 34

1970VO09 P. Vogt and D. Kamke, Nucl. Phys. A151 (1970) 1

1970VO1D von Oertzen, Nucl. Phys. A148 (1970) 529

1970WE09 L.C. Welch, C.C. Chang, H.H. Forster, C.C. Kim, D.W. Devins and P.A. Deutchman, Nucl. Phys. A158 (1970) 644

1970WE1D Westrom, Nucl. Phys. A142 (1970) 321

1970WE1J L.C. Welch, Thesis, Univ. of Southern California (1970)

1970WI04 G. Wittwer, H.-G. Clerc and G.A. Beer, Z. Phys. 234 (1970) 120

1970WO1E Wong, Thesis, Univ. of Saskatchewan (1970)

1970YA1C Yang, Thesis, Univ. of Saskatchewan (1970)

1970YO1C Yost and Pitkanen, Trans. Amer. Nucl. Soc. 13 (1970) 728

1971ADZZ J.M. Adams, A. Adams and J.M. Calvert, AERE-R-6473 (1971)

1971AL1D Alder and Trautmann, Nucl. Phys. A178 (1971) 60

1971AN12 R. Anni, L. Taffara and V. Vanzani, Nucl. Phys. A178 (1971) 214

1971AN1L Anderson and Hertz, Nucl. Sci. Eng. 44 (1971) 437

1971AR02 A.G. Artukh, V.V. Avdeichikov, J. Ero, G.F. Gridnev, V.L. Mikheev, V.V. Volkov and J. Wilczynski, Nucl. Phys. A160 (1971) 511

1971AR03 A. Arima and S. Yoshida, Nucl. Phys. A161 (1971) 492

1971AR1R A. Arima and I. Hamamoto, Ann. Rev. Nucl. Sci. 21 (1971) 55

1971AU02 N. Auerbach and A. Lev, Phys. Lett. B34 (1971) 13

1971AU1G N. Auerbach, A. Lev and E. Kashy, Phys. Lett. B36 (1971) 453

1971BA1A Barnes, Advances in Nucl. Phys. 4 (1971) 133

1971BA2V Bassani, CEA N 1474 (1971)

1971BA2Y Baus-Baghdikian, Univ. libre Bruxelles, Bull. No. 45 (1971)

1971BA68 P.H. Barker, P.M. Cockburn, A. Huber, H. Knoth, U. Matter, H.-P. Seiler and P. Marmier, Ann. Phys. 66 (1971) 705

1971BE1D Benenson, Locard, Escudie and Moss, Bull. Amer. Phys. Soc. 16 (1971) 509

1971BE25 H.A. Bentz, Z. Phys. 243 (1971) 138

1971BE51 J.C. Bergstrom, H. Crannell, F.J. Kline, J.T. O’Brien, J.W. Lightbody, Jr. and S.P. Fivozinsky, Phys. Rev. C4 (1971) 1514

1971BI22 R. Bimbot and H. Gauvin, Compt. Rend. B273 (1971) 1054

1971BL12 R.J. Blin-Stoyle, J.A. Evans and A.M. Khan, Phys. Lett. B36 (1971) 202

1971BO07 P. Boschung, J.T. Lindow and E.F. Shrader, Nucl. Phys. A161 (1971) 593

1971BO50 I. Borbely, Phys. Lett. B37 (1971) 243

1971BO52 H.G. Bohlen and W. von Oertzen, Phys. Lett. B37 (1971) 451

1971BR1H Bremmer, Koshel and Kazaks, Bull. Amer. Phys. Soc. 16 (1971) 1158

1971BR33 H.J. Brede, M. Morike, B. Schurenberg, G. Staudt and F. Weng, Z. Phys. 245 (1971) 1

1971BU02 V.E. Bunakov, K.A. Gridnev and L.V. Krasnov, Phys. Lett. B34 (1971) 27

1971BU1K Burymov et al., Izv. Akad. Nauk SSSR Ser. Fiz. 35 (1971) 159

1971CH01 J.S. Chalmers, Phys. Rev. C3 (1971) 968

1971CH1B V. I. Chuev, V.V. Davidov, B.G. Novatskii, A.A. Ogloblin, S.B. Sakuta and D.N. Stepanov, J. Phys. (Paris) 32 (1971) C6-167

1971CO07 J.R. Comfort, H.T. Fortune, J.V. Maher and B. Zeidman, Phys. Rev. C3 (1971) 1086

1971CO14 W.R. Coker, P.D. Miller, J.L. Duggan, M.M. Duncan, R.L. Dangle and J. Lin, Nucl. Phys. A168 (1971) 307

1971CR06 L. Cranberg, J.P. Barnett, D.S. Cramer and R.D. Wilson, Nucl. Instrum. Meth. 96 (1971) 493

1971CR1A Cramer et al., Bull. Amer. Phys. Soc. 16 (1971) 829

1971CU01 T.H. Curtis, H.F. Lutz, D.W. Heikkinen and W. Bartolini, Nucl. Phys. A165 (1971) 19

1971CU1B Cuzzocrea, Perillo and Notarrigo, Nuovo Cim. A4 (1971) 251

1971DA10 S. Dahlgren, B. Hoistad and P. Grafstrom, Phys. Lett. B35 (1971) 219

1971DE18 F.P. Denisov, B.P. Bulatov, A.A. Volkov, V.E. Dudkin and L.N. Filin, Yad. Fiz. 13 (1971) 925; Sov. J. Nucl. Phys. 13 (1971) 531

1971DI1G Divon, Thesis, Cornell Univ. (1971)

1971DO15 C.B. Dover and N. Van Giai, Nucl. Phys. A177 (1971) 559

1971DU09 G. Duhamel, L. Marcus, H. Langevin-Joliot, J.P. Didelez, P. Narboni and C. Stephan, Nucl. Phys. A174 (1971) 485

1971EL1B Elwyn, Monahan and Schiffer, Nucl. Fusion 11 (1971) 551

1971FE1D Fetscher et al., Polarization Phenom. in Nucl. Reactions, Madison, 1970; Eds., H.H. Barschall and W. Haeberli (1971) 772

1971FO06 P. Fontes, C. Perrin, J. Lestringuez, F. Yiou and R. Bernas, Nucl. Phys. A165 (1971) 405

1971FO1P D.G. Foster, Jr. and D.W. Glasgow, Phys. Rev. C3 (1971) 604

1971FO24 D.G. Foster, Jr. and D.W. Glasgow, Phys. Rev. C3 (1971) 576

1971GA05 R.M. Gaedke, W. Tobocman and K.S. Toth, Phys. Rev. C3 (1971) 1444

1971GE12 H.V. Geramb, Phys. Lett. B37 (1971) 351

1971GO24 V.Z. Goldberg, V.V. Davydov, A.A. Ogloblin, S.B. Sakuta and V.I. Chuev, Izv. Akad. Nauk SSSR Ser. Fiz. 35 (1971) 1663; Bull. Acad. Sci. USSR Phys. Ser. 35 (1972) 1514

1971GR02 L. Grunbaum and M. Tomaselli, Nucl. Phys. A160 (1971) 437

1971GR16 R.C. Grimm, I.E. McCarthy and R.G. Storer, Nucl. Phys. A166 (1971) 330

1971GR44 K.O. Groeneveld, A. Richter, U. Strohbusch and B. Zeidman, Phys. Rev. Lett. 27 (1971) 1806

1971GR48 V.V. Grushin and Y.P. Nikitin, Yad. Fiz. 13 (1971) 156; Sov. J. Nucl. Phys. 13 (1971) 89

1971GU23 P. Guazzoni, I. Iori, S. Micheletti, N. Molho, M. Pignanelli and G. Semenescu, Phys. Rev. C4 (1971) 1092

1971HA16 H. Hansgen and M. Nitzsche, Nul. Phys. A165 (1971) 401

1971HI09 D. Hilscher, J.C. Davis and P.A. Quin, Nucl. Phys. A174 (1971) 417

1971HIZF F. Hibou, Thesis, Univ. of Louis Pasteur (1971)

1971HO25 A.B. Holman, J.-L. Perrenoud, J.C. Young, M.B. Epstein and B.T. Wright, Nucl. Phys. A174 (1971) 161

1971HS03 T.H. Hsu, J.L. Honsaker, W.J. McDonald and G.C. Neilson, Nucl. Phys. A174 (1971) 365

1971IN05 A. Ingemarsson and G. Tibell, Phys. Scr. 4 (1971) 235

1971IN1A Ingram, Tanner, Domingo and Rohlin, Nucl. Phys. B31 (1971) 331

1971JA13 H.U. Jager, H.R. Kissener and R.A. Eramzhian, Nucl. Phys. A171 (1971) 16

1971JA14 H.U. Jager, H.R. Kissener and R.A. Eramzhian, Nucl. Phys. A171 (1971) 584

1971JU05 J.A. Jungerman, F.P. Brady, W.J. Knox, T. Montgomery, M.R. McGie, J.L. Romero and Y. Ishizaki, Nucl. Instrum. Meth. 94 (1971) 421

1971KA04 S. Kahana and D. Kurath, Phys. Rev. C3 (1971) 543

1971KA18 S. Kardonsky, H.L. Finston and E.T. Williams, Phys. Rev. C4 (1971) 846

1971KA62 V.V. Karapetyan and G.Y. Korenman, Yad. Fiz. 14 (1971) 1199; Sov. J. Nucl. Phys. 14 (1972) 668

1971KL03 A.P. Klyucharev and R.P. Slabospitskii, Izv. Akad. Nauk SSSR Ser. Fiz. 35 (1971) 71; Bull. Acad. Sci. USSR Phys. Ser. 35 (1972) 65

1971KL04 J.T. Klopcic and S.E. Darden, Phys. Rev. C3 (1971) 2171; Erratum Phys. Rev. C4 (1971) 1494

1971KN05 H. Knoth, P.H. Barker, A. Huber, U. Matter, P.M. Cockburn and P. Marmier, Nucl. Phys. A172 (1971) 25

1971KO1F L. Koester and W. Nistler, Phys. Rev. Lett. 27 (1971) 956

1971LI11 M. Liu, W. von Oertzen, J.C. Jacmart, F. Pougheon, M. Riou, J.C. Roynette and C. Stephan, Nucl. Phys. A165 (1971) 118

1971LI1H H.J. Lipkin, Phys. Rev. Lett. 27 (1971) 432

1971MA1M Mack et al., Polarization Phenom. in Nucl. Reactions, Madison, 1970; Eds., H.H. Barschall and W. Haeberli (1971) 615

1971MC15 G.M. McAllen, W.T. Pinkston and G.R. Satchler, Part. Nucl. 1 (1971) 412

1971ME01 C. Meynadier, J.F. Allard, M. Amiel, H. Beaumevielle, B. Chambon and C. Morand, Nucl. Phys. A161 (1971) 305

1971ME09 J.J.H. Menet, E.E. Gross, J.J. Malanify and A. Zucker, Phys. Rev. C4 (1971) 1114

1971MI07 O. Mikoshiba, T. Terasawa and M. Tanifuji, Nucl. Phys. A168 (1971) 417

1971MI12 D. Miljanic and V. Valkovic, Nucl. Phys. A176 (1971) 110

1971MU11 K.M. Murray and M.E. Toms, Lett. Nuovo Cim. 1 (1971) 571

1971MU18 G.S. Mutchler, D. Rendic, D.E. Velkley, W.E. Sweeney, Jr. and G.C. Phillips, Nucl. Phys. A172 (1971) 469

1971NA29 M. Nakamura, E. Takasaki, M. Takai, T. Hasegawa and S. Kobayashi, Prog. Theor. Phys. 46 (1971) 1942

1971NG01 Nguyen Van Giai, D. Vautherin, M. Veneroni and D.M. Brink, Phys. Lett. B35 (1971) 135

1971NO02 J.L. Norton and P. Goldhammer, Nucl. Phys. A165 (1971) 33

1971NY03 K. Nyberg-Ponnert, B. Jonsson and I. Bergqvist, Phys. Scr. 4 (1971) 165

1971OT02 V.A. Otte, W. von Witsch, J. Sandler, D. Rendic and G.C. Phillips, Phys. Rev. C4 (1971) 322

1971PE10 J.-L. Perrenoud and R.M. Devries, Phys. Lett. B36 (1971) 18

1971PL1C Plattner, Polarization Phenom. in Nucl. Reactions, Madison, 1970; Eds., H.H. Barschall and W. Haeberli (1971) 107

1971PU01 G.D. Putt, Nucl. Phys. A161 (1971) 547

1971RI19 S.M. Rizvi, P. Huber, F. Seiler and H.R. Striebel, Helv. Phys. Acta 44 (1971) 803

1971SA1E Satchler, Polarization Phenom. in Nucl. Reactions, Madison, 1970; Eds., H.H. Barschall and W. Haeberli (1971) 155

1971SA31 W. Salathe, E. Baumgartner and P. Huber, Helv. Phys. Acta 44 (1971) 815

1971SC1F Scott et al., J. Phys. (Paris) 32 (1971) C6-275

1971SE1C D. Sen and C.S. Shastry, Phys. Rev. C4 (1971) 349

1971SE1D Sene, Delpierre, Kahane and de Billy de Crespin, Polarization Phenom. in Nucl. Reactions, Madison, 1970; Eds., H.H. Barschall and W. Haeberli (1971) 611

1971SH09 Y.M. Shin, C.F. Wong and H.S. Caplan, Nucl. Phys. A166 (1971) 162

1971SH26 V.S. Shirley, Proc. Int. Conf. Hyperfine Interactions Detected by Nucl. Radiation, Israel, 1970 (1971) 1255

1971ST21 D.M. Stupin, R.A. Ristinen and P. Schwandt, Nucl. Phys. A173 (1971) 286

1971TA1A Talmi, Proc. Int. Conf. Hyperfins Interactions Detected by Nucl. Radiation, Israel, 1970 (1971) 1133

1971TA1D Taylor et al., Polarization Phenom. in Nucl. Reactions, Madison, 1970; Eds., H.H. Barschall and W. Haeberli (1971) 754

1971TAZN J. Taylor, Thesis, Duke Univ. (1971); Diss. Abst. Int. 32B (1971) 3574

1971TR03 G.F. Trentelman, B.M. Preedom and E. Kashy, Phys. Rev. C3 (1971) 2205

1971VA1C E. Vatai, Phys. Lett. B34 (1971) 395

1971VA29 S.S. Vasilev, B.S. Galakhmatova, A.S. Demyanova, T.N. Mikhaleva, L.I. Nikitina, E.A. Romanovskii and D.L. Chuprunov, Izv. Akad. Nauk SSSR Ser. Fiz. 35 (1971) 1693; Bull. Acad. Sci. USSR Phys. Ser. 35 (1972) 1541

1971VO01 W. Von Oertzen, G. Bohlen, B. Gebauer, E.E. Habib and N. Marquardt, Phys. Lett. B34 (1971) 51

1971WA1D Walter, Polarization Phenom. in Nucl. Reactions, Madison, 1970; Eds., H.H. Barschall and W. Haeberli (1971) 317

1971WE08 G.D. Westin and J.L. Adams, Phys. Rev. C4 (1971) 363; Erratum Phys. Rev. C4 (1972) 1971

1971WI07 D.H. Wilkinson, D.E. Alburger, D.R. Goosman, K.W. Jones, E.K. Warburton, G.T. Garvey and R.L. Williams, Nucl. Phys. A166 (1971) 661.

1971WI09 R.L. Williams, Jr. and L. Madansky, Phys. Rev. C3 (1971) 2149

1971WI18 D.H. Wilkinson, Phys. Rev. Lett. 27 (1971) 1018

1971WI1J Wieland et al., Bull. Amer. Phys. Soc. 16 (1971) 100

1971WU1A Wu, Thesis, Univ. of Georgia (1971)

1971WY01 H.W. Wyborny and R.R. Carlson, Phys. Rev. C3 (1971) 2185

1971YA02 C.S. Yang, E.L. Tomusiak, R.K. Gupta and H.S. Caplan, Nucl. Phys. A162 (1971) 71

1971ZA04 N.I. Zaika, Y.V. Kibkalo, E.B. Levshin, G.B. Lyubanskii, O.F. Nemets, R.G. Ofengenden, P.L. Shmarin, A.M. Shchur and A.M. Yasnogorodskii, Yad. Fiz. 13 (1971) 928; Sov. J. Nucl. Phys. 13 (1971) 533

1971ZE1C Zeidman, Strohbusch, Ritcher and Grdeneveld, J. Phys. (Paris) 32 (1971) C6-295

1972AD02 M.L. Adelberg and A.M. Saperstein, Phys. Rev. C5 (1972) 1180

1972AL1K Allard et al., J. Phys. (France) 33 (1972) 477

1972AN05 R.K. Anderson, M.R. Wilson and P. Goldhammer, Phys. Rev. C6 (1972) 136

1972AN25 R. Anni, P. Ladiana and L. Taffara, Lett. Nuovo Cim. 5 (1972) 723

1972AU01 M. Auman, F.P. Brady, J.A. Jungerman, W.J. Knox, M.R. McGie and T.C. Montgomery, Phys. Rev. C5 (1972) 1

1972BA14 A.D. Bacher, E.A. McClatchie, M.S. Zisman, T.A. Weaver and T.A. Tombrello, Nucl. Phys. A181 (1972) 453

1972BA52 G. Bassani, N. Saunier, B.M. Traore, J. Raynal, A. Foti and G. Pappalardo, Nucl. Phys. A189 (1972) 353

1972BE05 R.A.I. Bell, I.G. Graham and J.V. Thompson, Nucl. Phys. A179 (1972) 408

1972BE15 E.M. Bernstein, J.J. Ramirez, R.E. Shamu, Pui-Wah Cheng and M. Soga, Phys. Rev. Lett. 28 (1972) 923

1972BE1E Bertsch and Mekjian, Ann. Rev. Nucl. Sci. (1972) 25

1972BE23 H.W. Bertini, Phys. Rev. C5 (1972) 2118

1972BE54 J.E. Beam and V. Valkovic, Phys. Lett. B41 (1972) 13

1972BE56 R.A.I. Bell, I.G. Graham, J.V. Thompson and E.W. Titterton, Nucl. Phys. A193 (1972) 385

1972BO56 V.I. Borovlev, I.D. Lopatko, G.B. Andreev and R.P. Slabospitsky, Ukr. Fiz. Zh. 17 (1972) 966

1972BO68 H.G. Bohlen, M. Feil, A. Gamp, B. Kohlmeyer, N. Marquardt and W. Von Oertzen, Phys. Lett. B41 (1972) 425

1972BO71 V.V. Boikov, B.V. Velberg, I.I. Loshchakov and V.I. Ostroumov, Yad. Fiz. 16 (1972) 901; Sov. J. Nucl. Phys. 16 (1973) 497

1972BO73 V.V. Bobyr, G.I. Primenko, K.K. Revyuk, V.I. Strizhak, Y.I. Totskii and V.T. Tustanovskii, Izv. Akad. Nauk SSSR Ser. Fiz. 36 (1972) 2621; Bull. Acad. Sci. USSR Phys. Ser. 36 (1973) 2272

1972BR21 D.M. Brink, Phys. Lett. B40 (1972) 37

1972BU20 W.P. Bucher and W.B. Beverly, Phys. Rev. C6 (1972) 1106

1972BU29 A.P. Bukhvostov, A.M. Chatrchyan, G.E. Dogotar, R.A. Eramzhyan, N.P. Popov and V.A. Vartanjan, Acta Phys. Pol. B3 (1972) 375

1972BU31 G.W. Butler, S.B. Kaufman, E.P. Steinberg and B.D. Wilkins, Phys. Rev. C6 (1972) 1153

1972CA1N Caughlan and Fowler, Nature Phys. Sci. 238 (1972) 23

1972CA37 P. Camiz, E. Olivieri, M. Scalia and A. D'Andrea, Nuovo Cim. A12 (1972) 71

1972CE1A Cerny, At. Masses Fund. Constants, Teddington, 1971 (1972) 26

1972CH16 E.F. Chaffin and N.V.V.J. Swamy, Nucl. Phys. A187 (1972) 593

1972CH1G Chatterjee, Tobias and Smith, Bull. Amer. Phys. Soc. 17 (1972) 438

1972CH1H Chua et al., Bull. Amer. Phys. Soc. 17 (1972) 529

1972CH21 A.K. Chatterjee and P.A. Deutchman, Nucl. Phys. A189 (1972) 20

1972CL1A Clayton, Encyclopedia of the Twentieth Century (1972)

1972DA02 J.R. Davis and G.U. Din, Nucl. Phys. A179 (1972) 101; Erratum Nucl. Phys. A211 (1973) 619

1972DA09 S. Das, B.K. Gupta, P.C. Bhattacharya and M.M. Biswas, Nucl. Phys. A190 (1972) 501

1972DA1J M. Danos, J. Phys. (Paris) 33 (1972) C5-171

1972DE13 R. de Swiniarski and J. Oms, Compt. Rend. B274 (1972) 506

1972DE1H De Meijer, Philpott, West and Maripuu, Bull. Amer. Phys. Soc. 17 (1972) 553

1972DR03 L. Drigo, C. Manduchi, G. Moschini, M.T.R. Manduchi, G. Tornielli and G. Zannoni, Nucl. Phys. A181 (1972) 177

1972DU01 L.M.C. Dutton, J.D. Jafar, H.B. van der Raay, D.G. Ryan, J.A. Stiegelmair and R.K. Tandon, Nucl. Phys. A178 (1972) 488

1972DZ06 P.O. Dzhamalov, E.I. Dolinskii and A.M. Mukhamedzhanov, Yad. Fiz. 15 (1972) 258; Sov. J. Nucl. Phys. 15 (1972) 147

1972ED01 G. Eder, G. Winkler and P. Hille, Z. Phys. 253 (1972) 335

1972EL1C Elliott, Proc. Roy. Soc. 326 (1972) 199

1972ER1A Ericson and Rho, Phys. Rept. 50 (1972) 57

1972EY01 Y. Eyal, I. Dostrovsky and Z. Fraenkel, Nucl. Phys. A180 (1972) 545

1972FI1E Fick, MPI H-1972-V17 (1972)

1972FR09 V. Franco, Phys. Rev. C6 (1972) 748

1972GA13 W. Galati, J.D. Brandenberger and J.L. Weil, Phys. Rev. C5 (1972) 1508

1972GA1E Garrett, Symp. on Two-Nucleon Transfer and Pairing Excitations, Argonne (1972) 232; CONF-720309

1972GE11 R.W. Gellie, K.H. Lokan, N.K. Sherman, R.G. Johnson and J.I. Lodge, Can. J. Phys. 50 (1972) 1689

1972GE1G Gemmeke, Baumgartner, Richter and Lassen, Few Particle Problems, UCLA, 1972 (1972) 715

1972GL06 D. Glas, Z. Phys. 255 (1972) 175

1972GO27 N.G. Goncharova and G.S. Sagijan, Vestnik Mos. Univ. Fiz. Astron. (USSR) 13 (1972) 121

1972GR02 P.D. Greaves, V. Hnizdo, J. Lowe and O. Karban, Nucl. Phys. A179 (1972) 1

1972GU05 M.R. Gunye and C.S. Warke, Phys. Rev. C5 (1972) 1860

1972HA08 G. Hauser, R. Lohken, G. Nowicki, H. Rebel, G. Schatz, G. Schweimer and J. Specht, Nucl. Phys. A182 (1972) 1

1972HA16 E. Hayward, B.F. Gibson and J.S. O'Connell, Phys. Rev. C5 (1972) 846

1972HA1X Hardy, Symp. on Two-Nucleon Transfer and Pairing Excitations, Argonne (1972) 203; CONF-720309

1972HA2B Halbert and Nagatani, Bull. Amer. Phys. Soc. 17 (1972) 530

1972HA32 M. Hasinoff, D. Johnson and D.F. Measday, Phys. Lett. B39 (1972) 506

1972HA57 H.H. Hackenbroich and T.H. Seligman, Phys. Lett. B41 (1972) 102

1972HO01 R.J. Holt, F.W.K. Firk, R. Nath and H.L. Schultz, Phys. Rev. Lett. 28 (1972) 114

1972HU13 M. Huez, M. Quadlia and G. Weber, Nucl. Instrum. Meth. 105 (1972) 197

1972JO11 R.C. Johnson and D.C. Martin, Nucl. Phys. A192 (1972) 496; Erratum Nucl. Phys. A211 (1973) 617

1972JO1B Johnson, Ebisawa, Liu and Wieman, Bull. Amer. Phys. Soc. 17 (1972) 930

1972KI12 M.V. Kirichenko and Z.I. Soloveva, Yad. Fiz. 16 (1972) 17; Sov. J. Nucl. Phys. 16 (1973) 9

1972KO1A Kocharov, Izv. Akad. Nauk SSSR Ser. Fiz. 36 (1972) 2052

1972KU19 B.I. Kuznetsov, P.E. Ovsyannikova and I.P. Chernov, Yad. Fiz. 15 (1972) 673; Sov. J. Nucl. Phys. 15 (1972) 377

1972KU1H Kurath, Comments Nucl. Part. Phys. 5 (1972) 55

1972LA03 J. Lang, J.F. Valley, R. Muller and P. Marmier, Phys. Rev. Lett. 28 (1972) 623

1972LA1F Lane, COO-1717-3 (1972)

1972LE06 R. Leonardi, Phys. Rev. Lett. 28 (1972) 836

1972LE1L Lee and Cusson, Ann. Phys. 72 (1972) 353

1972LE1N Leonardi, Proc. Int. Conf. on Nucl. Struct. Studies Using Electron Scattering and Photoreaction, Sendai, Japan (1972) 443

1972MA21 C. Maples and J. Cerny, Phys. Lett. B38 (1972) 504

1972MA62 A.M. MacLeod and G.R. Milne, J. Phys. (London) A5 (1972) 1252

1972ME06 M.M. Meier and R.L. Walter, Nucl. Phys. A182 (1972) 468

1972MO1E Morrison, J. Phys. (Paris) 33 (1972) C5-111

1972MO39 T. Mo, R.A. Blue and H.R. Weller, Nucl. Phys. A197 (1972) 290

1972NA05 P.T. Nang, Nucl. Phys. A185 (1972) 413

1972OB01 A.W. Obst, T.B. Grandy and J.L. Weil, Phys. Rev. C5 (1972) 738

1972OH01 I.K. Oh, C.S. Zaidins, C.D. Zafiratos and S.I. Hayakawa, Nucl. Phys. A178 (1972) 497

1972OP01 A.M.F. Op den Kamp and A.M.J. Spits, Nucl. Phys. A180 (1972) 569

1972PE11 C.A. Pearson, J.M. Covan, D. Zissermann, T.G. Miller, F.P. Gibson, R. Haglund, W. Morrison and G. Westley, Nucl. Phys. A191 (1972) 1

1972PE1H Pearlstein, Nucl. Sci. Eng. 49 (1972) 162

1972PEYR F.G. Perey, T.A. Love and W.E. Kinney, ORNL-4823 (1972)

1972RE06 P.U. Renberg, D.F. Measday, M. Pepin, P. Schwaller, B. Favier and C. Richard-Serre, Nucl. Phys. A183 (1972) 81

1972RH1A Rho, J. Phys. (Paris) 33 (1972) C5-155

1972RO07 B.A. Robson and W.J. Van Megen, Nucl. Phys. A184 (1972) 50

1972RO08 B.A. Robson and W.J. Van Megen, Nucl. Phys. A184 (1972) 67

1972RU03 C. Rudy, R. Vandenbosch, P. Russo and W.J. Braithwaite, Nucl. Phys. A188 (1972) 430.

1972SC1M Schwaller et al., CERN 72-13 (1972)

1972SC21 D.K. Scott, P.N. Hudson, P.S. Fisher, C.U. Cardinal, N. Anyas-Weiss, A.D. Panagiotou and P.J. Ellis, Phys. Rev. Lett. 28 (1972) 1659

1972SE09 F. Seiler, Nucl. Phys. A187 (1972) 379

1972SI19 A.G. Sitenko and A.D. Foursat, Ukr. Fiz. Zh. 17 (1972) 110

1972TH13 C. Thibault and R. Klapisch, Phys. Rev. C6 (1972) 1509

1972TH14 G. Thornton, T. Joy and J.M. Calvert, Nucl. Phys. A198 (1972) 397

1972THZF H. Theissen, Springer Tracts in Mod. Phys.; Ed., Hohler, Vol. 65 (1972) 1

1972UL1A Ulrich and Scalo, OAP-303 (1972)

1972VA10 J.F. Valley, J. Lang, R. Muller and P. Marmier, Nucl. Phys. A184 (1972) 577

1972VA36 J.F.A. Van Hienen and P.W.M. Glaudemans, Phys. Lett. B42 (1972) 301

1972VO20 V.G. Vovchenko, A.A. Zhdanov, V.M. Zheleznyakov, O.Y. Fedorov and A.V. Shvedchikov, Yad. Fiz. 16 (1972) 1145; Sov. J. Nucl. Phys. 16 (1973) 628

1972WA07 G.E. Walker and R.H. Stokes, Part. Nucl. 3 (1972) 1

1972WA30 J.W. Wachter, W.A. Gibson and W.R. Burrus, Phys. Rev. C6 (1972) 1496

1972WA31 J.W. Watson, Nucl. Phys. A198 (1972) 129

1972WI1C Wilkinson, Few Particle Problems, UCLA, 1972 (1972) 191

1972WI26 K. Wienhard, G. Clausnitzer and G. Hartmann, Z. Phys. 256 (1972) 457

1972WI28 D.H. Wilkinson, Proc. Roy. Soc. Edinburgh A70 (1972) 307

1972WY01 H.W. Wyborny, Nucl. Phys. A185 (1972) 669

1973AB07 U. Abbondanno, F. Demanins, M. Lagonegro and G. Nardelli, Lett. Nuovo Cim. 8 (1973) 259

1973AD01 M.L. Adelberg and A.M. Saperstein, Phys. Rev. C7 (1973) 63

1973AD02 E.G. Adelberger, A.B. McDonald, C.L. Cocke, C.N. Davids, A.P. Shukla, H.B. Mak and D. Ashery, Phys. Rev. C7 (1973) 889

1973AL1D Alster et al., Contrib., Uppsala (1973) 75

1973AN07 G.B. Andreev, A.P. Klyucharev and R.P. Slabospitskii, Izv. Akad. Nauk SSSR Ser. Fiz. 37 (1973) 183; Bull. Acad. Sci. USSR Phys. Ser. 37 (1973) 160

1973AR1E Arnett, Ann. Rev. Astron. Astrophys. 11 (1973) 73

1973AR1L Arad and Ben-David, Rev. Mod. Phys. 45 (1973) 230

1973AU06 N. Auerbach and J. Warszawski, Phys. Lett. B45 (1973) 171

1973AU1B Audouze, Truran and Zimmerman, OAP-315 (1973)

1973AU1C Audouze, Explosive Nucleosynthesis (1973) 47

1973AU1D Audouze and Fricke, Astrophys. J. 186 (1973) 239

1973BA1H Bahcall, in Munich, 2 (1973) 682

1973BA1M Barashenkov, Il'inov, Sobolevskii and Toneev, Sov. Phys. Usp. 16 (1973) 31

1973BA2K Baur and Gelbke, Nucl. Phys. A204 (1973) 138

1973BA34 G.C. Ball, G.J. Costa, W.G. Davies, J.S. Forster, J.C. Hardy and A.B. McDonald, Phys. Rev. Lett. 31 (1973) 395

1973BA81 L.K. Batist, E.E. Berlovich, Y.S. Blinnikov, Y.V. Elkin, Y.N. Novikov, B.M. Ovchinnikov and V.K. Tarasov, Izv. Akad. Nauk SSSR Ser. Fiz. 37 (1973) 1944; Bull. Acad. Sci. USSR Phys. Ser. 37 (1974) 124

1973BE25 M. Berrada and L. Marquez, Part. Nucl. 5 (1973) 89

1973BE36 F.E. Bertrand and R.W. Peelle, Phys. Rev. C8 (1973) 1045

1973BE37 E.M. Bernstein, J.J. Ramirez, L. Baumann and M. Soga, Phys. Rev. C8 (1973) 1162

1973BI1H Birchall et al., in Munich, 1 (1973) 371

1973BO1R Bochsler and Geiss, Solar Phys. 32 (1973) 3

1973BO26 M. Bormann, D. Kaack, V. Schroder, W. Scobel and L. Wilde, Z. Phys. 258 (1973) 285

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

1973CH1L Chua et al., in Munich, 1 (1973) 345

1973CH20 Il-Tong Cheon, Phys. Rev. C8 (1973) 534

1973CL01 B.C. Clark, R.L. Mercer, D.G. Ravenhall and A.M. Saperstein, Phys. Rev. C7 (1973) 466

1973CL04 R.G. Clarkson, Phys. Rev. C7 (1973) 1770

1973CL1E Clayton and Woosley, in Munich, 2 (1973) 718

1973CO1B Colgate, Explosive Nucleosynthesis (1973) 248

1973CO1P Cohen, J. Phys. Soc. Jpn. Suppl. 34 (1973) 63

1973CO23 B.J. Cole and R. Huby, Phys. Lett. B46 (1973) 55

1973CO27 B.J. Cole, R. Huby and Q.K.K. Liu, J. Phys. A6 (1973) 1224

1973DA17 S.E. Darden, S. Sen, H.R. Hiddleston, J.A. Aymar and W.A. Yoh, Nucl. Phys. A208 (1973) 77

1973DA1L Day, Lambert and Sneden, Astrophys. J. 185 (1973) 213

1973DA24 S. Dahlgren, P. Grafstrom, B. Hoistad and A. Asberg, Nucl. Phys. A211 (1973) 243

1973DE02 R.M. DeVries and K.I. Kubo, Phys. Rev. Lett. 30 (1973) 325

1973DE13 R.J. de Meijer, Nucl. Phys. A204 (1973) 427

1973DE14 D.C. De Martini, C.R. Soltesz and T.R. Donoghue, Phys. Rev. C7 (1973) 1824

1973DE1R DeVries, Symp. on Heavy Ion Transfer Reactions, ANL Phy-1973B, Vol. 1 (1973) 189

1973DE1T Deutchman, Bull. Amer. Phys. Soc. 18 (1973) 1400

1973DE30 V.P. Denisov and I.Y. Chubukov, Yad. Fiz. 17 (1973) 682; Sov. J. Nucl. Phys. 17 (1974) 354

1973DE35 R.M. DeVries, Phys. Rev. C8 (1973) 951

1973DI08 M. Dillig, H.M. Hofmann and M.G. Huber, Phys. Lett. B44 (1973) 484

1973DI1F Disque, Forssmann, Jochim and Traudt, in Munich, 1 (1973) 722

1973DO02 E.I. Dolinsky, P.O. Dzhamalov and A.M. Mukhamedzhanov, Nucl. Phys. A202 (1973) 97

1973DO1L Dodge and Murphy, Bull. Amer. Phys. Soc. 18 (1973) 70

1973EI01 J.M. Eisenberg, R. Guy, J.V. Noble and H.J. Weber, Phys. Lett. B43 (1973) 20; Erratum Phys. Lett. B45 (1973) 93

1973EI1B Eisenberg, Noble and Weber, in Asilomar (1973) 957

1973EM1B B. Eman, B. Guberina and D. Tadic, Phys. Rev. C8 (1973) 1301

1973FA06 U. Fasoli, A. Metellini, D. Toniolo and G. Zago, Nucl. Phys. A205 (1973) 305

1973FA10 B. Fagerstrom and J. Kallne, Phys. Scr. 8 (1973) 14

1973FE13 G. Fey, H. Frank, W. Schutz and H. Theissen, Z. Phys. 265 (1973) 401

1973FI1C Fick, MPI H-1973-V27 (1973)

1973FI1F Fivozinsky et al., Bull. Amer. Phys. Soc. 18 (1973) 68

1973FR1F Francis, Lubert, Mendelson and Block, in Asilomar (1973) 1095

1973GA19 S. Gamba, G. Ricco and G. Rottigni, Nucl. Phys. A213 (1973) 383

1973GO03 J.D. Goss, A.A. Rollefson, G.L. Marolt and C.P. Browne, Phys. Rev. C7 (1973) 663

1973GO15 J.D. Goss, S.L. Blatt, D.R. Parsignault, C.D. Porterfield and F.L. Riffle, Phys. Rev. C7 (1973) 1837

1973GO1H J.M.G. Gomez and J. Sesma, Phys. Lett. B44 (1973) 231

1973GO41 Y.P. Gorin, S.P. Denisov, S.V. Donskov, R.N. Krasnokutskii, A.I. Petrukhin, Y.D. Prokoshkin and D.A. Stoyanova, Yad. Fiz. 18 (1973) 336; Sov. J. Nucl. Phys. 18 (1974) 173

1973HA1Q Hanna, in Asilomar (1973) 417

1973HA2F Hasegawa et al., in Munich, 1 (1973) 409

1973HA49 P.S. Hauge and S. Maripuu, Phys. Rev. C8 (1973) 1609

1973HA59 T. Hasegawa, M. Nakamura, E. Takasaki and T. Komatsuzaki, Mem. Fac. Sci. Kyoto Univ. Ser. Phys. Astrophys. Geophys. Chem. 34 (1973) 149

1973HA77 J.C. Hardy, Nucl. Data Tables A11 (1973) 327

1973HAVZ R.C. Haskell and L. Madansky, J. Phys. Soc. Jpn. Suppl. 34 (1973) 167

1973HE12 H.-D. Helb, P. Duck, G. Hartmann, G. Ischenko, F. Siller and H. Voit, Nucl. Phys. A206 (1973) 385

1973HO39 R.J. Holt, F.W.K. Firk, R. Nath and H.L. Schultz, Nucl. Phys. A213 (1973) 147

1973HU07 E. Huenges, H. Rosler and H. Vonach, Phys. Lett. B46 (1973) 361

1973IN09 A. Ingemarsson, E. Hagberg and H. Sherif, Nucl. Phys. A216 (1973) 271

1973JO1G Joseph and Goulard, Contrib., Uppsala (1973) 143

1973JU2A M. Juric, G. Bohm, J. Klabuhn, U. Krecker, F. Wysotzki, G. Coremans-Bertrand, J. Sacton, G. Wilquet, T. Cantwell, F. Esmael et al., Nucl. Phys. B52 (1973) 1

1973KA04 V.V. Karapetyan, V.N. Mileev and N.N. Titarenko, Nucl. Phys. A203 (1973) 561

1973KA1H Kao, Ann. Phys. 81 (1973) 113

1973KE02 M.P. Keating and J.G. Wills, Phys. Rev. C7 (1973) 1336

1973KI05 H.R. Kissener, R.A. Eramzhian and H.U. Jager, Nucl. Phys. A207 (1973) 78

1973KI12 H.R. Kissener, A. Aswad, H.U. Jager and R.A. Eramzhian, Nucl. Phys. A215 (1973) 424

1973KN06 H.D. Knox, J.M. Cox, R.W. Finlay and R.O. Lane, Nucl. Phys. A217 (1973) 611

1973KO1D Kovar, Symp. on Heavy Ion Transfer Reactions, ANL Phy-1973B, Vol. 1 (1973) 59

1973KO1J Kochetov and Khrylin, JETP Lett. 18 (1973) 79

1973KR09 S.T. Kruger and D. Heymann, Phys. Rev. C7 (1973) 2179

1973KU03 D. Kurath, Phys. Rev. C7 (1973) 1390

1973KU12 K.-I. Kubo, H.H. Duhm and N. Ueta, Phys. Lett. B45 (1973) 299

1973KU18 B.I. Kuznetsov, I.P. Chernov and R.E. Ovsyannikova, Yad. Fiz. 18 (1973) 950; Sov. J. Nucl. Phys. 18 (1974) 490

1973KU1D Kubodera, Delorme and Rho, Nucl. Phys. B66 (1973) 253

1973LE02 T.T. Leung and R.D. Koshel, Ann. Phys. 75 (1973) 132

1973LE06 A. Lev and N. Auerbach, Nucl. Phys. A206 (1973) 563

1973LE26 D. Lemann and H.J. Treffkorn, Izv. Akad. Nauk SSSR Ser. Fiz. 37 (1973) 1870; Bull. Acad. Sci. USSR Phys. Ser. 37 (1974) 65

1973LE28 V.M. Lebedev, A.V. Spasskii and I.B. Teplov, Izv. Akad. Nauk SSSR Ser. Fiz. 37 (1973) 2663; Bull. Acad. Sci. USSR Phys. Ser. 37 (1974) 177

1973MA1K Maripuu, 5th Symp. Struct. Low-Medium Mass Nuclei (1973) 63

1973MA1X Maragoni, Ottaviani and Sarius, Asilomar (1973) Paper 5A10

1973MA48 F. Malaguti and P.E. Hodgson, Nucl. Phys. A215 (1973) 243

1973MC17 C.A. McMahan and W. Tobocman, Nucl. Phys. A212 (1973) 465

1973MC1J McMahan and Tobocman, Nucl. Phys. A202 (1973) 561

1973ME03 H.O. Meyer and G.R. Plattner, Nucl. Phys. A199 (1973) 413

1973ME12 D.F. Measday, M. Hasinoff and D.L. Johnson, Can. J. Phys. 51 (1973) 1227

1973ME1J Meyer, Bull. Amer. Phys. Soc. 18 (1973) 698

1973MI1H Miller and Kerman, Bull. Amer. Phys. Soc. 18 (1973) 674

1973MO1E Moffa and Walker, Bull. Amer. Phys. Soc. 18 (1973) 624

1973MO1F Mori, Prog. Theor. Phys. 49 (1973) 1960

1973MU11 N.C. Mukhopadhyay, Phys. Lett. B45 (1973) 309

1973MU14 S.F. Mughabghab and D.I. Garber, BNL 325, 3rd Edition, Vol. 1 (1973)

1973MU18 A. Muller-Arnke, Phys. Lett. B46 (1973) 325

1973MU1B Mukgopadhyay, Lett. Nuovo Cim. 7 (1973) 460

1973MU1D N.C. Mukhopadhyay and L.D. Miller, Phys. Lett. B47 (1973) 415

1973MU1H Munger and Peterson, Bull. Amer. Phys. Soc. 18 (1973) 1389

1973NA14 A. Nagl and H. Uberall, Phys. Lett. B45 (1973) 99

1973NA1H Nagl, Lamers and Uberall, in Munich, 1 (1973) 637

1973OG1A Ogloblin, Sov. J. Part. Nucl. 3 (1973) 467

1973OK06 V.V. Okorokov, V.M. Serezhin, V.A. Smotryaev, D.L. Tolchenkov, I.S. Trostin and Y.N. Cheblukov, Yad. Fiz. 17 (1973) 678; Sov. J. Nucl. Phys. 17 (1974) 352

1973OS03 A. Osman, Atomkernenergie 22 (1973) 62

1973PH1B Phelps and Weiland, Phys. Med. Bio. 18 (1973) 284

1973RA1E Rayet, Nucl. Phys. B57 (1973) 269

1973RO10 E. Rost and P.D. Kunz, Phys. Lett. B43 (1973) 17

1973RO1R Robson, Nucl. Phys. A204 (1973) 523

1973RO1U Roughton et al., Bull. Amer. Phys. Soc. 18 (1973) 651

1973RO1V Roche, Clark and Viola, Bull. Amer. Phys. Soc. 18 (1973) 651

1973SA03 J. Sandler, G.S. Mutchler, W. von Witsch, V.A. Otte, G.C. Phillips and D. Rendic, Nucl. Phys. A202 (1973) 49

1973SA1J Sackmann, Smith and Despain, OAP-324 (1973)

1973SA1K Satchler, Symp. on Heavy Ion Transfer Reactions, ANL Phy-1973B, Vol. 1 (1973) 145

1973SA1N Sakaguchi, Matsuoka, Koyama and Takeuchi, in Munich, 1 (1973) 506

1973SA25 H. Sato and S. Yoshida, Nucl. Phys. A211 (1973) 509

1973SA30 R. Saayman, P.R. de Kock and J.H. van der Merwe, Z. Phys. 265 (1973) 69

1973SC01 W. Schimmerling, T.J. Devlin, W.W. Johnson, K.G. Vosburgh and R.E. Mischke, Phys. Rev. C7 (1973) 248

1973SC1B Scott, in Munich, 2 (1973) 216

1973SC1J Scott, Symp. on Heavy Ion transfer Reactions, ANL Phy-1973B, Vol. 1 (1973) 97

1973SC1T J.M. Scalo and R.K. Ulrich, Astrophys. J. 183 (1973) 151

1973SC26 P. Schumacher, N. Ueta, H.H. Duhm, K.-I. Kubo and W.J. Klages, Nucl. Phys. A212 (1973) 573

1973SH04 T.C. Sharma, J.M. Cameron and G.C. Neilson, Nucl. Phys. A202 (1973) 59

1973SK1B Skoski and Merker, Bull. Amer. Phys. Soc. 18 (1973) 692

1973SM03 S.M. Smith, G. Tibell, A.A. Cowley, D.A. Goldberg, H.G. Pugh, W. Reichart and N.S. Wall, Nucl. Phys. A207 (1973) 273

1973SM1A Smith, Sackmann and Despain, Explosive Nucleosynthesis (1973) 168

1973SM1D Smith and Sackman, OAP-316 (1973)

1973SP1A Sprung, Nucl. Many-Body Problem, 1972, Vol. 2 (1973) 123

1973SU1B Sugimoto, J. Phys. Soc. Jpn. Suppl. 34 (1973) 197

1973SU1C Sugimoto and Tanihata, J. Phys. Soc, Jpn. Suppl. 34 (1973) 245

1973SU1E Suffert, in Asilomar (1973) 741

1973SZ1B Szucs, Cairns, Greene and Kuehner, Phys. in Canada 29 (1973) 4

1973TA1D Talbot, Explosive Nucleosynthesis (1973) 47

1973TA27 M. Tanifuji and H. Noya, Prog. Theor. Phys. 50 (1973) 515

1973TO05 W. Tobocman, R. Ryan, A.J. Baltz and S.H. Kahana, Nucl. Phys. A205 (1973) 193

1973TO14 I.S. Towner, Nucl. Phys. A216 (1973) 589

1973TO16 L. Tomlinson, At. Data Nucl. Data Tables 12 (1973) 179

1973TR02 S. Tryti, T. Holtebekk and J. Rekstad, Nucl. Phys. A201 (1973) 135

1973TR1B Truran, Cosmochemistry; Ed., Cameron (1973) 23

1973TR1E Trimble and Reines, Rev. Mod. Phys. 45 (1973) 1

1973UL1B Ulrich, Explosive Nucleosynthesis (1973) 139

1973VA07 S.S. Vasilev, B.S. Galakhmatova, A.S. Demyanova, T.N. Mikhaleva, E.A. Romanovskii, D.L. Chuprunov and N.V. Orlova, Izv. Akad. Nauk SSSR Ser. Fiz. 37 (1973) 99; Bull. Acad. Sci. USSR Phys. Ser. 37 (1973) 87

1973VA1L Van Oers and Haw, Contrib., Uppsala (1973) 93

1973VA25 L. Van der Zwan and K.W. Geiger, Nucl. Phys. A216 (1973) 188

1973VE03 D.E. Velkley, J.D. Brandenberger, D.W. Glasgow, M.T. McEllistrem, J.C. Manthuruthil and C.P. Poirier, Phys. Rev. C7 (1973) 1736

1973VO04 W. von Oertzen and W. Norenberg, Nucl. Phys. A207 (1973) 113

1973VO1D Volkov, in Munich, 2 (1973) 280

1973VO1E von Oertzen, Lect. Notes in Phys. 23 (1973) 267

1973WA1G Watcher, Santoro, Love and Zobel, Bull. Amer. Phys. Soc. 18 (1973) 1601

1973WE03 H. Werle, L. Van der Zwan and K.W. Geiger, Z. Phys. 259 (1973) 275

1973WE06 G.D. Westin and J.L. Adams, Phys. Rev. C8 (1973) 1

1973WE12 H.R. Weller and R.A. Blue, Nucl. Phys. A211 (1973) 221

1973WE19 K.A. Weaver, J.D. Anderson, H.H. Barschall and J.C. Davis, Nucl. Sci. Eng. 52 (1973) 35

1973WE1N Welch, in Asilomar (1973) 1179

1973WI04 D.H. Wilkinson, Phys. Rev. C7 (1973) 930

1973WI11 D.H. Wilkinson, Nucl. Phys. A209 (1973) 470

1973WI15 J. Wilczynski, Phys. Lett. B47 (1973) 124

1973WU01 R.R. Wu, R.L. Dangle, M.M. Duncan, J.L. Duggan, P.D. Miller and Jung Lin, Nucl. Phys. A199 (1973) 23

1973YO1D Youngblood, Nagatani, Kenefick and Bronson, Symp. on Heavy Ion Transfer Reactions, ANL Phy-1973B, Vol. 2 (1973) 689

1974AD1B Adelberger, Proc. Int. Conf. Nucl. Struct. Spectroscopy, Amsterdam, 1974, Vol. 2 (1974) 641

1974AD1D Adelberger, Marrs, Snover and Cooper, Bull. Amer. Phys. Soc. 19 (1974) 452

1974AE01 D. Aebischer, B. Favier, G. Greeniaus, R. Hess, A. Junod, C. Lechanoine, J.C. Nikles and D. Rapin, Helv. Phys. Acta 47 (1974) 74

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

1974AL11 D.E. Alburger and D.R. Goosman, Phys. Rev. C10 (1974) 912

1974AL12 D.E. Alburger and D.R. Goosman, Phys. Rev. C10 (1974) 935.

1974AL31 N.V. Alekseev, I.R. Gulamov, S.B. Ignatev, E.A. Romanovski, E.I. Sirotinin, T.I. Spasskaya, K.S. Shishkin and V.B. Gubin, Izv. Akad. Nauk SSSR Ser. Fiz. 38 (1974) 2637; Bull. Acad. Sci. USSR Phys. Ser. 38 (1974) 152

1974AM05 K.A. Amos, H.V. Geramb, R. Sprickmann, J. Arvieux, M. Buenerd and G. Perrin, Phys. Lett. B52 (1974) 138

1974AN36 N. Anyas-Weiss, J.C. Cornell, P.S. Fisher, P.N. Hudson, A. Menchaca-Rocha, D.J. Millener, A.D. Panagiotou, D.K. Scott, D. Strottman, D.M. Brink et al., Phys. Rept. 12 (1974) 201

1974AV02 G.V. Avakov, E.S. Belyaeva and E.I. Dolinsky, Nucl. Phys. A220 (1974) 205

1974BA37 J.E.E. Baglin, E.J. Bentz and R.W. Carr, Phys. Rev. C10 (1974) 24

1974BA52 A. Babaev, E. Brackman, G. Eliseev, A. Ermilov, Y. Galaktionov, Y. Kamyshkov, V. Lubimov, N. Lugetsky, V. Nagovitzin, V. Nozik et al., Phys. Lett. B51 (1974) 501

1974BA62 A.I. Babaev, E.V. Brakhman, Y.V. Galaktionov, G.P. Eliseev, A.I. Ermilov, O.Y. Zeldovich, Y.A. Kamyshkov, N.N. Luzhetskii, V.A. Lyubimov, V.V. Nagovitsin et al., Yad. Fiz. 20 (1974) 71; Sov. J. Nucl. Phys. 20 (1975) 37

1974BE10 J. Bernabeu and J. Ros, Nucl. Phys. A220 (1974) 1

1974BE1J Becker, Joffily, Beccaria and Baron, Nucl. Phys. A221 (1974) 475

1974BE1R Bertojo, Chui and Townes, Science 104 (1974) 619

1974BE48 J.R. Beene, J. Asher, N. Ayres de Campos, R.D. Gill, M.A. Grace and W.L. Randolph, Nucl. Phys. A230 (1974) 141

1974BE65 H.W. Bertini, G.D. Harp and F.E. Bertrand, Phys. Rev. C10 (1974) 2472

1974BL06 S.L. Blatt, G.L. Marolt and J.D. Goss, Phys. Rev. C10 (1974) 1319

1974BO05 J.D. Bowman, A.M. Poskanzer, R.G. Korteling and G.W. Butler, Phys. Rev. C9 (1974) 836

1974BO2K Bogdanov and Ostroumov, Izv. Akad. Nauk SSSR Ser. Fiz. 38 (1974) 1811

1974BO53 I.I. Bondouk, Atomkernenergie 24 (1974) 201

1974BR18 P. Braun-Munzinger and H.L. Harney, Nucl. Phys. A223 (1974) 381

1974BR37 P. Braun-Munzinger, H.L. Harney and S. Wenneis, Nucl. Phys. A235 (1974) 190

1974BU05 I.F. Bubb, S.N. Bunker, M. Jain, J.W. Leonard, A. McIlwain, K.I. Roulston, K.G. Standing, D.O. Wells and B.G. Whitmore, Can. J. Phys. 52 (1974) 648

1974BU06 C.E. Busch, T.B. Clegg, S.K. Datta and E.J. Ludwig, Nucl. Phys. A223 (1974) 183

1974CA1H Cantwell et al., Nucl. Phys. A236 (1974) 445

1974CH1Q Chechik, Stocker, Eyal and Fraenkel, Proc. Conf. Reactions between Complex Nuclei, Vol. 1 (1974) 6

1974CH46 M. Chemtob and S. Furui, Nucl. Phys. A233 (1974) 435

1974CH58 I.P. Chernov, B.I. Kuznetsov, V.V. Kozyr and V.A. Matusevich, Izv. Akad. Nauk SSSR Ser. Fiz. 38 (1974) 2530; Bull. Acad. Sci. USSR Phys. Ser. 38 (1974) 58

1974CL1G Clark, Roche and Viola, Bull. Amer. Phys. Soc. 19 (1974) 1007

1974CR03 D.J. Crozier and J.C. Legg, Phys. Rev. Lett. 33 (1974) 782

1974CR1E Cramer and Oblow, ORNL-TM-4404

1974DA06 N.E. Davison, P. Fintz and A. Gallmann, Nucl. Phys. A220 (1974) 166

1974DA13 N. Dalkhazhav, G.S. Shabratova, K.D. Tolstov, M.I. Adamovich and V.G. Larionova, Nucl. Phys. A222 (1974) 614

1974DA1D Datta and Thompson, Bull. Amer. Phys. Soc. 19 (1974) 552

1974DA1N Danks, Lambert and Appigny, Astrophys. J. 194 (1974) 745

1974DE03 R.M. DeVries, M.S. Zisman, J.G. Cramer, K.-L. Liu, F.D. Becchetti, B.G. Harvey, H. Homeyer, D.G. Kovar, J. Mahoney and W. von Oertzen, Phys. Rev. Lett. 32 (1974) 680

1974DE1E De Jager, De Vries and De Vries, At. Data Nucl. Data Tables 14 (1974) 479

1974FE08 G.A. Feofilov, A.E. Denisov, R.P. Kolalis, V.S. Sadkovskii, O.V. Chubinskii, Y.F. Andronov and L.I. Vinogradov, Izv. Akad. Nauk SSSR Ser. Fiz. 38 (1974) 2591; Bull. Acad. Sci. USSR Phys. Ser. 38 (1974) 113

1974FL1A Fleury and Alexander, Ann. Rev. Nucl. Sci. 24 (1974) 279

1974FO1J Fortune, Proc. Int. Conf. Nucl. Struct. Spectroscopy, Amsterdam, 1974 (1974) 341

1974GA1L Galster, Ischenko, Siller and Voit, Proc. Conf. Reactions between Complex Nuclei, Vol. 1 (1974) 37

1974GEZL H.V. Geramb, Proc. Int. Conf. Nucl. Struct. Spectroscopy, Amsterdam, 1974, Vol. 2 (1974) 290

1974GM01 K. Gmur and H.H. Muller, Helv. Phys. Acta 46 (1974) 807

1974GO02 L.J.B. Goldfarb and K. Takeuchi, Nucl. Phys. A218 (1974) 396

1974GO1L Gobbi, in Nashville, Vol. 2 (1974) 211

1974GO1T Goosman and Gorodetzky, Bull. Amer. Phys. Soc. 19 (1974) 432

1974GO23 D.R. Goosman, D.F. Geesaman, F.E. Cecil, R.L. McGrath and P. Paul, Phys. Rev. C10 (1974) 1525

1974GR1Q Grossman, Lenz and Locher, Ann. Phys. 74 (1974) 348

1974GU04 I.R. Gulamov, E.A. Romanovskii, T.I. Spasskaya and O.A. Goncharov, Izv. Akad. Nauk SSSR Ser. Fiz. 38 (1974) 140; Bull. Acad. Sci. USSR Phys. Ser. 38 (1974) 122

1974GU1D Gurbanovich et al., Ann. Phys. 87 (1974) 263

1974HA1C Hanna, Proc. Int. Conf. Nucl. Struct. Spectroscopy, Amsterdam, 1974, Vol. 2 (1974) 249

1974HA1G Hanna, Nukelonika (Poland) 19 (1974) 655

1974HA27 S.R. Habbal and H.A. Mavromatis, Nucl. Phys. A223 (1974) 174

1974HA32 P.S. Hauge, Nucl. Phys. A223 (1974) 394

1974HA61 G.D. Harp, Phys. Rev. C10 (1974) 2387

1974HE1E Hermsdorf et al., Zfk 277 (1974)

1974HO06 C.H. Holbrow, H.G. Bingham, R. Middleton and J.D. Garrett, Phys. Rev. C9 (1974) 902

1974HO13 B. Hoistad, S. Dahlgren, P. Grafstrom and A. Asberg, Phys. Scr. 9 (1974) 201

1974IM1B Imanishi, Ohnishi and Tanimura, Proc. Conf. Reactions between Complex Nuclei, Vol. 1 (1974) 25, 26

1974IN01 A. Ingemarsson, Phys. Scr. 9 (1974) 73

1974IN04 A. Ingemarsson, Phys. Scr. 9 (1974) 156

1974IN06 A. Ingemarsson, Phys. Scr. 10 (1974) 149

1974IN07 A. Ingemarsson and G. Tibell, Phys. Scr. 10 (1974) 159

1974JO13 L.W. Jones, C.A. Ayre, H.R. Gustafson, M.J. Longo and P.V. Ramana Murthy, Phys. Rev. Lett. 33 (1974) 1440

1974JO14 P.L. Jolivette, J.D. Goss, G.L. Marolt, A.A. Rollefson and C.P. Browne, Phys. Rev. C10 (1974) 2449

1974KA07 W.B. Kaufmann, J.C. Jackson and W.R. Gibbs, Phys. Rev. C9 (1974) 1340

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

1974KI03 H.R. Kissener, A. Aswad, R.A. Eramzhian and H.U. Jager, Nucl. Phys. A219 (1974) 601

1974KO1V Komarov et al., Joint Inst. Nucl. Res., Lab. Nucl. Problems, USSR, Rept. P1 7784 (1974)

1974KO25 D.G. Kovar, W. Henning, B. Zeidman, Y. Eisen and H.T. Fortune, Phys. Rev. Lett. 33 (1974) 1611

1974KU15 B.I. Kuznetsov and I.P. Chernov, Yad. Fiz. 20 (1974) 632; Sov. J. Nucl. Phys. 20 (1975) 340

1974LA1J Lambert, Dearborn and Sneden, Astrophys. J. 193 (1974) 621

1974LA1K Lambert and Tomkin, Astrophys. J. 194 (1974) L89

1974LE1G K.W.D. Ledingham, J.Y. Gourlay, M. Campbell, M.L. Fitzpatrick and A.D. Baillie, Phys. Lett. B50 (1974) 247

1974LE25 T.-S.H. Lee and J.D. Vergados, Phys. Lett. B53 (1974) 125

1974LI15 B.J. Lieb and H.O. Funsten, Phys. Rev. C10 (1974) 1753

1974LO1G Lorenzen, Nucl. Instrum. Meth. 121 (1974) 467

1974LU06 E.J. Ludwig, C.E. Busch, T.B. Clegg, S.K. Datta and A.C. Watkins, Nucl. Phys. A230 (1974) 271

1974MA10 M. Marangoni, P.L. Ottaviani and A.M. Saruis, Phys. Lett. B49 (1974) 253

1974MA12 J.A. Macdonald, J. Cerny, J.C. Hardy, H.L. Harney, A.D. Bacher and G.R. Plattner, Phys. Rev. C9 (1974) 1694

1974MA1T Madey, Waterman, Baldwin and Wall, Bull. Amer. Phys. Soc. 19 (1974) 1022

1974MC19 W.F. McGill, R.F. Carlson, T.H. Short, J.M. Cameron, J.R. Richardson, I. Slaus, W.T.H. van Oers, J.W. Verba, D.J. Margaziotis and P. Doherty, Phys. Rev. C10 (1974) 2237

1974MI05 C.A. Miller, J.W. Watson, D.I. Bonbright, F.J.S. Wilson and D.O. Wells, Phys. Rev. Lett. 32 (1974) 684

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

1974MI11 G.A. Miller and S.C. Phatak, Phys. Lett. B51 (1974) 129

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

1974MU1G Muhanji, Soga and Bernstein, Bull. Amer. Phys. Soc. 19 (1974) 1021

1974NE1B Negele, Proc. Int. Conf. Nucl. Struct. Spectroscopy, Amsterdam, 1974, Vol. 2 (1974) 618

1974NO01 J.W. Noe, D.P. Balamuth and R.W. Zurmuhle, Phys. Rev. C9 (1974) 132

1974OL03 V.S. Olkhovskii, V.I. Strizhak, Y.I. Totskii, V.T. Tustanovskii and V.A. Chinarov, Yad. Fiz. 19 (1974) 580; Sov. J. Nucl. Phys. 19 (1974) 293

1974OL1D Olkhovskii, Izv. Akad. Nauk SSSR Ser. Fiz. 38 (1974) 165

1974OR1A Orlov, Vestnik Mos. Univ. Fiz. Astron. (USSR) 15 (1974) 259

1974OS1A Osman, Part. Nucl. 7 (1974) 29

1974PEZU G. Perrin, J. Arvieux, M. Buenerd, J. Cole, J.L. Durand, D. Horen, P. Martin, C. Perrin and P. de Saintignon, Proc. Int. Conf. Nucl. Struct. Spectroscopy, Amsterdam, 1974, Vol. 1 (1974) 158

1974PH03 R.J. Philpott and J. George, Nucl. Phys. A233 (1974) 164

1974PH1D Philpott, Bull. Amer. Phys. Soc. 19 (1974) 527

1974PI05 M. Pignanelli, S. Micheletti, I. Iori, P. Guazzoni, F.G. Resmini and J.L. Escudie, Phys. Rev. C10 (1974) 445

1974PL02 A.V. Plavko, R.M. Lombard, J. Gosset, V.I. Kudryashov and B. Mayer, Izv. Akad. Nauk SSSR Ser. Fiz. 38 (1974) 878; Bull. Acad. Sci. USSR Phys. Ser. 38 (1974) 189

1974PL05 A.V. Plavko, Izv. Akad. Nauk SSSR Ser. Fiz. 38 (1974) 2618; Bull. Acad. Sci. USSR Phys. Ser. 38 (1974) 137

1974PO03 V.A. Poyarkov, G.A. Prokopets and V.I. Strizhak, Yad. Fiz. 19 (1974) 705; Sov. J. Nucl. Phys. 19 (1974) 357

1974RA11 J.R. Radin, A.R. Smith and N. Little, Phys. Rev. C9 (1974) 1718

1974RE1B E.F. Redish, Nucl. Phys. A235 (1974) 82

1974RE1E Reitan, Nucl. Phys. B68 (1974) 387

1974RO1R Rolfs and Tombrello, Bull. Amer. Phys. Soc. 19 (1974) 451

1974RO1T Rolfs and Tombrello, LAP-128 (1974)

1974RO29 C. Rolfs and R.E. Azuma, Nucl. Phys. A227 (1974) 291

1974RO42 E.A. Romanovskii, I.R. Gulamov, V.B. Gubin, T.I. Spasskaya and Z.F. Kalacheva, Izv. Akad. Nauk SSSR Ser. Fiz. 38 (1974) 2550; Bull. Acad. Sci. USSR Phys. Ser. 38 (1974) 75

1974ROXP V.C. Rogers, V.J. Orphan, C.G. Hoot and V.V. Verbinski, DNA-3495F (1974)

1974SA16 Z.A. Saleh, F. Machali, I.I. Bondouk and D.A. Darwish, Ann. Phys. (Leipzig) 31 (1974) 76

1974SC1F Scalo, OAP-352 (1974)

1974SC1M Scott, LBL-3434 (1974)

1974SHYR V.S. Shirley and C.M. Lederer, LBL-3450 (1974)

1974SI04 B. Singh, Nucl. Phys. A219 (1974) 621

1974TA1E Talmi, Proc. Int. Conf. Nucl. Struct. Spectroscopy, Amsterdam, 1974 (1974) 696

1974TH01 C. Thibault and R. Klapisch, Phys. Rev. C9 (1974) 793

1974TH02 S.T. Thornton, R.C. Jordan, C.L. Morris and R.P. Rotter, Z. Phys. 266 (1974) 329

1974TO1C Tomkin and Lambert, Astrophys. J. 193 (1974) 441

1974UL02 H. Ullrich, E.T. Boschitz, H.D. Engelhardt and C.W. Lewis, Phys. Rev. Lett. 33 (1974) 433

1974UL1B Ulrich, Astrophys. J. 188 (1974) 369

1974VA24 J.H. van der Merwe and C.M. Villet, Phys. Rev. C10 (1974) 1498

1974VAZO N. Van Sen, H. Muller, J.C. Gondrand, A. Fiore and G. Perrin, Proc. Int. Conf. Nucl. Struct. Spectroscopy, Amsterdam, 1974, Vol. 1 (1974) 180

1974WE1Q Weil, McDaniel and Burrows, Bull. Amer. Phys. Soc. 19 (1974) 477

1974WI1M D.H. Wilkinson, Nucl. Phys. A225 (1974) 365

1974WO1F Wolk, Austin, Bortins and Galonsky, MSUCL-109 (1974)

1974ZA04 S.A.A. Zaidi and Y.L. Tyan, Phys. Lett. B50 (1974) 305

1974ZH1B Zhurkin et al., Yad. Fiz. 20 (1974) 362

1974ZU1A Zuker, Proc. Int. Conf. Nucl. Struct. Spectroscopy, Amsterdam. 1974 (1974) 115

1975AB14 A.Y. Abul-Magd, Prog. Theor. Phys. 53 (1975) 997

1975AE1A Aebischer et al., Nucl. Instrum. Meth. 124 (1975) 49

1975AJ02 F. Ajzenberg-Selove, Nucl. Phys. A248 (1975) 1

1975AJ1C Ajzenberg-Selove, Flynn, Garrett and Hansen, Bull. Amer. Phys. Soc. 20 (1975) 596

1975AL19 J.M. Alexander, H. Delagrange and A. Fleury, Phys. Rev. C12 (1975) 149

1975AL1B Almond, Phys. Rept. C17 (1975) 1

1975AL1K Alster et al., Bull. Amer. Phys. Soc. 20 (1975) 84

1975AN01 B. Antolkovic and Z. Dolenec, Nucl. Phys. A237 (1975) 235

1975AR19 E.D. Arthur, D.M. Drake and I. Halpern, Phys. Rev. Lett. 35 (1975) 914

1975AR1E Arnould and Norgaard, Astron. Astrophys. 42 (1976) 55

1975AU1D Audouze, Lequeux and Vigroux, Astron. Astrophys. 43 (1975) 71

1975AU1F Austin, Galonsky, Bortins and Wolk, Nucl. Instrum. Meth. 126 (1975) 373

1975BA05 S. Barshay, C.B. Dover and J.P. Vary, Phys. Rev. C11 (1975) 360

1975BE1T Bertozzi, Bull. Amer. Phys. Soc. 20 (1975) 708

1975BE31 M. Beiner, R.J. Lombard and D. Mas, Nucl. Phys. A249 (1975) 1

1975BI1K Bizard et al., Nucl. Instrum. Meth. 129 (1975) 569

1975BO1W Bondouk, Ann. Phys. (Leipzig) 32 (1975) 261

1975BO32 J. Bommer, M. Ekpo, H. Fuchs, K. Grabisch and H. Kluge, Phys. Rev. C12 (1975) 1069

1975BO35 J. Bommer, M. Ekpo, H. Fuchs, K. Grabisch and H. Kluge, Nucl. Phys. A251 (1975) 257

1975BR1J Branch and Bell, Monthly Notice Roy. Astron. Soc. 173 (1975) 29

1975CA05 G. Cattapan, G. Pisent and V. Vanzani, Nucl. Phys. A241 (1975) 204

1975CA1L Carlson et al., Nucl. Instrum. Meth. Phys. Res. 123 (1975) 509

1975CA1V Caparis et al., Helv. Phys. Acta 48 (1975) 45

1975CE04 F.E. Cecil, J.R. Shepard, R.E. Anderson, R.J. Peterson and P. Kaczkowski, Nucl. Phys. A255 (1975) 243

1975CR06 A. Cristallini, C. Maroni, I. Massa and G. Vannini, Phys. Lett. B56 (1975) 245

1975DE09 G. Delic, Phys. Rev. Lett. 34 (1975) 1468

1975DE1F Dearborn, Bolton and Eggleton, Monthly Notice Roy. Astron. Soc. 170 (1975) 7P

1975DE1H Dearborn, Lambert and Tomkin, Astrophys. J. 200 (1975) 675

1975DE32 R. De Leo, G. D'Erasmo, F. Ferrero, A. Pantaleo and M. Pignanelli, Nucl. Phys. A254 (1975) 156

1975DI1J Dinh-Lien Pham, Cluster (1975)

1975DO1J Doggett, Stringfield, Morrow and Bennett, Bull. Amer. Phys. Soc. 20 (1975) 585

1975EI1B Eisenberg, AIP Conf. Proc. 26 (1975) 17

1975EI1D J.M. Eisenberg and A. Gal, Phys. Lett. B58 (1975) 390

1975EN1A Endal, Astrophys. J. 195 (1975) 187

1975FA1A Fagg, Rev. Mod. Phys. 47 (1975) 683

1975FO09 H.T. Fortune, W. Henning, D.C. Kovar, B. Zeidman and Y. Eisen, Phys. Lett. B57 (1975) 445

1975FO19 W.A. Fowler, G.R. Caughlan and B.A. Zimmerman, Ann. Rev. Astron. Astrophys. 13 (1975) 69

1975FO1L Fox, Polchinski, Rolfs and Tombrello, LAP-144 (1975)

1975FU01 C.B. Fulmer and D.A. Goldberg, Phys. Rev. C11 (1975) 50

1975GI1B Gibson et al., Bull. Amer. Phys. Soc. 20 (1975) 1193

1975GL1C Glavish, Cheng, Kurjan and Mavis, Bull. Amer. Phys. Soc. 20 (1975) 85

1975GO03 J.D. Goss, C.P. Browne, A.A. Rollefson and P.L. Jolivette, Phys. Rev. C11 (1975) 710

1975GR03 P.T. Greenland, J. Phys. (London) G1 (1975) 1

1975GR12 K.A. Gridnev and E.F. Hefter, Z. Phys. A273 (1975) 99

1975HA1P Harvey, Clustering Phenom. in Nucl., II, ORO-4856-26 (1975) 392

1975HA1Z Haouat et al., CEA-R-4641 (1975)

1975HA2C Haouat et al., Paper, Natl. Sov. Conf. Neutron Phys., Kiev (1975)

1975HA2D Haouat et al., Conf. Nucl. Cross Sections Tech., Washington (1975)

1975HE02 H.T. Heaton, II, J.L. Menke, R.A. Schrack and R.B. Schwartz, Nucl. Sci. Eng. 56 (1975) 27

1975HI07 F. Hinterberger, P.V. Rossen, H.G. Ehrlich, B. Schuller, R. Jahn, J. Bisping and G. Welp, Nucl. Phys. A253 (1975) 125

1975HO1N Holt, Smith and Whalen, Bull. Amer. Phys. Soc. 20 (1975) 145

1975HU01 R. Huby and D. Kelvin, J. Phys. (London) G1 (1975) 203

1975HU14 J. Hufner, K. Schafer and B. Schurmann, Phys. Rev. C12 (1975) 1888

1975HU1D Hufner, Phys. Rept. C21 (1975) 1

1975HU1H Hugg, Minamisono, Glavish and Hanna, Bull. Amer. Phys. Soc. 20 (1975) 1495

1975IS03 M.Y. Ismail and M.I. Yousef, Atomkernenergie 25 (1975) 55

1975JA1A Jaros et al., Bull. Amer. Phys. Soc. 20 (1975) 666

1975JE02 N.A. Jelley, J. Cerny, D.P. Stahel and K.H. Wilcox, Phys. Rev. C11 (1975) 2049

1975KA1R Kaufmann, Hess and Gibbs, Bull. Amer. Phys. Soc. 20 (1975) 84

1975KA26 K. Katori and K. Furuno, Nucl. Instrum. Meth. 127 (1975) 381

1975KI1D Kikuchi and Okazaki, Pub. Astron. Soc. Jpn. 27 (1975) 107

1975KI1E L.S. Kisslinger and G.A. Miller, Nucl. Phys. A254 (1975) 493

1975KO29 L. Koester and W. Nistler, Z. Phys. A272 (1975) 189

1975KR14 S. Krol and S. Szpikowski, Acta Phys. Pol. B6 (1975) 409

1975KU01 D. Kurath and D.J. Millener, Nucl. Phys. A238 (1975) 269

1975KU21 D. Kurath, Phys. Rev. Lett. 35 (1975) 1546

1975LA1K Lachkar et al., NEANDC (E) 168 L, INDC (FR)-7L (1975)

1975LA23 L. Lapikas, G. Box and H. De Vries, Nucl. Phys. A253 (1975) 324

1975LI11 D.A. Lind, R.J. Peterson and H.W. Fielding, Phys. Rev. C11 (1975) 2099

1975LU1B Lunnon et al., Bull. Amer. Phys. Soc. 20 (1975) 567

1975MA21 R.E. Marrs, E.G. Adelberger, K.A. Snover and M.D. Cooper, Phys. Rev. Lett. 35 (1975) 202

1975MA41 G. Mairle and G.J. Wagner, Nucl. Phys. A253 (1975) 253

1975MC19 M.W. McNaughton, N.S.P. King, F.P. Brady and J.L. Ullmann, Nucl. Instrum. Meth. Phys. Res. 129 (1975) 241

1975ME1E Meneguizzi and Reeves, Astron. Astrophys. 40 (1975) 91, 99

1975ME1H Meyer, Weitkamp and Dunham, Helv. Phys. Acta 48 (1975) 559

1975ME24 M.R. Meder and J.E. Purcell, Phys. Rev. C12 (1975) 2056

1975MI01 S. Micheletti, M. Pignanelli and P. Guazzoni, Phys. Rev. C11 (1975) 64

1975MI12 D.J. Millener and D. Kurath, Nucl. Phys. A255 (1975) 315

1975MO1M Mondal, Basak, Kasim and Husain, Nuovo Cim. A28 (1975) 42

1975MU1B Murthy, Nucl. Phys. B92 (1975) 269

1975NA15 K.G. Nair, H. Voit, C.W. Towsley, M. Hamm, J.D. Bronson and K. Nagatani, Phys. Rev. C12 (1975) 1575

1975NA1C Nathan, Thesis, Princeton Univ. (1975)

1975NA1M Nair, Hamm, Towsley and Nagatani, Clustering Phenom. in Nucl., II, ORO-4856-26 (1975) 421

1975NO05 J.V. Noble, Nucl. Phys. A244 (1975) 526

1975NO1D Norgaard and Arnould, Astron. Astrophys. 40 (1975) 331

1975OS01 A. Osman, Nuovo Cim. A25 (1975) 571

1975PA09 B.H. Patrick, E.M. Bowey, E.J. Winhold, J.M. Reid and E.G. Muirhead, J. Phys. (London) G1 (1975) 874

1975PU01 R.J. Puigh, K.W. Kemper, G.E. Moore and R.L. White, Nucl. Phys. A237 (1975) 1

1975RA13 L. Ray, W.R. Coker and T. Udagawa, Phys. Lett. B56 (1975) 318

1975RA14 G.M. Raisbeck, J. Lestringuez and F. Yiou, Phys. Lett. B57 (1975) 186

1975RA22 V.K. Rasmussen and F.R. Metzger, Phys. Rev. C12 (1975) 706

1975RA29 D.C. Radford and A.R. Poletti, Nucl. Phys. A254 (1975) 183

1975RA33 L. Ray, G. Westfall, S.A.A. Zaidi and W.R. Coker, Phys. Lett. B59 (1975) 427

1975RE01 A. Reitan, Nucl. Phys. A237 (1975) 465

1975RE04 W. Reisdorf, Nucl. Phys. A242 (1975) 406

1975RI1A Rickards, Nucl. Instrum. Meth. 127 (1975) 397

1975RO1G Rosen, AIP Conf. Proc. 26 (1975) 265

1975RO27 P.G. Roos, S.M. Smith, V.K.C. Cheng, G. Tibell, A.A. Cowley and R.A.J. Riddle, Nucl. Phys. A255 (1975) 187

1975SC1H J.M. Scalo, K.H. Despain and R.K. Ulrich, Astrophys. J. 196 (1975) 805

1975SC35 W.F.W. Schneider, B. Kohlmeyer, F. Puhlhofer and R. Bock, Nucl. Phys. A251 (1975) 331

1975SC42 W.F.W. Schneider, B. Kohlmeyer and F. Puhlhofer, Z. Phys. A275 (1975) 249

1975SE07 F. Seiler, Nucl. Phys. A244 (1975) 236

1975SH18 E.B. Shera, Phys. Rev. C12 (1975) 1003

1975SH20 R. Sherr and G. Bertsch, Phys. Rev. C12 (1975) 1671

1975SI1H Sick, AIP Conf. Proc. 26 (1975) 388

1975SL02 I. Slaus, D.J. Margaziotis, R.F. Carlson, W.T.H. van Oers and J.R. Richardson, Phys. Rev. C12 (1975) 1093

1975SM02 L.G. Smith and A.H. Wapstra, Phys. Rev. C11 (1975) 1392

1975SN1A Sneden and Lambert, Monthly Notices Roy. Astron. Soc. 170 (1975) 533

1975SW1C Switkowski and Parker, LAP-141 (1975)

1975TO01 D. Tow and J.M. Eisenberg, Nucl. Phys. A237 (1975) 441

1975TO1B Tomkin, Lambert and Ljck, Astrophys. J. 199 (1975) 436

1975TR07 S. Tryti, T. Holtebekk and F. Ugletveit, Nucl. Phys. A251 (1975) 206

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

1975VA1J Vaalburg et al., Appl. Rad. Isotopes 26 (1975) 317

1975VI09 R.D. Viollier, Ann. Phys. 93 (1975) 335

1975VO05 H. Voit, M. Hamm, K.G. Nair, C. Towsley, A.D. Bacher, K. Nagatani and F. Siller, Phys. Lett. B58 (1975) 152

1975VO1B Von Oertzen and Bohlen, Phys. Rept. 19 (1975) 1

1975WE1D Westfall and Zaidi, Bull. Amer. Phys. Soc. 20 (1975) 718

1975WI04 S.J. Wilson, Phys. Rev. C11 (1975) 1071

1975WI1E Wilkinson, Proc. Int. Symp. on Interaction Studies in Nucl., Germany, 1975 (1975) 147

1975ZA06 N.I. Zaika and P.L. Shmarin, Ukr. Fiz. Zh. 20 (1975) 238

1976AH02 S.S. Ahmad, R.F. Barrett and B.A. Robson, Nucl. Phys. A257 (1976) 378

1976EDZZ R.D. Edge, Bull. Amer. Phys. Soc. 21 (1976) 29, BE4

1976GI01 W.R. Gibbs, B.F. Gibson, A.T. Hess, G.J. Stephenson, Jr. and W.B. Kaufmann, Phys. Rev. Lett. 36 (1976) 85

1976HO1B Hogue et al., Bull. Amer. Phys. Soc. 21 (1976) 188

1976JU1A Jury, Johnson, McNeill and Woodworth, Bull. Amer. Phys. Soc. 21 (1976) 67

1976KA01 S.B. Kaufman, M.W. Weisfield, B.D. Wilkins, D. Henderson and E.P. Steinberg, Phys. Rev. C13 (1976) 253

1976KO03 V.I. Komarov, G.E. Kosarev, E.S. Kuzmin, A.G. Molokanov, G.P. Reshetnikov, O.V. Savchenko and S. Tesch, Nucl. Phys. A256 (1976) 362

1976LE02 T.-S.H. Lee and S. Pittel, Nucl. Phys. A256 (1976) 509

1976MA04 F. Malaguti and P.E. Hodgson, Nucl. Phys. A257 (1976) 37

1976MC1L McNeil et al., Bull. Amer. Phys. Soc. 21 (1976) 68

1976MO03 T. Motobayashi, I. Kohno, K. Katori, M. Yoshie, T. Ohi and H. Kamitsubo, Phys. Rev. Lett. 36 (1976) 390

1976NAZZ K.G. Nair and K. Nagatani, Bull. Amer. Phys. Soc. 21 (1976) 64, GE3

1976PA03 K.-H. Passler, Nucl. Phys. A257 (1976) 253

1976PO02 J.E. Poling, E. Norbeck and R.R. Carlson, Phys. Rev. C13 (1976) 648

1976SC1G Schulte, Kamykowski, Pacawer and Stauber, Bull. Amer. Phys. Soc. 21 (1976) 109

1976SH01 Y. Shamai, J. Alster, D. Ashery, S. Cochavi, M.A. Moinester, A.I. Yavin, E.D. Arthur and D.M. Drake, Phys. Rev. Lett. 36 (1976) 82

1976SO02 M. Soga and E.M. Bernstein, Phys. Rev. C13 (1976) 473

1976WE01 H.R. Weller, R.A. Blue, S.E. Darden and W.A. Yoh, Phys. Rev. C13 (1976) 38

1977AJ02 F. Ajzenberg-Selove, Nucl. Phys. A281 (1977) 1