Revised Manuscript *08 April 2020*

Energy Levels of Light Nuclei
$A = 14$

F. Ajzenberg-Selove

University of Pennsylvania, Philadelphia, Pennsylvania 19104-6396

Abstract: An evaluation of $A = 13$–15 was published in *Nuclear Physics A*360 (1981), p. 1. This version of $A = 14$ 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. Also, Reference key numbers have been changed to the NNDC/TUNL format.

(References closed August 1, 1980)

The original work of Fay Ajzenberg-Selove was supported by the US Department of Energy [DE-AC02-76-ER02785]. Later modification by the TUNL Data Evaluation group was supported by the US Department of Energy, Office of High Energy and Nuclear Physics, under: Contract No. DEFG05-88-ER40441 (North Carolina State University); Contract No. DEFG05-91-ER40619 (Duke University).

Table of Contents for $A = 14$

Below is a list of links for items found within the PDF document. Figures from this evaluation are not included in the PDF document but have been scanned in and are available on this website or via the link below.

^{14}Li

(Not illustrated)

^{14}Li has not been observed: it is calculated to be particle unstable with a binding energy of -2.66 MeV for decay into ^{13}Li + n and of -3.23 MeV for decay into ^{12}Li + 2n. The calculated mass excess is 72.29 MeV (1974TH01).

^{14}Be

(Figs. 5 and 9)

^{14}Be has been observed in the 4.8 GeV proton bombardment of uranium; it is particle stable: see (1976AJ04). Its atomic mass excess is calculated to be 40.69 MeV. ^{14}Be is then bound by 2.73 and 0.55 MeV, respectively, with respect to decay into ^{13}Be + n and ^{12}Be + 2n (1974TH01). [See (1980AJ01) for a discussion of the mass of ^{12}Be]. See also (1976BE1G, 1976BE1V, 1977SE1D, 1979BO22; theor.).

^{14}B

(Figs. 5 and 9)

GENERAL: (See also (1976AJ04).)

See (1975FE1A, 1977AR06, 1979KI11).

Mass of ^{14}*B:* The atomic mass excess of ^{14}B is 23.644 ± 0.027 MeV, based on the mean of the values reported by (1973BA34) and (1980NA14).

$T = 2$ *states of* $A = 14$. On the basis of the mass of ^{14}B, the lowest $T = 2$ states in ^{14}C, ^{14}N and ^{14}O are estimated to lie at $E_x = 22.5$, 24.8 and 22.5 MeV (1973BA34).

1. ^{14}B(β^-)^{14}C $\qquad Q_m = 20.62$

^{14}B has a half-life of 16.1 ± 1.2 msec. The β-decay is primarily to ^{14}C*(6.09) [$J^\pi = 1^-$] and (6.73) [$J^\pi = 3^-$]: see Table 14.2. The measured γ-ray intensity ratios are $I_{6.09}/I_{6.73}/I_{7.34} = 100/(10.0 \pm 2.0)/< 2.2$. The nature of the decay fixes the J^π of ^{14}B to be 2^- (1974AL11).

2. ^{10}Be(^{6}Li, 2p)^{14}B $\qquad Q_m = -11.53$

^{14}B has been populated in this reaction at $E(^6\text{Li}) = 31$ MeV (1974AL11).

Table 14.1: Energy levels of ^{14}B

E_x (MeV $\pm$ keV)	$J^\pi; T$	$\tau_{1/2}$ (msec)	Decay	Reactions
g.s.	$2^-; 2$	16.1 ± 1.2 msec	β^-	1, 2, 3, 4
0.74 ± 40	$(1^-); 2$			3
1.38 ± 30	$(3^-); 2$			3
1.82 ± 60	$(2^-); 2$			3
2.08 ± 50	$(4^-); 2$			3
(2.32 ± 40)				3
2.97 ± 40				3

Table 14.2: Beta decay of ^{14}B [a]

Decay to ^{14}C* (MeV)	J^π	Branch (%)	log ft
0	0^+	(5 ± 3) [d]	
6.09 [b]	1^-	81 ± 9	4.22 ± 0.05
6.73	3^-	$8.6^{+1.7}_{-4.0}$	$5.10^{+0.30}_{-0.08}$
7.34	2^-	< 11 [e]	> 4.9
[c]			

[a] (1974AL11).

[b] E_{β^-}(max) $= 14.0 \pm 0.7$ MeV to this state.

[c] A search for possible delayed neutrons following the population of higher states has not yet been carried out.

[d] This branch has not been observed. It is assumed to be (5 ± 3)% in the calculation of the branching ratios to ^{14}C*(6.09, 6.73). However, (1975MI12; theor.) suggest that the branch may be as small as $\approx$ 0.3%. The errors shown for the branching ratios reflect this uncertainty (1974AL11).

[e] This branch has not been observed: the upper limit is shown. In the calculations of the branching ratios to ^{14}C*(6.09, 6.73) a value (5 ± 5)% was used.

3. ^{14}C(^{7}Li, ^{7}Be)^{14}B $Q_{\rm m} = -21.49$

^{14}B states with $0 < E_{\rm x} < 3$ MeV have been populated in this reaction at $E(^{7}{\rm Li}) = 52$ MeV: see Table 14.1. Similarities in the relative intensities of ^{14}B*(0, 0.74, 1.38, 1.82, 2.08) and of ^{12}B*(1.67, 2.62, 3.39, 4.37, 4.52) [populated in ^{12}C(^{7}Li, ^{7}Be)^{12}B], and the similarity in the $\Delta E_{\rm x}$ of these ^{12}B states with the $E_{\rm x}$ of the ^{14}B states suggest that they have the same J^{π} (1973BA34).

4. ^{14}C(^{14}C, ^{14}N)^{14}B $Q_{\rm m} = -20.47$

At $E(^{14}{\rm C}) = 87.4$ MeV, the ground state of ^{14}B is observed: the atomic mass excess is 23.59 ± 0.06 MeV. The first excited state is not populated (1980NA14).

^{14}C
(Figs. 6 and 9)

GENERAL: (See also (1976AJ04).)

Nuclear models: (1976VO1C).

Special levels: (1978AL1T, 1979HOZW).

Special reactions involving ^{14}C: (1976AB04, 1976BU16, 1976LE1F, 1977AR06, 1978AB08, 1978GE1C, 1978HE1C, 1978KA23, 1978KO01, 1978LE15, 1978TU06, 1979AL22, 1979BO22).

Giant resonance: (1979DO17, 1979KI11).

Astrophysical questions: (1976DE1G, 1976LI1K, 1977BR1N, 1977CO1U, 1977HA1L, 1977KU1J, 1978BU1B, 1979DE1V, 1979OL1B, 1980ST1C).

Muon and neutrino capture and reactions: (1977GO13, 1978DE15, 1979GO1M, 1980LO07, 1980MU1B).

Pion and kaon capture and reactions (See also reactions 19, 36 and 44.): (1976DI11, 1976DI10, 1976EN02, FI76F, 1977DO06, 1977RI1H, 1978DA1A, 1978SH16, 1979KI11, 1980ER01, 1980FI05).

Applied work: (1976LI1K, 1977ME1D, 1977MU1B, 1977RY1A, 1978AI1A, 1978BE2D, 1978DO1G, 1978HE1M, 1978MU1E, 1979BE2J, 1979GO1L, 1979LI1C, 1979MU1E, 1979ST1P, 1979TA1N, 1980GO1B).

Other topics: (1976ST13, 1978DA1A, 1978GA1C, 1978PO1A, 1978SO1A, 1979KA13).

Ground state of ^{14}C: (1976BE1G, 1977AN21, 1978AN07, 1978HE1D, 1978NA07, 1978SM02, 1978TA09).

1. ^{14}C(β^-)^{14}N $\quad Q_{\rm m} = 0.1565$

The adopted value of the half-life is 5730 ± 40 y: see (1976AJ04). Using $Q_{\rm m}$, $\log ft = 9.04$ (1971GO40). For discussions of the lifetime of ^{14}C see (1959AJ76, 1970AJ04, 1976AJ04). See also (1978MA1P), (1976BE1E), (1980RO1D; applied) and (1977GO13, 1977IK1B, 1977RI08, 1979DE15, 1979FE1E, 1979PR1D, 1980LO07; theor.).

2. (a) ^{7}Li(^{7}Li, n)^{13}C $\quad Q_{\rm m} = 18.620 \quad E_{\rm b} = 26.796$
   (b) ^{7}Li(^{7}Li, p)^{13}B $\quad Q_{\rm m} = 5.965$
   (c) ^{7}Li(^{7}Li, d)^{12}B $\quad Q_{\rm m} = 3.311$
   (d) ^{7}Li(^{7}Li, t)^{11}B $\quad Q_{\rm m} = 6.199$

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

(f) ^{7}Li(^{7}Li, ^{7}Li)^{7}Li

(g) ^{7}Li(^{7}Li, ^{8}Be)^{6}He $\qquad Q_m = 7.281$

Table 14.3: Energy levels of ^{14}C [a]

E_x in ^{14}C (MeV ± keV)	$J^\pi; T$	τ or $\Gamma_{c.m.}$	Decay	Reactions
g.s.	$0^+; 1$	$\tau_{1/2} = 5730 \pm 40$ y	β^-	1, 3, 4, 5, 9, 10, 11, 12, 15, 16, 19, 20, 22, 23, 24, 25, 26, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 50, 51
6.0942 ± 1.6	1^-	$\tau_m < 10$ fsec	γ	3, 4, 5, 6, 10, 11, 19, 20, 22, 27, 37, 40, 42, 49
6.5898 ± 1.6	0^+	4.3 ± 0.6 psec	γ	3, 4, 5, 10, 11, 20, 40
6.7282 ± 1.3	3^-	96 ± 11 psec $\lvert g \rvert = 0.272 \pm 0.007$	γ	3, 4, 5, 6, 10, 11, 12, 13, 14, 15, 20, 22, 23, 27, 30, 33, 37, 40, 42, 44, 49
6.9023 ± 1.8	0^-	36 ± 4 fsec	γ	3, 4, 5, 6, 10, 11, 20, 40, 44
7.0120 ± 4.2	2^+	13 ± 2 fsec	γ	3, 4, 5, 9, 10, 11, 20, 29, 30, 36, 40, 42, 45
7.3414 ± 3.1	2^-	160 ± 60 fsec	γ	3, 4, 5, 9, 10, 11, 20, 23, 29, 42
8.3179 ± 0.8	2^+	$\Gamma = 3.4 \pm 0.6$ keV	γ, n	3, 4, 5, 10, 11, 16, 17, 19, 20, 29, 36, 42, 45
9.746 ± 7	0^+	18		11
9.801 ± 6	(1^-)	45 ± 12	n	3, 5, 10, 11, 17, 20, 29, 42
10.425 ± 5	2^+	15	n	10, 11, 17, 20, 42, 45
10.449 ± 7	≥ 1	9	n	3, 10, 11, 17, 20, 42, 45
10.498 ± 4	(3^-)	26 ± 8		3, 10, 11, 20, 29

Table 14.3: Energy levels of ^{14}C [a] (continued)

E_x in ^{14}C (MeV ± keV)	$J^\pi; T$	τ or $\Gamma_{c.m.}$	Decay	Reactions
10.736 ± 5	4^+	20 ± 7		3, 10, 11, 12, 13, 15, 36, 40
11.306 ± 15 [b]	1^+	46 ± 12	γ	3, 10, 29, 42
11.395 ± 8	1^-	22 ± 7		3, 10, 11
11.666 ± 10	(5^-)	20 ± 7		3, 10, 11, 42
11.730 ± 10	(5^-)			3, 11
11.9 ± 300		950 ± 300	n	11, 20
12.583 ± 10		95 ± 15		3, 11, 20, 42
12.863 ± 8		30 ± 10		3, 11, 20
12.963 ± 9	(1^-)	30 ± 10		3, 11, 20, 29
14.667 ± 20	$2^+, 3, 4, 5, 6^+$	57 ± 15		3, 29
14.867 ± 25				3, 12, 19, 42
15.19 ± 30				3
(15.37 ± 30)				3
15.44 ± 40				3
(16.02 ± 50)				3
16.411 ± 20				3
(16.57 ± 40)				3
16.715 ± 30			γ, n	3
(17.28 ± 40)			γ	3
17.95 ± 40				3
18.10 ± 40				4

[a] See also Tables 14.4 and 14.5.

[b] (1977CR02) [see reaction 29] identify a state with $E_x = 11.31 \pm 0.02$ MeV, $J^\pi = 1^+$, $\Gamma = 207 \pm 13$ keV, $\Gamma_{\gamma 0} = 6.8 \pm 1.4$ keV. It is difficult to understand the large Γ difference with that reported in reaction 3. 1^+ is consistent with the state not being reported in ^{12}C(t, p).

These reactions have been studied with $E(^7\text{Li})$ to 6.5 MeV: see (1970AJ04) for the early references. For $E(^7\text{Li}) = 2.3$ to 5.8 MeV, the cross section for emission of α_0, α_1 and α_{2+3+4} is found to increase monotonically with energy (1964DZ1A, 1969CA1A). However, (1971WY01) reports several broad structures in the 0° yield of α_0 and α_1 for $E(^7\text{Li}) = 2$ to 20 MeV: it is suggested that these are neither compound nucleus resonances nor Ericson-type fluctuations but that they are

Table 14.4: Lifetimes of bound excited states of ^{14}C [a]

^{14}C* (MeV)	τ_m	Reaction	Refs.
6.09	< 10 fsec	^{9}Be(^{13}C, ^{8}Be)	(1975SE04)
6.59	3.7 ± 0.9 psec	^{7}Li(^{9}Be, np)	(1979KOZM) [b]
	4.6 ± 0.7 psec	^{2}H(^{13}C, p)	(1980TO05)
	4.3 ± 0.6 psec		mean
6.73	97 ± 15 psec [c]	^{12}C(t, p)	(1968AL12)
6.90	36 ± 4 fsec	^{9}Be(^{13}C, ^{8}Be)	(1975SE04)
7.01	13 ± 2 fsec [A]	^{14}C(e, e)	(1972CRZN)
	< 7 fsec	^{11}B(α, p)	(1976GR02)
7.34	160 ± 60 fsec	^{11}B(α, p)	(1976GR02)

A = adopted value.

[a] See also Table 14.10 in (1976AJ04).

[b] And E.K. Warburton, private communication.

[c] (1981KO08) find 96 ± 15 psec leading to a weighted mean of 96 ± 11 psec (E.K. Warburton, private comminucation).

due to a forward-direction cluster transfer process (1971WY01). For reaction (f) see (1978NO1F: $2.0 \rightarrow 5.5$ MeV).

3. ^{9}Be(^{6}Li, p)^{14}C $\qquad Q_m = 15.126$

Observed proton groups are displayed in Table 14.6 (1973AJ01). See also (1976AJ04) and ^{15}N.

4. ^{9}Be(^{7}Li, d)^{14}C $\qquad Q_m = 10.100$

Angular distributions of the deuterons to ^{14}C*(0, 6.09, $6.59 + 6.73$, $6.90 + 7.01$, 7.34, 8.32) have been measured at $E(^7\text{Li}) = 5.6$, 5.8, 6.0 and 6.2 MeV (1969SN02). (1969TH01) report $E_\gamma = 6094.5 \pm 3.2$, 6728.1 ± 1.4 and 7011.7 ± 5.2 keV for the ground state transitions of these states. See also (1976AJ04).

5. ^{9}Be(^{9}Be, α)^{14}C $\qquad Q_m = 17.2511$

At $E(^9\text{Be}) = 5$ MeV ^{14}C*(0, 6.09, 6.6, 6.9, 7.34, 8.32, 9.80) are populated. The α_0 angular distributions have been measured at 5 and 12 MeV (1977YO02).

6. ^{9}Be(^{13}C, ^{8}Be)^{14}C $\qquad Q_\text{m} = 6.5114$

τ_m for ^{14}C*(6.09, 6.73, 6.90) are < 10, $> 5 \times 10^4$ and 36 ± 4 fsec, respectively (1975SE04): see Table 14.4.

7. ^{10}Be(α, p)^{13}B $\qquad Q_\text{m} = -8.818 \qquad E_\text{b} = 12.0126$

A preliminary report of a resonance corresponding to a $T = 2$ state has not been published: see (1976AJ04).

8. (a) ^{11}B(t, n)^{13}C $\qquad Q_\text{m} = 12.4214 \qquad E_\text{b} = 20.5979$

(b) ^{11}B(t, α)^{10}Be $\qquad Q_\text{m} = 8.585$

For possible resonant structure in (a) see (1976AJ04). For reaction (b) see (1977CI1A).

9. ^{11}B(α, p)^{14}C $\qquad Q_\text{m} = 0.7839$

Angular distributions of p_0 have been measured at $E_\alpha = 1.43$ to 25.1 MeV [see (1976AJ04)] and at $E_\alpha = 1.43$ to 2.94 MeV (1976DA06) and 4.4 to 6.7 MeV (1978HO08). See also Table 14.4, ^{15}N and (1976EP1A, 1980DO1C; astrophys.).

10. ^{11}B(^{7}Li, α)^{14}C $\qquad Q_\text{m} = 18.131$

At $E(^7\text{Li}) = 5$ MeV, α-particle groups are observed to the known states of ^{14}C with $E_\text{x} < 10$ MeV except ^{14}C*(6.90), and to the unresolved $10.4 - 10.5$ MeV states. There is some indication also of ^{14}C states at (10.71), 11.35, 11.66, (14.15), (14.73) and (15.07) MeV ($\pm$ approx. 50 keV). Angular distributions have been obtained for the α-particles to ^{14}C*(0, 6.09, 8.32) (1966MC05).

11. ^{12}C(t, p)^{14}C $\qquad Q_\text{m} = 4.6410$

Table 14.5: Branching ratios of γ-rays in ^{14}C

E_i (MeV)	J_i^π	E_f (MeV)	Branch (%)	
			A	B
6.09	1^-	0		
6.59	0^+	0	1.1 ± 0.1 [c]	
		6.09	98.9 ± 0.1 [d]	
6.73	3^-	0	93 ± 2	97.3 ± 1
		6.09	7 ± 2	2.7 ± 1
6.90	0^-	6.09	100 [a,e,g]	
7.01	2^+	0		98.6 ± 0.7
		6.09		1.4 ± 0.7
7.34	2^-	0	18 ± 4	14 ± 4
		6.09	47 ± 4 [f]	52 ± 5 [b]
		6.73	35 ± 7	34 ± 4 [b]

A: (1966AL10): ^{13}C(d, p)^{14}C.
B: (1968BE30): ^{12}C(t, p)^{14}C.
[a] (1958WA02).
[b] δ(M2/E1) $= -0.04 \pm 0.09$ and $+0.07 \pm 0.30$, respectively (1968BE30).
[c] Internal pairs. $\Gamma_\pi/\Gamma = (1.1 \pm 0.1) \times 10^{-2}$, $\langle M \rangle_\pi = 0.36 \pm 0.06$ fm^2 (1980TO05).
[d] $E_\gamma = 495.35 \pm 0.10$ keV (1981KO08) and E.K. Warburton (private communication).
[e] $E_\gamma = 808.7 \pm 1.0$ keV (1966AL10).
[f] $E_\gamma = 1248 \pm 3$ keV (1966AL10).
[g] The ground state branch via pair emission is $< 1.1 \times 10^{-4}$ (1978AL19).

Observed proton groups are displayed in Table 14.7. Angular distributions have been measured at $E_t = 5.5$ to 23 MeV: see (1976AJ04) and Table 14.6 (1978AJ02, 1978MO07, 1978MO08, 1979PI01). (1978FO06) report that a calculation which treats the positive parity states of ^{14}C as (sd)^2 two-neutron states coupled to an inert ^{12}C core gives good agreement with the (t, p) strengths and the experimental E_x. τ_m of ^{14}C*(6.73) is 97 ± 15 psec (1968AL12); the nuclear gyromagnetic ratio is $|g| = 0.272 \pm 0.007$ showing that the state is not of a pure $(p_{1/2}^{-3} d_{5/2})$ configuration (1974AL07). See also (1977FO1E) and ^{15}N.

12. ^{12}C(α, 2p)^{14}C $\qquad Q_m = -15.1731$

At $E_\alpha = 65$ MeV ^{14}C*(6.73, 10.74) are strongly populated. Angular distributions are measured to ^{14}C*(0, 6.73, 10.74, 14.9 ± 0.1): the distribution to ^{14}C*(10.74) is consistent with $L = 4$

(1976JA13, 1978JA10). See also (1976CE1E).

Table 14.6: Levels of ^{14}C from ^{9}Be(^{6}Li, p)^{14}C [a]

E_x (MeV $\pm$ keV)	$\Gamma_{c.m.}$ (keV)	σ [b] (μb)	$2J_f + 1$ [c]	J^π [d]	θ_n^2 [e]
6.089 ± 10		71	2.5 [3]		
6.588 ± 10		30	1.0 [1]		
6.726 ± 10		220	7.6 [7]		
6.899 ± 10		31	1.1 [1]		
7.016 ± 10		130	4.5 [5]		
7.341 ± 10		151	5.2 [5]		
8.318 ± 10	22 ± 6	146	5.1	2^+	0.08 ± 0.02
9.796 ± 10	45 ± 12	223	7.7	3	0.4 ± 0.1 if $\pi = +$ 0.04 ± 0.01 if $\pi = -$
10.441 ± 15		312	10.8	2^+, 3	
10.512 ± 15	26 ± 8	262	9.1	4	0.08 ± 0.02 if $\pi = +$ 1.3 ± 0.4 if $\pi = -$
10.743 ± 15	20 ± 7	444	15.4		
11.306 ± 15	46 ± 12	70	2.4	1^-	0.012 ± 0.003
11.397 ± 15	22 ± 7	179	6.2	2^+, 3	
11.667 ± 15	20 ± 7	358	12.4	5^-	0.20 ± 0.07
11.74 ± 20					
12.57 ± 25	80 ± 20	435	15.1		
12.867 ± 20	30 ± 10	300	10.4	4, 5	
12.970 ± 20	30 ± 10	225	7.8	3, 4	
14.667 ± 20	57 ± 15			2^+, 3, 4, 5, 6^+	
14.867 ± 25					
15.19 ± 30					
(15.37 ± 30)					
15.44 ± 40					
(16.02 ± 50)					
16.411 ± 20					
(16.57 ± 40)					
16.715 ± 30					

Table 14.6: Levels of ^{14}C from ^{9}Be(^{6}Li, p)^{14}C [a] (continued)

E_x (MeV $\pm$ keV)	$\Gamma_{c.m.}$ (keV)	σ [b] (μb)	$2J_f+1$ [c]	J^{π} [d]	θ_n^2 [e]
(17.28 ± 40)					
17.95 ± 40					
18.10 ± 40					

[a] (1973AJ01): $E(^{6}\mathrm{Li}) = 20$ MeV.
[b] Total cross section for formation of this state; absolute value: $\pm 20\%$ except for the last six values, $\pm 30\%$.
[c] The first number gives $2J_f+1$, based on a best fit to the experimentally determined values for the cross section of the states with known spins. These $2J_f+1$ values are determined to $\pm 10\%$, except for the last six values which are determined to $\pm 20\%$. The second number, in bracktes, gives $2J_f+1$ derived from the J_f assignments shown in Table 14.3.
[d] Suggested from the $2J_f+1$ rule and comparison of predicted neutron width with observed $\Gamma_{c.m.}$ assuming $0.01 < \theta_n^2 < 1.0$.
[e] Calculated from neutron penetration of the centrifugal barrier, assuming that the total width is the neutron decay width Γ_n.

13. ^{12}C(^{10}B, ^{8}B)^{14}C $Q_m = -13.890$

At $E(^{10}\mathrm{B}) = 100$ MeV ^{14}C*(6.72, 10.74) are strongly populated and the angular distributions to these states are reported. ^{14}C*(15.0) is also observed (1978HA10).

14. ^{12}C(^{12}C, ^{10}C)^{14}C $Q_m = -18.7228$

At $E(^{12}\mathrm{C}) = 114$ MeV ^{14}C*(6.73, 10.25) [3^- and 4^+, respectively] are populated (1972SC21, 1974AN36).

15. (a) ^{12}C(^{14}N, ^{12}N)^{14}C $Q_m = -17.494$
(b) ^{12}C(^{16}O, ^{14}O)^{14}C $Q_m = -15.7652$
(c) ^{12}C(^{18}O, ^{16}O)^{14}C $Q_m = 0.9341$

For reaction (a) see (1976AJ04). At $E(^{16}\mathrm{O}) = 128$ MeV angular distributions are reported to ^{14}C*(0, 6.73, 10.74) [$J^{\pi} = 0^+, 3^-, 4^+$] (1979PR07). For reaction (c) see (1976WE05) and (1976AJ04). See also (1976KA04; theor.).

Table 14.7: ^{14}C states from ^{12}C(t, p)^{14}C [a]

E_x [b] (MeV ± keV)	E_x [c] (MeV ± keV)	L [b]	L [c]	Γ (keV) [b]	J^π
-0.006 ± 10	0	0	0		0^+
6.087 ± 10	6.099 ± 10	1	1		1^-
6.577 ± 10	6.589 ± 10	0	0		0^+
6.725 ± 10	6.731 ± 10	3 [e]	3		3^-
6.895 ± 10	6.899 ± 10	weak			
$\equiv 7.012$	7.017 ± 10	2 [e]	2		2^+
7.336 ± 10	7.342 ± 10	weak			
8.307 ± 12	8.315 ± 10	2	2		2^+
9.746 ± 7		0		18	0^+
9.809 ± 10	9.80 ± 20 [d]	(1)		40	(1^-)
10.425 ± 6	10.419 ± 20	2		14	2^+
10.448 ± 10					
10.498 ± 4	10.492 ± 20	(3)		18	(3^-) [f]
10.736 ± 5	10.730 ± 20	4		15	4^+
11.398 ± 10	11.377 ± 20	1			1^-
11.665 ± 13	11.647 ± 30	(1)			(1^-)
11.727 ± 10	[d]	(5)			(5^-)
12.580 ± 12		(2, 3)			$(2^+, 3^-)$
12.867 ± 10	12.849 ± 20	2, 3			$2^+, 3^-$
12.963 ± 10	12.945 ± 30	(1)			(1^-)

[a] See also Table 14.5 in (1976AJ04).
[b] $E_t = 18$ MeV (1978MO07, 1978MO08).
[c] $E_t = 23$ MeV (1978AJ02).
[d] Very weak at all angles.
[e] See also (1979PI01; $E_t = 15$ MeV).
[f] See also the note added in proof on p. 476 of (1978MO08).

Table 14.8: Resonances in ^{13}C(n, γ) and (n, n)

E_{res} (keV)	E_x (MeV $\pm$ keV)	Γ_{lab} (keV)	Γ_γ (eV)	σ [a] (b)	l_n	J^π
152 ± 1 [b]		5 ± 1	4.0 ± 1.6 [f]			
	8.3184 ± 0.9					
152.9 ± 1.4 [c]		3.7 ± 0.7 [f]		21 ± 2	1	2^+
1751 ± 8 [d]	9.801 ± 8	20		$[\approx 1.3]$	> 0	1
2432 ± 10 [d]	10.433 ± 10	17		$[\approx 1.3]$		2
2454 ± 10 [d]	10.454 ± 10	10		$[\approx 0.7]$		≥ 1
3800 [e]	11.7					

[a] Corrected peak cross section above background.
[b] (1971AL09): (n, γ).
[c] (1975HE02).
[d] (1961CO05).
[e] Broad resonance structure. See, however, the structures observed by (1979AU07).
[f] Recommended by (1973MU14). I am indebted to S.F. Mughabghab for a very useful discussion.

16. ^{13}C(n, γ)^{14}C 		$Q_m = 8.1765$
$Q_0 = 8176.477 \pm 0.047$ keV (1979GR1J; prelim.).

The thermal capture cross section is 0.9 ± 0.2 mb (1973MU14, 1974SH1E). The neutron capture yield has been measured from $E_n = 95$ to 235 keV: see Table 14.8. The (n, γ_0) cross section has also been measured for $E_n = 5.6$ to 14.0 MeV (1980JE1A). ^{13}C is probably not significantly involved as a neutron poison in s-process nucleosynthesis: see (1976AJ04). Two γ-rays are observed in thermal neutron capture with $E_\gamma = 8174 \pm 2$ and 6093 ± 2 keV [$E_x = 6094 \pm 2$ keV], with intensities of 87 ± 5 and 13 ± 1%. Intensities of transitions via other ^{14}C states are $< 2\%$ (1967TH05). [(1979GR1J; prelim.) find $E_\gamma = 8173.92 \pm 0.05$ keV].

17. ^{13}C(n, n)^{13}C 		$E_b = 8.1765$

The coherent scattering length (thermal, bound) is 6.19 ± 0.09 fm, $\sigma_{scatt} = 4.16 \pm 0.13$ b (1979KO26). The total cross section has been measured for $E_n = 0.10$ to 9 MeV and 16 to 23 MeV: observed resonances are displayed in Table 14.8. High resolution σ_t measurements by (1979AU07) for $E_n = 1.2$ to 13.9 MeV are displayed in Fig. 6 of that paper but an analysis in terms of resonances has not been reported. See also (1978LA1H) and (1976GAYV).

18. (a) ^{13}C(n, t)^{11}B $\quad Q_m = -14.403 \quad E_b = 8.1765$

(b) ^{13}C(n, α)^{10}Be $\quad Q_m = -3.836$

For reaction (a) see (1973BI1B). For reaction (b) see (1970AJ04).

19. ^{13}C(p, π^+)^{14}C $\quad Q_m = -132.173$

At $E_p = 185$ MeV (1973DA37) and 200 MeV (1979HO1F) the angular distributions of π^+ and π^- to the ground states of ^{14}C and ^{14}O are very different. The population of ^{14}C*(6.09, 8.32, 14.9 ± 0.2) is also reported (1973DA37). For cross-section measurements near threshold see (1979MA38, 1979MA39). See also (1976BO2C, 1979SOZY) and (1976NO1D; theor.).

20. ^{13}C(d, p)^{14}C $\quad Q_m = 5.9519$

Observed proton groups are displayed in Table 14.9. Angular distributions have been measured at a number of energies up to $E_d = 14.8$ MeV [see (1976AJ04)] and at $E_{\vec{d}} = 13$ MeV (1978DA17; to ^{14}C*(0, 6.09, 7.34)). For listings of θ_n^2 see Table 14.5 in (1970AJ04).

Gamma rays are exhibited in Table 14.5: studies of these, of the angular distributions analyzed by DWBA, and of pγ correlations lead to the following J^π assignments [see reaction 14 in (1970AJ04) for a full discussion of the evidence and of the relevant references]. ^{14}*C*(6.09)* is 1^- (decay is E1); ^{14}*C*(6.59)* is 0^+ (internal pairs only); ^{14}*C*(6.73)* is 3^- (γ_0 is E3; $l_n = 2$); ^{14}*C*(6.90)* is 0^- (no γ_0; 0.81 MeV cascade via 6.09 is predominantly dipole; $\gamma_{0.8} + \gamma_{6.1}$ correlation is only consistent with $J = 0$, and plane polarization leads to negative parity); ^{14}*C*(7.34)* is 2^- (strength of cascade decay and angular correlation results). See also (1974FI1D) and ^{15}N.

21. ^{13}C(t, d)^{14}C $\quad Q_m = 1.9192$

See (1976AJ04).

22. ^{13}C(^{7}Li, ^{6}Li)^{14}C $\quad Q_m = 0.926$

At $E(^7\text{Li}) = 34$ MeV the angular distribution has been measured for the ground state transition. ^{14}C*(6.09, 6.73) and possibly other states are also populated (1973SC26).

23. ^{13}C(^{11}B, ^{10}B)^{14}C $\quad Q_m = -3.2787$

Table 14.9: Proton groups from ^{13}C(d, p)^{14}C

E_x (MeV ± keV)	(1954SP01, 1955MC75) l_n [a]	J^π	(1958WA02, 1959WA04) J^π
0	1	$0^+, 1^+, 2^+$	0^+
6.091 ± 10 [b]	0	$0^-, 1^-$	1^-
6.589 ± 20	1, 2, 3 [f]	$(1^-, 2, 3^-)$	
6.723 ± 10 [b,c]	2	$1^-, 2^-, 3^-$	$3^-(2^-)$
6.894 ± 10 [b,c]	0, 1 [f]	$0, 1, 2^+$	0^-
7.346 ± 20	2	$1^-, 2^-, 3^-$	$2^-, 3^-$
8.321 ± 20			
9.800 ± 20			
10.433 ± 20			
10.505 ± 20			
11.9 ± 300 [d]			
12.601 ± 20 [e]			
12.854 ± 20			
12.958 ± 20			

[a] See also (1959AJ76).
[b] (1979SO01) report $E_x = 6.094$, 6.733 and 6.904 MeV [±4 keV].
[c] The spacing of these two levels is 171 ± 3 keV (1954SP01).
[d] $\Gamma_{lab} = 1.10 \pm 0.30$ MeV.
[e] $\Gamma_{lab} = 0.130 \pm 0.020$ MeV.
[f] See footnotes 18 and 31 in (1958WA02).

At $E(^{11}B) = 114$ MeV $^{14}C_{g.s.}$ is weakly excited but ^{14}C*(6.73, 7.34) [$J^\pi = 3^-$ and 2^-] are strongly populated (1974AN36).

24. ^{13}C(^{13}C, ^{12}C)^{14}C $\quad Q_m = 3.2302$

See (1979KOZZ).

25. (a) ^{13}C(^{14}N, ^{13}N)^{14}C $\quad Q_m = -2.377$
(b) ^{13}C(^{15}N, ^{14}N)^{14}C $\quad Q_m = -2.6568$

See (1976GA37) and (1976AJ04). See also (1978OS06; theor.).

26. (a) ^{13}C(^{17}O, ^{16}O)^{14}C $\quad Q_m = 4.032$
(b) ^{13}C(^{18}O, ^{17}O)^{14}C $\quad Q_m = 0.132$

Angular distributions have been measured at $E(^{17}\text{O}) = 29.8$ and 32.3 MeV (1977CH22, 1978CH16) and $E(^{18}\text{O}) = 31.0$ MeV (1978CH16).

27. ^{14}B(β^-)^{14}C $\quad Q_m = 20.62$

^{14}B decays primarily to ^{14}C*(6.09, 6.73): see Table 14.2. The half-life is 16.1 ± 1.2 msec: see ^{14}B.

28. ^{14}C(γ, n)^{13}C $\quad Q_m = -8.1765$

See (1976AJ04) and (1979KI11; theor.).

29. ^{14}C(e, e)^{14}C

The charge radius of ^{14}C, $r_{\text{rms}} = 2.56 \pm 0.05$ fm (1973KL12). At $E_e = 37$, 50 and 60 MeV ($\theta = 180°$), inelastic groups are observed to ^{14}C*(7.01, 7.34, 8.32, 9.80, 10.5, 11.31 ± 0.02, 12.96, 14.67) with $J^\pi = 2^+, 2^-, 2^+$, (1), $-$, 1^+ and (3, 4), respectively, for the states with $7.0 < E_x < 13.0$ MeV. ^{14}C*(11.31) dominates the spectrum: this 1^+ state has $\Gamma = 207 \pm 13$ keV and $\Gamma_{\gamma_0} = 6.8 \pm 1.4$ eV (1977CR02). There is no evidence of sharp structure in the region $E_x = 19$ to 24 MeV where the $T = 2$ analog state of ^{14}B$_{\text{g.s.}}$ would be expected (1974KL12: $E_e = 61.5$ and 80.7 MeV). See also (1976AJ04) and (1979KI11, 1980ER01; theor.).

30. (a) ^{14}C(p, p)^{14}C
(b) ^{14}C(d, d)^{14}C

For reaction (a) see (1976AJ04). Angular distributions have also been studied at $E_d = 17$ MeV to ^{14}C*(0, 6.73, 7.01) (1975CE04). See also (1976AJ04).

31. ^{14}C(^{3}He, ^{3}He)^{14}C

Elastic angular distributions have been measured at $E(^{3}\mathrm{He}) = 4.5$, 5.1 and 5.8 MeV (1972KE08) and 10, 12, 15 and 18 MeV (1970DU07).

32. ^{14}C(α, α)^{14}C

Elastic angular distributions have been studied at $E_{\alpha} = 22$, 24 and 28 MeV (1972OE01, 1973OE01).

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

The elastic scattering for reaction (a) has been studied at $E(^{12}\mathrm{C}) = 12$, 15, 18 and 20 MeV and for reaction (b) at 15 MeV (1972BO68). Yields of γ-rays from ^{14}C*(6.73) for $E(^{14}\mathrm{C}) = 40$ to 57 MeV are reported by (1980FR03).

34. ^{14}C(^{14}N, ^{14}N)^{14}C

See (1976AJ04).

35. ^{14}C(^{16}O, ^{16}O)^{14}C

The elastic scattering angular distributions have been measured at $E(^{16}\mathrm{O}) = 20$, 25 and 30 MeV (1975SC35). See also (1978BE2C) and (1979HE02; theor.).

36. ^{14}N(π^{-}, γ)^{14}C $\qquad Q_{\mathrm{m}} = 139.410$

Branching ratios have been measured for the capture of stopped pions to ^{14}C*(0, 7.0 ± 0.1, 8.3, 11.3, 20.0 ± 1.0) (1975BA52): the total radiative capture branching is $2.1 \pm 0.2\%$. The preliminary results of (1979AL1M) are in general agreement, but it is suggested that the E_{x} of the fourth group is 10.7 MeV. See also (1977RI1H, 1979PE1C) and the “GENERAL” section here.

37. ^{14}N(n, p)^{14}C $\qquad Q_{\rm m} = 0.6259$

The p_0 angular distribution has been measured at $E_{\rm n} = 14$ MeV (1971CO32). See also ^{15}N, (1976KI1D, 1978NE1B, 1978NE1A), (1977CO1U: astrophys.) and (1976AJ04).

38. ^{14}N(t, ^{3}He)^{14}C $\qquad Q_{\rm m} = -0.1379$

See (1970AJ04).

39. ^{14}N(^{7}Li, ^{7}Be)^{14}C $\qquad Q_{\rm m} = -1.018$

See (1976AJ04).

40. (a) ^{15}N(γ, p)^{14}C $\qquad Q_{\rm m} = -10.2074$
(b) ^{15}N(e, e$'$p)^{14}C $\qquad Q_{\rm m} = -10.2074$

For $E_{\rm bs} = 19.6$ to 38.3 MeV, ^{14}C*(0, 6.1 + 6.6 + 6.9, 7.0, 10.7) are preferentially excited (1972DE1D, 1976PA22). See also ^{15}N. For reaction (b) see (1975MU07).

41. ^{15}N(n, d)^{14}C $\qquad Q_{\rm m} = -7.9828$

Ground state angular distributions have been measured for $E_{\rm n} = 14.1 - 14.8$ MeV: see (1976AJ04) and (1978BA1M). See also ^{16}N in (1982AJ01).

42. ^{15}N(d, ^{3}He)^{14}C $\qquad Q_{\rm m} = -4.7139$

^{14}C states populated in this reaction are displayed in Table 14.9 of (1976AJ04), together with l and C^2S values (1971KA35: $E_{\rm d} = 52$ MeV).

43. ^{15}N(t, α)^{14}C $\qquad Q_{\rm m} = 9.6066$

See (1976AJ04).

44. ^{16}O(π^-, np)^{14}C $\quad Q_{\rm m} = 116.449$

At $E_{\pi^-} = 230$ MeV, γ-rays from the population of ^{14}C*(6.73, 6.90) are observed (1974LI15).

45. ^{16}O(^{6}Li, ^{8}B)^{14}C $\quad Q_{\rm m} = -16.592$

At $E(^{6}\text{Li}) = 93$ MeV ^{14}C*(0, 7.01, 8.32, 10.45) are populated, the first two of these strongly (1976WE09, 1977WE1B).

46. ^{16}O(^{11}B, ^{13}N)^{14}C $\quad Q_{\rm m} = -4.435$

See (1976AJ04).

47. ^{16}O(^{18}O, ^{20}Ne)^{14}C $\quad Q_{\rm m} = -1.4970$

Angular distributions are reported at $E(^{18}\text{O}) = 28$ and 32 MeV (1971BA68) and 36.1 MeV (1977KA26).

48. ^{17}O(n, α)^{14}C $\quad Q_{\rm m} = 1.8167$

See ^{18}O in (1978AJ03).

49. ^{18}O(γ, α)^{14}C $\quad Q_{\rm m} = -6.2279$

At $E_{\rm bs} = 23.5$ and 28 MeV ^{14}C*(6.09, 6.73) are excited (1976BA41). See also ^{18}O in (1978AJ03).

50. ^{18}O(d, ^{6}Li)^{14}C $\quad Q_{\rm m} = -4.7544$

See (1978BE1H) and (1976AJ04).

51. ^{19}F(d, ^{7}Be)^{14}C $\quad Q_{\rm m} = -7.142$

See (1976AJ04).

^{14}N

(Figs. 7 and 9)

GENERAL: (See also (1976AJ04).)

Model calculations: (1976CO1R, 1978FU13).

Special states: (1977GO1H, 1977RI08, 1979KI10).

Electromagnetic transitions: (1977DO06, 1977KO1N, 1977YO1D, 1978FU13, 1978KI08).

Giant resonances: (1979DO17, 1979KI11).

Astrophysical questions: (1976AU1B, 1976BO1M, 1976DI1F, 1976DW1A, 1976EP1A, 1976FI1E, 1976GI1C, 1976ME1H, 1976NO1C, 1976OS1E, 1976QU1A, 1976RO1J, 1976SI1D, 1976VA1D, 1976VI1B, 1977AU1B, 1977AU1E, 1977AU1F, 1977AU1J, 1977BE2J, 1977CA1N, 1977CA1J, 1977CA1K, 1977CL1E, 1977CL1C, 1977CO1W, 1977DE1N, 1977HA1L, 1977JO1D, 1977KI1M, 1977LA1G, 1977MA1T, 1977PR1E, 1977ST1J, 1977ST1H, 1977TR1D, 1977WA1P, 1978BO1M, 1978BU1H, 1978BU1B, 1978CL1F, 1978DE1R, 1978DI1D, 1978DW1B, 1978EN1C, 1978GL1E, 1978IB1A, 1978KA1R, 1978LA1K, 1978LU1C, 1978ME1D, 1978OR1A, 1978PO1B, 1978SN1A, 1978ST1C, 1978TO1C, 1978TR1C, 1979GU1D, 1979KA1T, 1979LA1H, 1979NO1F, 1979PE1E, 1979RA1C, 1979SA1M, 1979SW1B, 1979WE1F, 1980CA1C, 1980FR1G, 1980ME1B, 1980PE1F, 1980SP1B).

Special reactions involving ^{14}*N:* (1975KO1F, 1976AB04, 1976BA08, 1976BU16, 1976CH28, 1976EG02, 1976HI05, 1976NA11, 1977AR06, 1977CO14, 1977GE08, 1977GO07, 1977KU1D, 1977NA03, 1977PR05, 1977ST1J, 1977ST1G, 1977TO1G, 1978AB08, 1978BH03, 1978BI03, 1978CR1B, 1978GE1C, 1978GR1F, 1978HE1J, 1978HE1C, 1978KO01, 1979DY01, 1979GA04, 1979GE1A, 1979GO11, 1979HA1Q, 1979HE1D, 1979KO1M, 1979SA27, 1979SA26, 1979SC08, 1979ST1D, 1980MI01).

Applied work: (1975SE1J, 1976CH1N, 1976CH1P, 1976EA1A, 1976EC1B, 1976LE1Q, 1976RA1J, 1976SI1G, 1976ST1H, 1976SU1E, 1977LE1J, 1977LO1J, 1977MA1F, 1978MU1E, 1978OX1A, 1978VA1H, 1979AN1L, 1979EN1D, 1979GR1E, 1979VA1D, 1979WI1C, 1979WI1L).

Muon and neutrino capture and reactions: (1975BA40, 1975GE1E, 1977BA1P, 1977DO06, 1977GO13, 1977GO1H, 1977MU1A, 1978DE15, 1978GO1Q, 1979DE01, 1979DO1E, 1979GO1M, 1980LO07, 1980MU1B).

Pion capture and reactions: (1975BA1W, 1975KA1G, 1975KO25, 1975MA1M, 1976AS1B, 1976BA54, 1976BO2C, 1976EN02, 1976LI26, 1976RO14, 1977DO06, 1977GI14, 1977KO25, 1977MA1M, 1977MA35, 1977MA1F, 1977RI1H, 1977ST09, 1977VI1A, 1977WA1H, 1978BE27, 1978BO25, 1978GI05, 1978KI08, 1978KI13, 1978KW1A, 1978SH12, 1978SH16, 1978WE1H, 1979AMZY, 1979BA16, 1979BA2J, 1979DO17, 1979KI1K, 1979KL07, 1979MA2H, 1979PR1D, 1979SP1C, 1979UL1A, 1980DE10, 1980ER01, 1980FI05, 1980SI07).

Kaon capture and scattering: (1977JU1C, 1978AT01, 1978DA1A, 1979RA18).

Table 14.10: Energy levels of ^{14}N [a]

E_x in ^{14}N (MeV $\pm$ keV)	$J^\pi; T$	τ_m or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
g.s.	$1^+; 0$	stable		1, 7, 9, 10, 19, 20, 21, 22, 28, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 63, 64, 65, 67, 68, 69, 70, 71, 75
2.31287 ± 0.07	$0^+; 1$	$\tau_m = 92 \pm 10$ fsec	γ	1, 10, 19, 20, 22, 28, 34, 35, 36, 37, 40, 41, 45, 46, 47, 48, 50, 51, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71
3.9478 ± 0.4	$1^+; 0$	8.0 ± 1.0 fsec	γ	1, 7, 8, 10, 19, 20, 21, 22, 28, 34, 35, 36, 37, 40, 41, 42, 45, 46, 47, 48, 50, 51, 62, 63, 64, 66, 67, 68, 69, 70, 71
4.9150 ± 1.3	$0^-; 0$	7.6 ± 1.4 fsec	γ	1, 7, 8, 19, 20, 21, 22, 34, 35, 36, 41, 45, 46, 47, 48, 50, 51, 63, 64, 69
5.10587 ± 0.18	$2^-; 0$	6.2 ± 0.4 psec $\lvert g \rvert = 0.66 \pm 0.04$	γ	7, 8, 19, 20, 21, 22, 34, 35, 36, 41, 45, 46, 47, 48, 50, 51, 62, 63, 64, 66, 68, 69
5.6896 ± 1.1	$1^-; 0$	16 ± 8 fsec	γ	7, 8, 19, 20, 21, 22, 28, 34, 35, 41, 45, 46, 47, 48, 50, 51, 63, 64, 69
5.83423 ± 0.21	$3^-; 0$	13.5 ± 1.0 psec	γ	7, 8, 12, 19, 20, 21, 22, 25, 34, 35, 41, 45, 46, 47, 48, 50, 51, 62, 63, 64, 66, 69
6.2035 ± 0.6	$1^+; 0$	160 ± 20 fsec	γ	1, 7, 8, 19, 20, 21, 22, 28, 34, 35, 41, 42, 47, 48, 50, 51, 63, 64, 69
6.4444 ± 1.1	$3^+; 0$	627 ± 33 fsec	γ	1, 7, 8, 19, 20, 21, 22, 28, 34, 35, 41, 46, 47, 48, 51, 63, 64, 69
7.0279 ± 1.4	$2^+; 0$	5.4 ± 0.5 fsec	γ	7, 8, 19, 20, 21, 22, 28, 34, 35, 41, 42, 46, 47, 48, 50, 51, 62, 63, 64, 68, 69
7.9666 ± 0.6	$2^-; 0$	$\Gamma = (2.5 \pm 0.7) \times 10^{-3}$	γ, p	7, 8, 19, 20, 21, 22, 28, 34, 35, 47, 63, 64, 69
8.062 ± 1.0	$1^-; 1$	30 ± 1	γ, p	19, 20, 28, 29, 34, 44, 47, 63, 64
8.4877 ± 1.2	$4^-; 0$	$\tau_m = 18.8 \pm 1$ fsec	γ, p	7, 8, 19, 20, 21, 22, 28, 34, 35, 47, 69
8.618 ± 2	$0^+; 1$	$\Gamma = 7 \pm 1$	γ, p	19, 20, 28, 29, 34, 35, 47, 63, 64, 69

Table 14.10: Energy levels of ^{14}N [a] (continued)

E_x in ^{14}N (MeV $\pm$ keV)	$J^\pi; T$	τ_m or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
8.79 ± 50	$0^-; 1$	≈ 460	γ, p	28, 29
8.9091 ± 1.6	$3^-; 1$	19.7 ± 1.9	γ, p	20, 28, 29, 34, 35, 45, 47, 63, 64
8.9612 ± 1.3	$5^+; 0$	$\tau_m = 105 \pm 5$ fsec	γ, p	8, 12, 20, 21, 22, 24, 25, 28, 55, 63
8.979 ± 3	$2^+; (0)$	$\Gamma = 8 \pm 2$	γ, p	7, 8, 20, 28, 29, 34, 63
9.1241 ± 1.5	3^+	$\tau_m = 13 \pm 5$ fsec	γ, p	7, 8, 20, 28
9.1287 ± 1.0	$2^-; 0$			7, 8, 34
9.1707 ± 1.6	$2^+; 1$	$\Gamma = 0.078 \pm 0.016$	γ, p	20, 28, 34, 45, 47, 64, 68
9.3860 ± 1.4	$2^-; 3^-; 0$	15.6 ± 2.0	p	7, 8, 20, 21, 22, 29, 34, 35, 47, 64, 69
9.509 ± 3	$2^-; 1$	41 ± 2	γ, p	20, 28, 29, 34, 35, 47, 64, 69
9.703 ± 4	$1^+; 0$	15 ± 3	p	7, 20, 21, 22, 29, 34, 47, 64, 69
10.063 ± 15	$3^+, \geq 4$	< 10	p	8, 20
10.101 ± 15	$2^+, 1^+; 0$	5	γ, p	7, 20, 21, 22, 28, 29, 47, 69
10.228 ± 10	$1^{(-)}; 0$	80 ± 15	γ, p	20, 22, 28, 29, 69
10.434 ± 6	$2^+; 1$	33 ± 3	γ, p	7, 20, 28, 29, 41, 45, 47, 64, 69
(10.54)	(1)	(140)	p	20, 29
10.811 ± 7	$5^+; 0$	$(0.39 \pm 0.16) \times 10^{-3}$		8, 20, 21, 22, 63, 69
11.00 ± 30		165 ± 30	γ, p	8, 28
11.050 ± 5	3^+	1.2 ± 0.4	γ, p	7, 8, 20, 28, 63, 68
11.07	$1^+; 0$	100	n, p, d	8, 14, 21, 29, 30, 69
11.24 ± 20	$T = 1$	220 ± 30	γ, p, d	14, 20, 28, 69
11.24 ± 20	(3^-)	≈ 20	n, p	29, 30
11.29	$2^-; 0$	180	n, p, d	14, 15, 21, 29, 30
11.357 ± 15	$1^+; 0$	30	n, p, d	14, 15, 20, 21, 29, 30, 69
11.5135 ± 1.5	$2^+, 3^+$	7.0 ± 0.5	p, d	8, 14, 15, 20, 21, 69
11.68 ± 20	$1^-, 2^-$	150 ± 20	n, p, d	14, 15, 20
11.741 ± 6	$1^-, 2^-$	40 ± 9	(γ), p, d	14, 28
11.761 ± 6	$3^-, 4^-$	78 ± 6	(γ), p, d	8, 14, 20, 28
11.807 ± 7	(2^-)	119 ± 9	n, p, d	8, 14, 15, 17
11.874 ± 6	(2^-)	101 ± 9	p, d	8, 14
12.20 ± 20	$1^-, 2^-$	300 ± 30	n, p, d	14, 15, 21, 30, 63
(12.29 ± 15)				20
12.408 ± 3	(3^+)	37 ± 4	n, p, d	14, 15, 20, 21
12.418 ± 3	(4^-)	41 ± 4	p, d, α	4, 5, 14, 20

Table 14.10: Energy levels of ^{14}N [a] (continued)

E_x in ^{14}N (MeV $\pm$ keV)	$J^\pi; T$	τ_m or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
(12.47 ± 5)		≈ 20	p, α	4
12.497 ± 4		35 ± 10	γ, n, p, d, α	4, 14, 20, 28, 41, 63, 68
12.594 ± 3	3^+	48 ± 2	n, p, d, α	4, 14, 15, 20, 21, 30, 63
12.688 ± 4	3^-	22 ± 4	n, p, d, α	3, 4, 5, 6, 14, 15, 20, 21, 30
(12.708 ± 9)		(43 ± 15)	p, d	14
12.792 ± 4	4^+	18 ± 3	n, p, d, α	4, 5, 6, 12, 14, 15, 20, 24
(12.813 ± 5)		37 ± 6	p, d	14
12.819 ± 4	4^-	8 ± 3	n, p, d, α	4, 5, 14, 15
12.857 ± 6		78 ± 10	n, p, d	14, 30
12.923 ± 5	(4^+)	25 ± 3	p, d, α	4, 5, 14, 15, 20
13.03 ± 15		≈ 100	γ, p	8, 21, 28
13.166 ± 5	(1^+)	15 ± 5	n, p, d, α	3, 4, 5, 6, 14, 15, 20
13.192 ± 10	3^+	65 ± 10	α	6, 20
13.243 ± 10	2^-	92 ± 5	n, p, α	3, 4, 30
13.30 ± 40	(2^-); 1	1000 ± 150	γ, p	28
13.656 ± 5	$(2^+, 3^+)$	≈ 90	n, p, d, α	3, 4, 6, 14
13.714 ± 5	$2, 3^+$	105 ± 25	n, p, d, α	3, 4, 5
13.71 ± 30	1^+; 1	180 ± 25	(γ), n, p, d, α	3, 4, 6, 14, 15, 28, 64
13.72 ± 20		110	p, α	4
14.04 ± 30		100	n, p, d, α	3, 4, 14, 15, 30
14.16 ± 30		230	n, p, d, α	3, 4, 14, 15
14.25 ± 50	3^+	420 ± 100	p, α	4, 6
14.30 ± 20		150	p, α	4
14.56 ± 20		100	n, p, α	3, 4
14.59 ± 30		50	n, p, α	3, 4
14.66 ± 10	2^-	100 ± 20	α	6
14.73 ± 30		125	n, p, α	3, 4
14.86 ± 30		140	n, p, d, α	3, 4, 14, 15, 17, 30
14.92 ± 25		43 ± 8	n, p, α	3, 4, 20, 30
15.015 ± 15		≈ 60	n, α	3, 30
15.24 ± 20		100	p, d, α	4, 8, 14, 15
15.43 ± 20		100	n, p, d, α	3, 4, 14, 17, 21
15.7 ± 150		≈ 300	n, p, d, α	14, 15, 17, 20, 30
16.21 ± 20		125	(γ), n, p, α	3, 4, 30, 45
16.40 ± 20		150	p, d, α	4, 17
16.8	$4^+; T = 0 + 1$	≈ 300	d, α	17
16.91 ± 20	$(5^-); 0 + 1$	≈ 100	p, d, α	4, 17

Table 14.10: Energy levels of ^{14}N [a] (continued)

E_x in ^{14}N (MeV ± keV)	$J^\pi; T$	τ_m or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
17.17 ± 20	$4^+; 0+1$	≈ 300	n, p, d, α	4, 14, 15, 17, 21, 30
18.1	$(1^-, 2^+); 0+1$	(≈ 300)	d, α	17
18.1	$4^+; 0+1$	≈ 600	d, α	17, 30
18.2	$3^-; 0+1$	(≈ 400)	d, α	17
18.4	$3^-; 0+1$	(≈ 300)	d, α	17
18.50	$5^-; 0+1$	≈ 60	d, α	17
18.8	$4^+; 0+1$	(≈ 400)	d, α	17
20.1	$1^-; 0+1$	(≈ 500)	d, α	17
20.8	$5^-; 0+1$	≈ 600	d, α	17
20.8	$(3^-, 4^+); 0+1$	(≈ 500)	d, α	17
21.3	$4^+; 0+1$	(≈ 1000)	d, α	17
21.5	$3^-; 0+1$	(≈ 500)	d, α	17
21.7	$5^-; 0+1$	≈ 200	d, α	17
21.8		650	γ, ^{3}He	9
22.5 ± 100	$5^-; 0+1$	610 ± 100	d, α	17
22.5	$(2^-); 1$		γ, p	28
23.0	$(0, 1, 2)^-; 1$	≈ 3000	γ, n	43
23.0	$2^-; 1$		γ, p	28
23.3 ± 100	$5^-; 0+1$	500 ± 100	d, α	17
24.0		≈ 1000	n, ^{3}He, α	9

[a] See also Tables 14.11 and 14.12.

Reactions involving antiprotons: (1977WE1E, 1978PO02).

Other topics: (1976CO1R, 1978DA1A, 1978GA1C, 1978KW1A, 1978SO1A, 1979GA1D, 1979HE1F, 1979KA13, 1979KO1V).

Ground state of ^{14}N: (1977AN21, 1977GO1H, 1977MA35, 1978AN07, 1978HE1D, 1978ZA1D, 1979BU12, 1979SA27).

$$\mu = +0.4037607\ (2)\ \text{nm (1978LEZA).}$$

$$Q = +0.0156\ \text{b (1978LEZA).}$$

1. (a) ^{9}Be(^{6}Li, n)^{14}N $\quad Q_m = 14.500$
   (b) ^{9}Be(^{7}Li, 2n)^{14}N $\quad Q_m = 7.250$

A recent measurement of the (5.83 → 5.11) γ-ray in reaction (b), $E_\gamma = 728.34 \pm 0.10$ keV, leads to $E_x = 5834.23 \pm 0.21$ keV (1981KO08) and E.K. Warburton, private communication. See also (1976AJ04).

Table 14.11: Radiative decays in ^{14}N [a]

E_i (MeV)	$J^\pi_i; T$	E_f (MeV)	$J^\pi_f; T$	Branch (%)	Γ_γ (eV)	Refs.
2.31	$0^+; 1$	0	$1^+; 0$	100	$(7.2 \pm 0.8) \times 10^{-3}$	Table 14.12
3.95	$1^+; 0$	0	$1^+; 0$	[A] 3.9 ± 0.2 [b]	(M1)$(4.1 \pm 1.2) \times 10^{-4}$	(1967OL02, 1968RO1C, Table 14.12)
					(E2)$(3.2 \pm 0.4) \times 10^{-3}$	
		2.31	$0^+; 1$	[A] 96.1 ± 0.3 [b]	0.079 ± 0.010	(1967OL02, 1968RO1C, Table 14.12)
4.92	$0^-; 0$	0	$1^+; 0$	97 ± 3	$(8.4 \pm 1.6) \times 10^{-2}$	(1972RE10, Table 14.12)
		2.31	$0^+; 1$	< 1		(1966GO15)
		3.95	$1^+; 0$	1.3 ± 1.0		(1965NE06)
				≤ 0.5		(1966GO15)
5.11	$2^-; 0$	0	$1^+; 0$	[A] 79.9 ± 1.0 [b]	$(8.5 \pm 0.6) \times 10^{-5}$ [r]	(1966GO15, 1968AL12, Table 14.12)
		2.31	$0^+; 1$	[A] 19.4 ± 1.2 [b]		
		3.95	$1^+; 0$	(0.7 ± 0.4)		(1966GO15)
5.69 [c]	$1^-; 0$	0	$1^+; 0$	[A] 35.6 ± 1.2		mean
		2.31	$0^+; 1$	[A] 63.1 ± 1.2	$(2.6 \pm 1.3) \times 10^{-2}$	mean; Table 14.12
5.83 [d]	$3^-; 0$	0	$1^+; 0$	[A] 26.5 ± 2.5		mean
		5.11 [e]	$2^-; 0$	[A] 73 ± 3	$(3.6 \pm 0.3) \times 10^{-5}$	mean; Table 14.12
6.20 [f]	$1^+; 0$	0	$1^+; 0$	[A] 23.0 ± 1.9		mean
		2.31	$0^+; 1$	[A] 76.7 ± 2.0	$(3.2 \pm 0.4) \times 10^{-3}$	mean; Table 14.12
6.44 [h]	$3^+; 0$	0	$1^+; 0$	69.6 ± 1.5	$(7.3 \pm 0.4) \times 10^{-4}$ [g]	(1976SI07); Table 14.12
		3.95	$1^+; 0$	19.6 ± 1.0		(1976SI07)
		5.11	$2^-; 0$	6.4 ± 0.6		(1976SI07)
		5.83	$3^-; 0$	3.7 ± 0.6		(1976SI07)
7.03	$2^+; 0$	0	$1^+; 0$	[A] 98.6 ± 0.3	(M1)$(9.1 \pm 1.3) \times 10^{-2}$ [i]	(1967OL02, 1968RO1C)
					(E2)$(5.0 \pm 1.2) \times 10^{-2}$	
		2.31	$0^+; 1$	0.5 ± 0.1	(E2)$(6.2 \pm 1.4) \times 10^{-4}$	(1967OL02, 1968RO1C)
		3.95	$1^+; 0$	0.9 ± 0.25	$< (11 \pm 0.3) \times 10^{-4}$	(1967OL02, 1968RO1C)
		other states		≤ 0.4		(1967OL02)
7.97 [o]	$2^-; 0$	0	$1^+; 0$	55 ± 3	0.010	(1960HE14)
		3.95	$1^+; 0$	45 ± 3	0.008	(1960HE14)
		other states		≤ 3		(1960HE14)
8.06	$1^-; 1$	0	$1^+; 0$	80.3 ± 0.6	9.9 ± 2.5 [q]	(1972RE10); Table 14.19
		2.31	$0^+; 1$	1.40 ± 0.14	0.17 ± 0.05 [q]	(1972RE10)

Table 14.11: Radiative decays in ^{14}N [a] (continued)

E_i (MeV)	$J^\pi_i; T$	E_f (MeV)	$J^\pi_f; T$	Branch (%)	Γ_γ (eV)	Refs.
		3.95	$1^+; 0$	12.7 ± 0.4	1.56 ± 0.40 [q]	(1972RE10)
		4.92	$0^-; 0$	1.86 ± 0.14	0.23 ± 0.06 [q]	(1972RE10)
		5.11	$2^-; 0$	0.25 ± 0.14	0.03 ± 0.02 [q]	(1972RE10)
		5.69	$1^-; 0$	3.5 ± 0.4	0.43 ± 0.12 [q]	(1972RE10)
8.49	$4^-; 0$	5.11	$2^-; 0$	83 ± 3	$(6.1 \pm 1.5) \times 10^{-3}$	[p]
		5.83	$3^-; 0$	17 ± 3	$(1.3 \pm 0.4) \times 10^{-3}$	[p]
8.62	$0^+; 1$	0	$1^+; 0$	23	1.20	(1959WA16)
		3.95	$1^+; 0$	24	1.26	(1959WA16)
		5.69	$1^-; 0$	13	0.69	(1959WA16) [a]
		6.20	$1^+; 0$	40		(1957WI27)
8.79	$0^-; 1$	0	$1^+; 0$	90 ± 10 [s]	46 ± 12 [s]	(1953WO41)
8.91	$3^-; 1$	0	$1^+; 0$	1.6 ± 0.5 [q]	$(6.6 \pm 2.2) \times 10^{-3}$	(1968CL05)
		5.11	$2^-; 0$	5.4 ± 2.5 [q]	$(2.3 \pm 1.2) \times 10^{-2}$ [q]	(1959WA04)
		5.83	$3^-; 0$	89 ± 3 [q]	0.37 ± 0.10 [q]	(1959WA04)
		6.44	$3^+; 0$	3 ± 1	0.012 ± 0.006 [q]	(1959WA04)
		7.03	$2^+; 0$	1.4 ± 0.8	0.006 ± 0.004 [q]	(1959WA04)
8.96	$5^+; 0$	0 [a]	$1^+; 0$	< 1		
		6.44 [a]	$3^+; 0$	100	$\Gamma_\gamma = (1.2 \pm 0.2) \times 10^{-3}$ $\Gamma_p/\Gamma_\gamma = 4.1 \pm 0.5$	Table 14.12
9.13	$3^+; 0$	0	$1^+; 0$	82 ± 3	$\Gamma_\gamma = (8.5 \pm 1.0) \times 10^{-3}$ [j]	(1978KE01, 1978KE03)
		3.95	$1^+; 0$	≤ 2		(1978KE01)
		5.83	$3^-; 0$	9 ± 3		(1978KE01)
		6.44	$3^+; 0$	9 ± 3		(1978KE01)
9.17 [l]	$2^+; 1$	0	$1^+; 0$	85.1 ± 1.0	6.6 ± 1.3 [k]	(1976SI07); Table 14.19
		2.31	$0^+; 1$	0.85 ± 0.08		(1976SI07)
		5.69	$1^-; 0$	0.49 ± 0.10		(1976SI07)
		5.83	$3^-; 0$	0.61 ± 0.08		(1976SI07)
		6.44	$3^+; 0$	8.8 ± 0.8		(1976SI07)
		7.03	$2^+; 0$	3.2 ± 0.3		(1976SI07)
9.51	$2^-; 1$	0	$1^+; 0$	< 0.16 [q]	< 0.08 [q]	
		3.95	$1^+; 0$	6 ± 1	0.30 ± 0.09 [q]	(1959WA04)
		5.11	$2^-; 0$	78 ± 3	3.84 ± 0.97 [q]	(1959WA04)
		5.83	$3^-; 0$	16 ± 2	0.79 ± 0.22 [q]	(1959WA04)
10.23	$1^{(-)}; 0$	2.31	$0^+; 1$	≈ 100	4 ± 1.3	(1963RO17)
10.43 [m]	$2^+; 1$	0	$1^+; 0$	82 ± 6	9.6 ± 1.9	(1964RO03); Table 14.19
		5.11	$2^-; 0$	2 ± 1	0.2 ± 0.1	(1964RO03)
		6.44	$3^+; 0$	8 ± 1	0.9 ± 0.2	(1964RO03)

Table 14.11: Radiative decays in ^{14}N [a] (continued)

E_i (MeV)	$J^\pi_i; T$	E_f (MeV)	$J^\pi_f; T$	Branch (%)	Γ_γ (eV)	Refs.
		7.03	$2^+; 0$	6 ± 1	0.7 ± 0.2	(1964RO03)
10.81 [n]	$5^+; 0$	6.44	$3^+; 0$	100	$\Gamma_\gamma/\Gamma = 4.1 \pm 0.8\%$	(1972NO08)
11.05	3^+	0	$1^+; 0$		$\Gamma_\gamma = 0.12 \pm 0.02$	(1980RA06)
		3.95	$1^+; 0$		$= 0.09 \pm 0.02$	(1980RA06)

A = adopted. See also Table 14.12 in (1976AJ04).

[a] See also Table 14.9 in (1970AJ04), Table 14.12 in (1976AJ04) and Tables 14.12 and 14.16 here.

[b] Means of branching ratios quoted in Table 14.9 (1970AJ04).

[c] Transitions to ^{14}N*(3.95, 4.92) are ≤ 0.4 and $\leq 0.3\%$ (1972RE10).

[d] Transitions to ^{14}N*(2.31, 3.95, 4.92) are < 3, < 1 and < 1 percent (1966GO15).

[e] $5.83 \rightarrow 5.11$: $E_\gamma = 728.3 \pm 1.0$ keV (1966AL10); the plane polarization of the γ-rays leads to odd parity for ^{14}N*(5.83) (1962RO21).

[f] Transitions to ^{14}N*(3.95, 5.11) are $< 1\%$ (1966GO15).

[g] δ(M3/E2) $= -0.004 \pm 0.010$ (1976SI07).

[h] Transitions to ^{14}N*(4.92, 5.69) are < 0.4 and $< 0.3\%$ (1976SI07).

[i] δ(E2/M1) $= 0.74 \pm 0.09$ (1976SI07).

[j] $\Gamma_p = 43^{-15}_{+31}$ meV (1978KE03); δ(M3/E2) $= -0.03 \pm 0.02$ (1978KE01).

[k] δ(E2/M1) $= -0.003 \pm 0.003$, 0.031 ± 0.006 and -0.037 ± 0.015 for the transitions to ^{14}N*(0, 6.44, 7.03) (1976SI07).

[l] Transitions to ^{14}N*(3.95, 4.91, 5.11, 6.20) are $< 0.2\%$; transitions to ^{14}N*(7.97, 8.06, 8.49, 8.62) are $< 0.03\%$ (1976SI07).

[m] Transitions to ^{14}N*(2.31, 3.95, 5.69, 5.83) are < 1, < 2, < 3 and $< 1\%$ (1964RO03).

[n] $\Gamma = 0.39 \pm 0.16$ eV (J.W. Noe, private communication).

[o] $\Gamma_\gamma/\Gamma = 0.7 \pm 0.2\%$; $(2J+1)\Gamma_p = 12.6 \pm 3.6$ eV (1972BA56); $\Gamma = 2.5 \pm 0.7$ eV (J.W. Noe, private comm.).

[p] $\Gamma = (3.5 \pm 0.5) \times 10^{-2}$ eV from Table 14.12; $\Gamma_p/\Gamma = 3.7 \pm 1.1$ (1967GA12) leads to $\Gamma_\gamma = 7.4 \pm 2.5$ meV. I am indebted to P.M. Endt and E.K. Warburton for their comments.

[q] E.K. Warburton (private communication). See also (1981KO08).

[r] δ(M2/E1) $= -0.16 \pm 0.02$, δ(E3/E1) $= -0.15 \pm 0.025$: see (1981KO08).

[s] E.K. Warburton (private communication).

2. ^{9}Be(^{10}B, αn)^{14}N $Q_m = 10.040$

See (1979CH22).

3. ^{10}B(α, n)^{13}N $Q_m = 1.060$ $E_b = 11.6133$

Table 14.12: Lifetimes of some ^{14}N states [a]

E_x (MeV)	τ_m (fsec)	Reaction	Refs.
2.31	75 ± 19	^{13}C(p, γ)	(1972RE10)
	105 ± 15	^{13}C(p, γ)	(1977BI07)
	79 ± 7	^{13}C(p, γ)	(1980AN1E)
	106 ± 10	^{14}N(γ, γ)	(1975RA22)
	92 ± 10		adopted value
3.95	8.4 ± 0.4	^{13}C(p, γ)	(1977BI07)
	5.7 ± 0.7	^{13}C(p, γ)	(1980AN1E)
	8.7 ± 0.9	^{14}N(e, e)	see reaction 45
	8.0 ± 1.0		adopted value
4.92	7.6 ± 1.4 [A]		[b]
5.11	(6.2 ± 0.4) psec [c]	^{12}C(^{3}He, p)	(1978MO27)
5.69	16 ± 8 [d,A]	^{13}C(p, γ)	(1977BI07)
	≤ 5.5	^{13}C(p, γ)	(1980AN1E)
5.83	(13.7 ± 1.1) psec	^{12}C(^{3}He, p)	(1978MO27)
	(12.9 ± 1.9) psec	^{9}Be(^{7}Li, 2n)	(1981KO08)
	(13.5 ± 1.0) psec		mean: see (1981KO08) [g]
6.20 [a]	185 ± 15	^{13}C(p, γ)	(1977BI07)
	132 ± 8	^{13}C(p, γ)	(1980AN1E)
	160 ± 20		adopted value [f]
6.44	620 ± 60 [A]		adopted value [f]
7.03	5.4 ± 0.5	^{14}N(γ, γ)	(1966SW01)
8.49	19 ± 3	^{13}C(p, γ)	(1978KE03) [f]
8.96	105 ± 17	^{13}C(p, γ)	(1978KE03) [f]
9.13	13 ± 5	^{13}C(p, γ)	(1978KE03)

A = adopted.

[a] See also Table 14.13 in (1976AJ04) and Table 14.19 here.

[b] Based on unpublished measurements: see Table 14.13 (1976AJ04).

[c] $|g| = 0.66 \pm 0.04$ (1978MO27).

[d] Previous value [see (1976AJ04)] is unpublished.

[e] See also (1977FR1M, 1979EN01).

[f] I am indebted to P.M. Endt for his suggestions.

[g] See also (1980TO05).

Observed resonances are displayed in Table 14.13. See also (1976AJ04).

Table 14.13: Resonances in $^{10}B + \alpha$ [a]

E_α (MeV ± keV)	$\Gamma_{c.m.}$ (keV)	Outgoing particle [b] (x)	Γ_x [c] (keV)	$^{14}N^*$ (MeV)	J^π	Refs.
0.95		p_0		12.29		A
1.13 ± 5	30 ± 5	$p_0 \rightarrow p_3$, d		12.42	4^-	A
1.20 ± 5	≈ 20	p_0, (p_2), p_3		12.47		A
1.23 ± 5	35 ± 5	p_0, p_3		12.49		A
1.40 ± 5	46 ± 4	p_1, p_2, (p_3)		12.61	3^+	A
1.507 ± 5	18 ± 5	n_0	4.3	12.690	3^-	A
		p_0	0.62			
		p_1	0.17			
		p_2	0.70			
		p_3	5.6			
		d	0.93			
		α	1.7			
1.645 ± 5	16 ± 3	n_0	≤ 0.6	12.789	4^+	A
		p_0	0.18			
		p_1	0.085			
		p_2	0.44			
		p_3	9.6			
		d	2.0			
		α	1.0			
1.68 ± 5	5 ± 2	p_1, p_2, p_3, d		12.814	4^-	A
1.83 ± 5	22 ± 4	$p_0 \rightarrow p_3$, d		12.921	4^+	A
2.174 ± 5	15 ± 5	n_0, $p_0 \rightarrow p_3$, d, α_1		13.166	1^+	A, (1975WI04)
2.21 ± 10	65 ± 10	α_0		13.192	3^+	A
2.281 ± 10	92 ± 5	n_0, $p_0 \rightarrow p_3$		13.243	2^-	A, (1975WI04)
2.86 ± 5	≈ 90	n_0, p_1, p_2, α_1		13.656		A
2.94 ± 5	105 ± 25	n_0, $p_0 \rightarrow p_3$, d		13.714	2, 3^+	A, (1975WI04)

Table 14.13: Resonances in $^{10}B + \alpha$ [a] (continued)

E_α (MeV ± keV)	$\Gamma_{c.m.}$ (keV)	Outgoing particle [b] (x)	Γ_x [c] (keV)	$^{14}N^*$ (MeV)	J^π	Refs.
2.95 ± 50	180 ± 20	n_0, p_0, (p_2), α_0		13.72	$1^{(+)}$	A, (1975WI04) [d]
2.95 ± 20	110	p_1, p_3		13.72		A, (1975WI04) [d]
3.40 ± 30	100	n_0, p_1		14.04		A, (1975WI04)
3.56 ± 30	230	n_0, (p_0), p_3		14.16		A, (1975WI04)
3.69 ± 50	420 ± 100	p, α_0		14.25	3^+	A
3.76 ± 20	150	p_1		14.30		(1975WI04)
3.98 ± 20	100	n_0, p_0, p_2		14.56		A, (1975WI04)
4.16 ± 30	50	n_0, p_0, p_3		14.59		A, (1975WI04)
4.26 ± 10	100 ± 20	α_0		14.66	2^-	A
4.36 ± 30	125	n_0, p_0, p_1, (p_2)		14.73		A, (1975WI04)
4.54 ± 30	140	n_0, p_2, p_3		14.86		A, (1975WI04)
4.633 ± 30	43 ± 8	n_0, n_{2+3}, p_0		14.923		A, (1975WI04)
4.77 ± 20 [e]	≈ 60	n_0, n_1		15.02		A
5.08 ± 20	100	p_3		15.24		(1975WI04)
5.35 ± 20	100	n_1, p_2, p_3		15.43		A, (1975WI04)
6.44 ± 20	125	n_0, p_0, p_2		16.21		(1975WI04)
6.70 ± 20	150	p_2		16.40		(1975WI04)
7.42 ± 20		p_0		16.91		(1975WI04)
7.78 ± 20	50	p_3		17.17		(1975WI04)

A: See references quoted for this state in (1970AJ04, 1976AJ04).

[a] See Table 1 in (1975WI04) for a display of the resonance data obtained both in $^{12}C + d$, $^{13}C + p$ and $^{10}B + \alpha$.

[b] n_0, n_1, n_{2+3} correspond to the g.s. and ^{13}N*(2.37, 3.51 + 3.55); p_0, p_1, p_2, p_3 correspond to the g.s. and ^{13}C*(3.09, 3.68, 3.85) and the corresponding γ-rays; α_1 corresponds to the transition to ^{10}B*(0.7).

[c] For θ_x^2 see Table 14.8 in (1970AJ04).

[d] See reference (f) to Table 1 of (1975WI04).

[e] See text of reaction 6.

4. $^{10}B(\alpha, p)^{13}C$ $\qquad$ $Q_m = 4.0626$ $\qquad$ $E_b = 11.6133$

Excitation functions have been measured to $E_\alpha = 26$ MeV. Observed resonances are displayed in Table 14.13. (1975WI04) has expanded the angular distributions of the $p_0 \rightarrow p_3$ groups into Legendre polynomials and fitted the coefficients at the resonances corresponding to ^{14}N*(13.16, 13.24, 13.67, 13.76) obtaining $J^\pi = 1^+, 2^-$, 2 or 3^+, and 1, respectively, for these states. (1975WI04) also finds that a surprising proportion of states have a higher cross section for neutron than for proton emission: the fluctuations of σ_n/σ_p at low E_α suggest sizable isospin impurities in the ^{14}N states. See also (1970AJ04, 1976AJ04).

5. $^{10}B(\alpha, d)^{12}C$ $\qquad$ $Q_m = 1.3408$ $\qquad$ $E_b = 11.6133$

Excitation curves have been measured at E_α up to 27 MeV [see (1970AJ04, 1976AJ04)] and (1975VA19: $E_\alpha = 15$ to 25 MeV; d_0, d_1). The low energy resonances are exhibited in Table 14.13. At the higher energies the yield curves are fairly smooth although (1975VA19) show broad resonances in the d_1 and d_0 yields corresponding to ^{14}N*(23, 25) respectively, and at $\theta = 170°$ (1975SP04) report a sharp rise in the 15.1 MeV γ yield ≈ 1 MeV above the ^{12}C*(15.1) + p + n threshold, a channel which is not isospin forbidden. See also (1976LE1K).

6. $^{10}B(\alpha, \alpha)^{10}B$ $\qquad$ $E_b = 11.6133$

The yield of α-particles [and of 0.7 MeV γ-rays for $E_\alpha = 2.1$ to 3 MeV] has been measured for E_α to 30 MeV [see (1976AJ04)] and for $E_\alpha = 30$ to 50.6 MeV by (1976BE1M; α_0). Observed resonances are displayed in Table 14.13. In addition to two strong resonances in the α_0 yields at $E_\alpha = 2.21$ and 4.26 MeV (^{14}N*(13.19, 14.66)), two other states (^{14}N*(13.72, 14.25)) are required to fit the data: an R-matrix calculation leads to $J^\pi = 3^+, 1^+$ [see, however, (1975WI04)], 3^+ and 2^- for ^{14}N*(13.19, 13.72, 14.25, 14.66) (1973MO15). A strong resonance at $E_\alpha = 5.0 \pm 0.1$ MeV is reported in the reaction cross section for $E_\alpha = 4.0$ to 9.0 MeV (1976GR1F; abstract): it is suggested that $J^\pi = 6^+$.

7. ^{10}B(^{6}Li, d)^{14}N $\qquad Q_m = 10.140$

At $E(^6\text{Li}) = 5$ MeV ^{14}N*(0, 3.95, 4.92, 5.11, 5.69, 5.83, 6.20, 6.44, 7.03, 7.97, 8.49, 8.98, 9.12, 9.39, 9.70, 10.10, 10.43 ($T = 1$, weakly populated), 11.06) are populated ((1966MC05), and private communication). (1975FO01) have examined ^{14}N*(9.13) in detail and conclude that it is a closely spaced doublet of which one member is populated in ^{13}C(p, γ) and has been assigned $J^\pi = 2^-$, and the other member, populated here, has $J^\pi = 3^+$. This assignment is based on a DWBA analysis of the angular distributions at $E(^6\text{Li}) = 16.5$ and 21.0 MeV which shows the contributions of several L values and, in particular, $L = 0$. For γ branching ratios see Table 14.12 of (1976AJ04). See also reaction 22.

8. ^{10}B(^{7}Li, t)^{14}N $\qquad Q_m = 9.147$

At $E(^7\text{Li}) = 24$ MeV angular distributions of the tritons to ^{14}N*(3.95, 5.83, 6.44, 8.96, 9.13, 10.06, 10.81, 12.79 + 12.83, 13.03, 15.26) have been studied by (1977KO27). ^{14}N*(4.91, 5.11, 5.69, 6.20, 7.03, 7.97, 8.49, 8.98, 9.39, 11.04, 11.05, 11.52, 12.41) are also populated (1977KO27).

9. (a) ^{11}B(^{3}He, γ)^{14}N	$Q_m = 20.7358$	$E_b = 20.7358$
(b) ^{11}B(^{3}He, n)^{13}N	$Q_m = 10.182$	
(c) ^{11}B(^{3}He, p)^{13}C	$Q_m = 13.1851$	
(d) ^{11}B(^{3}He, d)^{12}C	$Q_m = 10.4634$	
(e) ^{11}B(^{3}He, t)^{11}C	$Q_m = -2.001$	
(f) ^{11}B(^{3}He, ^{3}He)^{11}B		
(g) ^{11}B(^{3}He, α)^{10}B	$Q_m = 9.1226$	
(h) ^{11}B(^{3}He, ^{6}Li)^{8}Be	$Q_m = 4.5702$	

The capture γ-rays [reaction (a)] have been studied at $E(^3\text{He}) = 0.9$ to 2.6 MeV (1970BL10; γ_0; $\theta = 0°$ and 90°). When the barrier penetration factor has been removed a single resonance is observed at $E(^3\text{He}) \approx 1.4$ MeV [^{14}N*(21.8)], $\Gamma_{\text{c.m.}} = 0.65$ MeV. The higher energy work quoted in (1976AJ04) has not been published.

The excitation function for reaction (b) has been measured for $E(^3\text{He}) = 1.5$ to 18 MeV [see (1976AJ04)] and 5.0 to 11.5 MeV (1977DA18; n_0). A broad peak at $E(^3\text{He}) = 4.15$ MeV may indicate the existence of ^{14}N*(24), $\Gamma \approx 1$ MeV (1966DI04).

Yield curves for protons [reaction (c)] have been measured for $E(^3\text{He}) = 3.0$ to 5.5 MeV (p_0, p_1, $p_1 + p_2 + p_3$): they are rather featureless (1959HO01). This is also true for the ground state deuterons of reaction (d) in the same energy interval (1959HO01). Yield curves for reaction (e) have been measured for $E(^3\text{He}) = 6$ to 30 MeV: see (1976AJ04). See also ^{13}C and ^{13}N, and ^{11}B, ^{11}C, ^{12}C in (1980AJ01).

The excitation functions for α-particle groups [reaction (g)] have been measured for $E(^3\text{He}) = 0.9$ to 5.5 MeV: see (1976AJ04). No significant resonance behavior is seen except for the α_2 group which, in the 15° excitation function, exhibits a resonance at $E(^3\text{He}) = 4$ MeV, $\Gamma \approx 1$ MeV (1965FO06). See also ^{10}B in (1979AJ01).

The excitation function for reaction (h) to $^6\text{Li}_{\text{g.s.}} + {}^8\text{Be}_{\text{g.s.}}$ has been measured for $E(^3\text{He}) = 1.4$ to 5.8 MeV: no pronounced structure is observed (1967YO02). At $E(^3\text{He}) = 25.20$ to 26.25 MeV the excitation functions for the transitions to ^{8}Be*(0, 16.63, 16.91, 17.64) are smooth, indicating a predominantly direct reaction mechanism (1974DE25).

10. $^{11}\text{B}(\alpha, \text{n})^{14}\text{N}$ $\qquad Q_{\text{m}} = 0.1580$

Angular distributions have been measured for E_α to 13.9 MeV [see (1970AJ04, 1976AJ04)] and at $E_\alpha = 2.05$ MeV (1977NI03). See also ^{15}N and (1976EP1A, 1980DO1C; astrophys.).

11. $^{11}\text{B}(^6\text{Li}, \text{t})^{14}\text{N}$ $\qquad Q_{\text{m}} = 4.9418$

See (1970AJ04).

12. $^{11}\text{B}(^{11}\text{B}, {}^8\text{Li})^{14}\text{N}$ $\qquad Q_{\text{m}} = -6.475$

At $E(^{11}\text{B}) = 114$ MeV the relatively strongly populated states are ^{14}N*(5.83, 8.96, 12.8) [$J^\pi = 3^-, 5^+, 4^+$] (1974AN36).

13. $^{12}\text{C}(\text{d}, \gamma)^{14}\text{N}$ $\qquad Q_{\text{m}} = 10.27240$

At $E_{\text{d}} = 1.5$ MeV the capture cross section is $< 1 \mu$b (1955AL16). [The other work quoted in (1976AJ04) has not been published.]

14. (a) $^{12}\text{C}(\text{d}, \text{n})^{13}\text{N}$ $\qquad Q_{\text{m}} = -0.2812$ $\qquad E_{\text{b}} = 10.27240$

(b) $^{12}\text{C}(\text{d}, \text{p})^{13}\text{C}$ $\qquad Q_{\text{m}} = 2.7218$

Resonances in the yields of neutrons and protons are displayed in Table 14.14. Measurements of the yields of neutrons (to $E_{\text{d}} = 17$ MeV) and of protons (to $E_{\text{d}} = 14.7$ MeV) are listed in Tables 14.11 (1970AJ04) and 14.16 (1976AJ04). The yield of n_0 has also been measured by (1976WA1L: $E_{\text{d}} = 5.5$ to 12.5 MeV). This preliminary work is characterized by a broad bump at $E_{\text{d}} \approx 7$ MeV and by a somewhat sharper one at $E_{\text{d}} \approx 9$ MeV (1976WA1L). For angular distributions see ^{13}C, ^{13}N. For spallation measurements see (1978AZ1E, 1978DU1B).

Table 14.14: Resonances in $^{12}C + d$ [a]

E_d (MeV ± keV)	$\Gamma_{c.m.}$ (keV)	Particles out	$^{14}N^*$ (MeV)	$J^\pi; T$
0.92	95	n, p_0, p_1	11.06	$1^+; 0$
1.13		p_0, p_1	11.24	T = 1
1.19	190	n, p_0, p_1, d	11.29	$2^-; 0$
1.23		p_0	11.33	(3^+)
1.30	30	n, p_0, p_1, d	11.39	$1^+; 0$
1.39		p_0	11.46	(2^-)
1.4495 ± 1.5	7.0 ± 0.5	p_0, p_1, d	11.5135	$2^+, 3^+$
1.55		p_0	11.60	(2^-)
1.640 ± 20	150 ± 20	n, p_1, d_0	11.68	$1^-, 2^-$ [b]
1.715 ± 6	40 ± 9	p_2	11.741	$1^-, 2^-$
1.738 ± 6	78 ± 6	p_1	11.761	$3^-, 4^-, (2^-)$
1.792 ± 7	119 ± 9	n, p_0, p_1, p_2, d_0	11.807	$2^-, (1^+)$ [b]
1.870 ± 6	101 ± 9	p_0, p_1, p_2	11.874 [c]	$2^-, (1^-)$
2.250 ± 19	300 ± 30	n, $p_0 \rightarrow p_3$, d_0	12.20	$1^-, 2^-$ [b]
2.494 ± 3 [d]	37 ± 4	n, $p_0 \rightarrow p_3$, d_0	12.408	$3^+, (3^-, 4^-)$ [b]
2.506 ± 3	41 ± 4	p_1	12.418	$3^-, 4^-, (2^+, 3^+)$
2.610 ± 20	30 ± 20	n, p_1, p_2, p_3	12.507	(b)
2.712 ± 3	48 ± 2	(n), $p_0 \rightarrow p_3$, d_0	12.594	3^+ [b]
(2.817 ± 7)	27 ± 6	n, p_1, p_2, p_3, d_0	(12.684)	(b)
2.844 ± 9	43 ± 15	p_2, p_3	12.708	
2.940 ± 10	30 ± 10	p_2, p_3, d	12.790	
2.967 ± 5	37 ± 6	p_1	12.813	
2.982 ± 6	11 ± 3	n, p_3, d	12.826	
3.018 ± 6	78 ± 10	n, p_0, p_1	12.857	
3.049 ± 8	134 ± 11	p_1	12.883	
3.100 ± 10	20 ± 14	p_1, p_2, p_3, d	12.927	$(3^-, 4^-)$
3.39 ± 12	47 ± 15	n, p_2, p_3, d	13.17	$(0^-, 1^-)$
3.97 ± 30	< 200	p_0, p_2, p_3, (d)	13.67	$(2^+, 3^+)$
4.02^{+20}_{-10}	≈ 235	n, (p), d	13.71	(1^+)
4.40		$p_0 \rightarrow p_3$, d	14.04	

Table 14.14: Resonances in ^{12}C + d [a] (continued)

$E_{\rm d}$ (MeV ± keV)	$\Gamma_{\rm c.m.}$ (keV)	Particles out	^{14}N* (MeV)	$J^\pi; T$
4.55		n, p_2, d	14.17	
4.80		p_0, p_2, d	14.38	
5.17		d	14.70	
5.34	≈ 100	$p_0 \rightarrow p_3$, d, α	14.84	
5.65		d	15.11	
5.83		p_1, p_3, d	15.26	
6.07		p_1, p_2, α	15.47	
6.3		p_0, p_3, d, α	15.7	
7.2		α	16.4	
7.6 [e]	≈ 300	α_2	16.8	4^+ [f]
7.8	≈ 100	α_2	16.9	(5^-)
8.1	≈ 300	p_0, p_2, d, α_2	17.2	4^+
9.1	(≈ 300)	α_2	18.1	$(1^-, 2^+)$
9.2	≈ 600	α_2	18.1	4^+
9.3	(≈ 400)	α_2	18.2	3^-
9.5	(≈ 300)	α_2	18.4	3^-
9.61	≈ 60	α_2	18.50	5^-
10.0 [g]	(≈ 400)	α_2	18.8	4^+
11.5	(≈ 500)	α_2, α_3	20.1	1^-
12.3	≈ 600	α_2	20.8	5^-
12.3	(≈ 500)	α_2	20.8	$(3^-, 4^+)$
12.9	(≈ 1000)	α_2	21.3	4^+
13.1	(≈ 500)	α_2	21.5	3^-
13.4	≈ 200	α_2	21.7	5^-
14.29 ± 100	610 ± 100	α_2	22.5	5^- [h]
15.28 ± 100	500 ± 100	α_2	23.3	5^- [h]

[a] For the references for each of the resonances, see Table 14.15 in (1976AJ04).
[b] See also (1976BO1Q; prelim.)
[c] (1974GM01) also report a state at 12.05 MeV with $\Gamma = 190$ keV seen as a structure in the p_0 yield.
[d] A study of this resonance shows that either f-shell components are present in the wave function or that the coupling is very strong or that both effects are present (1974DA06).
[e] For all states reported by (1972SM07) see their discussion of the S-matrix analysis of their α_2 data: the resonances shown below correspond to one possible (albeit the most reasonable) solution. The α_2 channel is sensitive only to ^{14}N states that have natural parity and are isospin mixed.
[f] These, and all the states shown below, are isospin mixed. (1972SM07) notes that the average spacing of these states, as observed via the α_2 channel, $D \approx 400$ keV, as is the average width of the states, so $\Gamma \approx D$.
[g] See also Table 14.10 in (1970AJ04) for states reported at ^{14}N*(17.2, 19.6, 20.4).
[h] These states appear to be an isospin mixed pair with $\langle H_c \rangle \geq 40$ keV (1974JO01).

The vector analyzing power and the $0°$ transverse vector polarization transfer coefficient, $K_y^{y'}(0°)$ have been measured for $E_{\vec{d}} = 5.7$ to 9.7 MeV [n_0, n_1]. The values of $K_y^{y'}$ are large, close to the maximum value of $\frac{2}{3}$, consistent with a model of the neutron as a simple spectator in the reaction (1976TE03). $K_y^{y'}(0°)$ has also been measured for $5 < E_{\vec{d}} < 12$ MeV (1976WA1L; prelim.; n_0, n_1). Other recent measurements are those of the tensor polarization power for $E_{\vec{d}} = 9$ to 11 MeV (1977DR1F; p; prelim.) and the vector analyzing power at $E_{\vec{d}} = 11$ MeV (1976KR1B; n_0, n_1; prelim.). See also (1979SI07). For the earlier polarization measurements of neutrons (to $E_d = 51.5$ MeV) and of protons (to $E_d = 51$ MeV) see the listings in Table 14.12 (1970AJ04) and 14.17 (1976AJ04).

See also (1974LO1B, 1977HA1P, 1977SE1C, 1977SE09), (1977YO1F, 1977YO1G; applications) and (1975BO58, 1976SA04, 1978HA1Q, 1979SE04; theor.).

15. ^{12}C(d, d)^{12}C $E_b = 10.27240$

Reported resonances are displayed in Table 14.14. Yield measurements of d_0 up to $E_d = 26.5$ MeV are listed in Table 14.16 of (1976AJ04). See also (1976BO1Q: $E_d = 1.6$ to 3.0 MeV). For total cross-section measurements at $E_d = 1.55$ and 2.89 GeV/c see (1978JA16). See also (1979DE1P).

Polarization measurements to $E_d = 51$ MeV are displayed in Table 14.17 of (1976AJ04). Recent work has been carried out at $E_d = 12.6$ MeV (1976ZA1B; d_0; VAP), $E_{\vec{d}} = 29.5$ MeV (1977PE07; d_0; VAP, TAP) and 52 MeV (1980MA10, 1976BE1U; to ^{12}C*(0, 4.4, 9.6)). The (d, np) processes are discussed in reaction 50 of ^{12}C in (1980AJ01), reaction 36 in ^{13}C and reaction 19 in ^{13}N. See also (1976GE20). See also (1975BO58, 1977FR12, 1978HA1Q; theor.).

16. (a) ^{12}C(d, t)^{11}C $\quad Q_m = -12.464 \quad E_b = 10.27240$

(b) ^{12}C(d, ^{3}He)^{11}B $\quad Q_m = -10.4634$

At $E_{\vec{d}} = 29$ MeV, polarizations to the ground states of ^{11}B and ^{11}C have been studied by (1978CO13). See also (1976AJ04).

17. ^{12}C(d, α)^{10}B $\quad Q_m = -1.3408 \quad E_b = 10.27240$

Reported resonances are displayed in Table 14.14. Listings of measurements of the yields of α-groups to $E_{\vec{d}}$ to 29.5 MeV are given in Tables 14.16 (1976AJ04) and 14.11 (1970AJ04).

The major interest in this reaction has been the study of the yield of the α_2 group to the $J^\pi = 0^+$, isospin "forbidden" $T = 1$ state. In particular, the work of (1972SM07, 1971RI15) has shown that while the α_0, α_1 and α_3 yields show only weak fluctuations, the α_2 "forbidden" yield shows narrow resonances which implies that the source of the isospin mixing (at least in the region which they, and the subsequent work of (1974JO01) studied: $E_d = 7.2$ to 16 MeV) is due to states in the ^{14}N compound nucleus. The ratio of the σ_t for the α_2 group compared to the σ_t for the "allowed" groups is $\approx 1\%$, an order of magnitude greater than predicted by direct or multistep processes (1972SM07). Partial wave analyses lead to the resonance parameters shown in Table 14.14 (1972SM07, 1974JO01). See also (1970AJ04).

Polarization measurements are reported for the $\alpha_0 \rightarrow \alpha_4$ groups at $E_{\vec{d}} = 11$ to 14 MeV (1976PE08) and 20.7 and 29 MeV (1977CO17). See also (1976KU1D), (1974LO1B) and (1977TO1E, 1978IZ02, 1979SE04; theor.).

18. (a) ^{12}C(d, ^{6}Li)^{8}Be $\quad Q_m = -5.893 \quad E_b = 10.27240$

(b) ^{12}C(d, ^{7}Li)^{7}Be $\quad Q_m = -17.542$

Vector analyzing power measurements have been carried out at $E_{\vec{d}} = 16$ MeV for the group to ^{8}Be$_{g.s.}$ (1976JA1G). See also (1976JA1H) and ^{7}Be and ^{8}Be in (1979AJ01).

19. ^{12}C(t, n)^{14}N $\quad Q_m = 4.01507$

Angular distributions have been measured at $E_t = 1.12$ to 1.68 MeV (1971MA46: n_0, n_1, n_2) and at 8 MeV (1972CO01: to ^{14}N states with $E_x < 8.7$ MeV).

20. ^{12}C(^{3}He, p)^{14}N $\quad Q_m = 4.7788$

Observed proton groups are displayed in Table 14.15. Angular distributions have been measured for E(^{3}He) to 25.3 MeV: see (1970AJ04, 1976AJ04).

Table 14.15: Excited states of ^{14}N from ^{12}C(^{3}He, p)^{14}N [a]

E_x (MeV ± keV)		L [i]	$J^\pi; T$
(1971DU03)	(1969HO23)		
	0	2	
	2.319 ± 15	0	
3.9502 ± 1.5	3.952 ± 15	0	
4.9153 ± 1.4	4.927 ± 15	1	
≡ 5.10587 ± 0.18 [b]	5.117 ± 15	1	
5.6888 ± 1.4	5.713 ± 15	1	
5.8324 ± 1.4	5.885 ± 15	3	
6.2025 ± 1.4	6.224 ± 15	0	
6.4449 ± 1.4	6.468 ± 15	2	
7.0279 ± 1.4	7.036 ± 15	2	
7.9649 ± 1.4	7.974 ± 15	3	
	8.072 ± 15	1	
8.4864 ± 1.5 [c]	8.493 ± 15	3	$4^-; 0$ [e,i]
8.6174 ± 4	8.625 ± 15	0	$(0^+; 1)$ [k]
8.9099 ± 1.9 [d]	8.912 ± 15		$(3^-; 1)$ [k]
8.9598 ± 1.4			
	8.97 ± 15		
8.9773 ± 4			$(2^+; 0)$ [k]
9.1241 ± 1.5	9.126 ± 15		[n]
9.1674 ± 1.4	9.176 ± 15	[j]	$(2^+; 1)$ [k]
9.3854 ± 1.6 [d]	9.389 ± 15		$2^-; 0$ [i,l]
	9.51 [e]		$(2^-; 1)$ [k]
	9.703 ± 15		$(1^+; 0)$ [k]
	10.063 ± 15 [f]		$3^+, \geq 4$ [e]
	10.101 ± 15		$1^+; 2^+$ [e]
	10.23 [e]		1 [e]
	10.441 ± 15	[j]	$(2^+; 1)$ [k]
	10.56 [e]		1, 2 [e]
	10.812 ± 15		$5^+; 0$ [e,m]
	11.053 ± 15		
	11.249 ± 15		
	11.357 ± 15		

Table 14.15: Excited states of ^{14}N from ^{12}C(^{3}He, p)^{14}N [a] (continued)

E_x (MeV ± keV) (1971DU03)	E_x (MeV ± keV) (1969HO23)	L [i]	$J^\pi; T$
	11.517 ± 15		
	[g]		
	12.29 ± 15		
	12.425 ± 15		
	12.506 ± 15		
	12.608 ± 15		
	12.69 ± 15		
	12.80 ± 15		
	12.90 ± 25 [h]		
	13.15 ± 40		
	14.91 ± 60		
	15.8 ± 200		
	17.4 ± 200		

[a] See also Tables 14.14 in (1970AJ04) and 14.18 in (1976AJ04).

[b] All E_x shown by (1971DU03) are measured relative to this energy obtained by (1967CH19) from E_γ.

[c] $\Gamma_p/\Gamma = 0.73 \pm 0.10$ (1974NO01).

[d] The widths of ^{14}N*(8.91, 9.39) are, respectively, 19.7 ± 1.9 and 15.6 ± 2.0 keV.

[e] (1974NO01): from a study of decay proton correlation (^{12}C(^{3}He, p′)^{14}N*(p)^{13}C$_{g.s.}$) with the relevant p′ group.

[f] $\Gamma < 10$ keV (J.W. Noe, private communication).

[g] Three states at 11.66 ± 0.04, 11.79 ± 0.11, 11.95 ± 0.03 MeV are reported by (1968MA29).

[h] This state and the states below are from (1968MA29).

[i] (1968MA29).

[j] $\theta_p^2(l = 3) = (2.3 \pm 1.1) \times 10^{-3}$ and $< 1.6 \times 10^{-3}$ for ^{14}N*(9.17, 10.43) (1974NO01).

[k] Known from other data: consistent with results of (1974NO01).

[l] The results of (1974NO01) are consistent with either $J^\pi = 2^-$ or 3^- for this state.

[m] (1972NO08): from study of angular correlations. See also (1968MA29).

[n] Unresolved doublet; see reactions 22 and 27.

Extensive studies of p′γ and p′p correlations (the latter from ^{12}C(^{3}He, p′)^{14}N*(p)^{13}C$_{g.s.}$) have led to the confirmation and determination of J^π of many of the unbound states: see Tables 14.15

and 14.11: see (1970AJ04, 1976AJ04) for a fuller discussion and a listing of the relevant references. Recently (1977HE04: $E(^3\mathrm{He}) = 11$ to 20 MeV) have studied p′γ angular correlations involving ^{14}N*(3.95, 5.10, 5.69, 6.21, 7.03). (1978MO27) find $|g| = 0.66 \pm 0.04$ for ^{14}N*(5.11): τ_m for ^{14}N*(5.11, 5.83) are displayed in Table 14.12. See also (1978MO1N). See also ^{15}O, (1966YO1A, 1979HAYZ), (1974LO1B) and (1976EP1A; astrophys.).

21. ^{12}C(α, d)^{14}N $\qquad Q_m = -13.57434$

Angular distributions of deuterons corresponding to $T = 0$ states in ^{14}N have been measured at $E_\alpha = 42$ MeV: see Table 14.19 in (1976AJ04), and (1970AJ04) for a listing of the references. At $E_\alpha = 55$ MeV, d_0 and d_1 angular distributions have been studied by (1976VA07). The deuteron spectrum is dominated by very strong groups corresponding to the $(d_{5/2})^2$, $J^\pi = 5^+$ state at 8.96 MeV, and to a state at 15.1 MeV: see (1976AJ04). See also (1976BU21).

22. ^{12}C(^{6}Li, α)^{14}N $\qquad Q_m = 8.7989$

At $E(^6\mathrm{Li}) = 20$ MeV, α groups corresponding to most of the $T = 0$ states with $E_x < 12.7$ MeV are reported: see Table 14.19 in (1976AJ04). The spectrum is dominated by the α-group corresponding to the 5^+ state at 9.0 MeV (1968ME10). Angular distributions have also been measured for $E(^6\mathrm{Li}) = 2$ to 33 MeV [see (1970AJ04, 1976AJ04)] and at $E(^6\mathrm{Li}) = 10.5$ to 13.75 and 20 MeV (1975SO1E, 1978SO01: α_0, α_1, α_2) and $E(^6\vec{\mathrm{Li}}) = 20$ MeV (1978MA13, 1979MA1T: analyzing power, all known $T = 0$ states with $E_x < 10.9$ MeV). For the yield of the isospin "forbidden" group, α_1, see ^{18}F in (1978AJ03, 1983AJ01). See also (1978AR01) and (1977WE08, 1978ME20; theor.).

23. ^{12}C(^{9}Be, ^{7}Li)^{14}N $\qquad Q_m = -6.424$

See (1976AJ04).

24. ^{12}C(^{11}B, ^{9}Be)^{14}N $\qquad Q_m = -5.544$

At $E(^{11}\mathrm{B}) = 114$ MeV the spectrum is dominated by groups to the 5^+ state at $E_x = 8.96$ MeV and to one or more of the states at 12.8 MeV, presumably the 4^+ one (1974AN36, 1975PO10). See also (1976AJ04).

25. ^{12}C(^{12}C, ^{10}B)^{14}N $\qquad Q_m = -14.915$

This reaction has been studied at $E(^{12}\text{C}) = 114$ MeV: the spectrum is dominated by ^{14}N*(8.96) [$J^\pi = 5^+$] but there is substantial population also of ^{14}N*(5.83) [3^-] and of a state at $E_\text{x} = 11.2$ MeV (1974AN36). Angular distributions are reported at $E(^{12}\text{C}) = 58$ to 64.5 MeV (1979CL06) and at 93.8 MeV (1979FU04).

26. ^{12}C(^{18}F, ^{16}O)^{14}N $\qquad Q_\text{m} = 2.746$

See (1976AJ04).

27. ^{12}C(^{20}Ne, ^{18}F)^{14}N $\qquad Q_\text{m} = -10.779$

See (1979MEZX).

28. (a) ^{13}C(p, γ)^{14}N $\qquad Q_\text{m} = 7.55063$
(b) ^{13}C(p, p$'\gamma$)^{13}C $\qquad E_\text{b} = 7.55063$

Observed resonances are displayed in Table 14.16. The decay schemes of various levels of ^{14}N, as derived from the γ-spectra in this and other reactions, are exhibited in Table 14.11. For τ_m see Table 14.12 and (1977BI07, 1980AN1E).

The low-energy capture cross section yields an extrapolated S-factor at $E_\text{p} = 25$ keV (c.m.), $S_0 = 6.0 \pm 0.8$ keV · b (1960HE14). See also (1970AJ04). The capture cross section rises from $(7.7 \pm 1.8) \times 10^{-10}$ b at $E_\text{p} = 100$ keV to $(9.8 \pm 1.2) \times 10^{-9}$ b at $E_\text{p} = 140$ keV (1961HE02).

Following is a summary of the reasons for the assignments of $J^\pi; T$ to some of the lower resonances displayed in Table 14.16: for a fuller discussion and complete references see (1970AJ04, 1976AJ04) and see Table 14.11. *^{14}N*(7.97)*: angular distribution of the γ-rays is consistent with $J^\pi = 2^-$. *^{14}N*(8.06)*: width of resonance, isotropy of γ-rays show $l_\text{p} = 0$: $J^\pi = 1^-$ from ^{13}C(p, p); E1 transition to g.s. is uninhibited, e.g., $T = 1$ [but 1.4% $8.06 \to 2.3$ transition [$E_\text{x} = 2312.6 \pm 0.3$ keV] shows $T = 0$ admixture: $\alpha^2 = 0.046$]. The strong transition $8.06 \to 5.69$ [3.5%] permits either E1 or M1, $\Delta T = 1$. Since $5.69 \to 2.31$ is seen *^{14}N*(5.69)* cannot have $J^\pi = 0^+$, and 2^+ is excluded by the strength of the $8.62 \to 5.69$ transition. It is then $J^\pi = 1^-; T = 0$ [the isospin mixing $\alpha^2 = 0.09$]; $E_\text{x} = 5690.5 \pm 1.5$ keV. *^{14}N*(8.49, 8.96, 9.12)* correspond to anomalies in the cross section. The nature of their γ-decays [see Table 14.11] and the angular distribution leads to $J^\pi; T = 4^-; 0, 5^+; 0, 3^+; 0$, respectively [see (1978KE01) for a recent study of ^{14}N*(9.13)].

^{14}N(8.62)* [$J^\pi = 0^+$ from ^{13}C(p, p)] shows strong transitions to ^{14}N*(0, 3.95, 5.69): $T = 1$. The strength of the $8.62 \to 3.95$ decay shows it is dipole and therefore $J = 1$ for ^{14}N*(3.95) [$E_\text{x} = 3947.6 \pm 0.4$ keV]. The strength of the transition $8.62 \to 6.21$ and the angular correlation $8.62 \to 6.21 \to$ g.s. is consistent with $J^\pi = 1^+, T = 0$ for *^{14}N*(6.20)* [$E_\text{x} = 6203.7 \pm 0.6$ keV]. *^{14}N*(8.79)* [$J^\pi = 0^-$ from ^{13}C(p, p)] has a large Γ_γ consistent with E1 and $T = 1$. *^{14}N*(9.17)*: angular correlation and angular distribution measurements indicate $J^\pi = 2^+$ for that state, 3^- for *^{14}N*(6.44)* [see, however, Table 14.10] and $J = 2$ for *^{14}N*(7.03)*.

Table 14.16: Levels of ^{14}N from ^{13}C(p, γ)^{14}N and ^{13}C(p, p)^{13}C [a]

E_p (MeV ± keV)	$\Gamma_{c.m.}$ (keV)	l_p	$\omega\Gamma_\gamma$ (eV)	$J^\pi; T$	^{14}N* (MeV)	Refs.
0.4485 ± 0.5	< 0.37	2	0.022	2^-	7.9669	A
0.551 ± 1	30 ± 1	0	9.2	$1^-; 1$	8.062	A
1.012 ± 2	≤ 0.2	4	≈ 0.01	$(4^-); 0$	8.490	A, (1978KE03)
1.150 ± 2	7 ± 1	1	1.3	$0^+; 1$	8.618	A
1.34 ± 50	≈ 460	0	12.8	$0^-; 1$	8.79	A
1.462 ± 3	16 ± 2	2	0.72	$3^-; 1$	8.907	A
1.523 ± 2	< 1		≈ 0.003	$5^+; 0$	8.964	A, (1978KE03)
1.540 ± 3	8 ± 2	1, (3)	0.13	2^+	8.980	A
1.7005 ± 1	< 1		[a]	$3^+; 0$	9.1287	A, (1978KE01, 1978KE03)
1.7476 ± 0.9	0.07 ± 0.05		14.8	$2^+; 1$	9.1724	A, (1976SI07)
1.980 ± 3	13 ± 3	2		$3^-, 2^-$	9.388	A
2.110 ± 3	41 ± 2	2	6.2	$2^-; 1$	9.509	A
2.319 ± 4	15 ± 3	1		1^+	9.703	A
2.743 [b]	5	1	[c]	$1^+, (2^+)$	10.096	A
2.885 ± 10 [b]	80 ± 15	0, 2		$1(^-); 0$	10.228	A
3.105 ± 7 [b]	33 ± 3	1	17	$2^+; 1$	10.432	A
3.20 [b]	140	0, 2		1^-	10.52	(1961KA04)
3.72 ± 30 [d]	165 ± 30				11.00	(1971RI13)
3.771 ± 5	1.2 ± 0.4		[i]	3^+	11.050	(1971RI13, 1980RA06)
3.79	100			1^+	11.07	A
3.94 ± 30 [e]	220 ± 30				11.21	(1971RI13)
3.98 [b]	11	2		3^-	11.24	(1961KA04)
4.04 [b]	175	2		2^-	11.30	A
4.14 [b]	28	1		1^+	11.39	A
4.525 ± 15 [f]	115 ± 10		[j]	1^+	11.750	A, (1971RI13)
5.325 ± 10	48 ± 7		[k]		12.492	(1971RI13)
5.88 ± 20 [d]	120 ± 30				13.01	(1971RI13)
6.20 ± 100 [g]	1000 ± 150		[l]	$(2^-); 1$	13.30	(1971RI13)
6.62 ± 20 [d]					13.69	(1971RI13)
[h]						

Table 14.16: Levels of ^{14}N from ^{13}C(p, γ)^{14}N and ^{13}C(p, p)^{13}C [a] (continued)

E_p (MeV ± keV)	$\Gamma_{c.m.}$ (keV)	l_p	$\omega\Gamma_\gamma$ (eV)	$J^\pi; T$	^{14}N* (MeV)	Refs.
16.1				$2^-; 1$	22.5	(1971RI13, 1980TU01)
16.7				$2^-; 1$	23.0	(1971RI13, 1980TU01)

A: See references for this state quoted in Table 14.16 in (1970AJ04) and 14.20 in (1976AJ04).

[a] See also Table 14.11.

[b] Reduced width for proton emission is of the order of 1% of the Wigner limit (1961KA04).

[c] $(2J+1)\Gamma_\gamma = 0.5 \pm 0.2$ eV, $\Gamma = 12 \pm 3$ eV (1960RO23).

[d] Weak resonance.

[e] See also Table 14.16 in (1970AJ04).

[f] In the $\gamma_{3.09}$ channel the peak occurs 55 keV higher (1971RI13); interference effects may be present.

[g] Part of the giant dipole resonance.

[h] Some broad structures are evident in the γ_0, $\gamma_{3.68}$ and $\gamma_{3.85}$ yields (1971RI13) and in the γ_0 yield (1980TU01). See also reaction 31.

[i] $\Gamma_\gamma = 1.2 \pm 0.4$ keV (1980RA06); $\Gamma_p = 0.5\%$ of single particle unit. J^π based on angular distribution of γ_0. For nature of γ-decay see Table 14.11.

[j] $(2J+1)\Gamma_\gamma = (18.5 \pm 4.2)\Gamma/\Gamma_p$ eV; if $J = 1$, $\Gamma_\gamma \geq 6$ eV (1971RI13).

[k] $(2J+1)\Gamma_{\gamma_0} = 2.3\,\Gamma/\Gamma_p$ eV; if $\Gamma = 38$ eV is assumed (1971RI13).

[l] $(2J+1)\Gamma_{\gamma_0} \geq 200$ eV (1971RI13): thus the transition is dipole and $T = 1$. The resonance is asymmetric and it is suggested that two states are invloved, one with $J^\pi = 1^-$ at $E_x = 12.7$ and the other one with 2^- at $E_x = 13.3$ MeV.

The angular distribution of the γ-rays from $10.23 \rightarrow 2.31$ is consistent with $J^\pi = 1^+$ for ^{14}*N*(10.23)*: $T = 0$ from M^2(M1) [see, however, Table 14.10]. The γ_0 angular distribution is consistent with $J = 2$ for ^{14}*N*(10.43)*: the similar decay characteristics of this state and of ^{14}*N*(9.17)* suggest that they are both $J^\pi = 2^+$, $T = 1$.

Below $E_p = 5.5$ MeV only γ_0 can be observed in the capture radiation. (1971RI13) have observed a number of resonances in the γ_0 yield and in the yield of the ground state γ-rays from ^{13}C*(3.09, 3.68, 3.85): these are shown in Table 14.16 in the range $E_p = 3.7$ to 6.6 MeV [see reaction 25 in (1970AJ04) for the earlier work]. Angular distributions and measurements of Γ_{γ_0} lead to the J^π values shown. Above $E_p = 7$ MeV the γ_0 yield shows broad structure and the giant dipole resonance at $E_x = 22.5$ and 23.0 MeV (1971RI13). Measurements by (1975PA18) of the γ_0 and γ_1 90° yields for $E_x = 23$ to 33 MeV find that the $T = 2$ resonances reported by (1971RI13) at $E_x = 23.7$ and 24.2 MeV do not exist and that there is no evidence for the $T = 2$ GDR between $E_x = 25$ and 29 MeV (1975PA18). The 90° yields of γ-rays to $T = 0$ states ($4.9 < E_x < 5.9$ MeV) and to $T = 1$ states ($8.0 < E_x < 9.5$ MeV) have been measured from $E_x = 23$ and 26 MeV, respectively, to $E_x = 33$ MeV (1975PA18). A recent study of the 90° yield of γ_0 and γ_1

[and of analyzing powers] has been reported for $E_{\bar{p}} = 6.25$ to 17.0 MeV by (1980TU01). The γ_0 results are in good agreement with those of (1974BA37) in the inverse reaction [^{14}N(γ, p)^{13}C]. Broad structures are observed at $E_p \approx 8$, 13, 14, 15 and 16.5 MeV. The γ_1 results indicate that the $T = 0$ strength is spread out fairly uniformly between $E_x = 13$ and 23 MeV (1980TU01). At $E_p = 25$ MeV strong transitions are observed to two groups of states centered near $E_x = 5.8$ and 8.9 MeV (1980MA1E).

See also (1966YO1A, 1976KR1A, 1979TR1G) and (1975ZI1A, 1976BR1H; astrophys.).

29. ^{13}C(p, p)^{13}C $\quad E_b = 7.55063$

The elastic scattering has been studied for $E_p = 0.14$ MeV to 11 MeV: see (1970AJ04, 1976AJ04). For observed resonances see Table 14.16; for angular distributions see ^{13}C. The yields of p_0 at eight angles (and the analyzing power) have been measured for $E_{\bar{p}} = 9.1$ to 18.4 MeV. A phase shift analysis implies the existence of resonances with $J^\pi = 1^-$, 2^- and 3^+ in the vicinity of $E_p \approx 15$ MeV. The 1^- and 2^- resonances have widths of $\approx 3 - 4$ MeV and have a total Γ_p/Γ value of 0.1. The correlation between these resonances and the GDR is not clear. There is no indication of the $T = 2$ states previously reported in reaction 30 (1978WE13). For other polarization measurements see (1976AJ04) and (1976TR1C). See also (1978DW1A; astrophys.).

30. ^{13}C(p, n)^{13}N $\quad Q_m = -3.0030 \quad E_b = 7.55063$

The yield of neutrons has been measured from threshold to $E_p = 13.7$ MeV: see (1970AJ04). Observed resonances are displayed in Table 14.17. The ratio of the reaction cross section at $E_p = 22.8$ MeV to the n_0 yield is 1.06 ± 0.07: thus there is little competition of γ-rays from excited states of ^{13}N with neutron emission making this a convenient fast neutron calibration source (1975LI11). The $0°$ polarization transfer coefficients have been measured for $E_{\bar{p}} = 7.9$ to 14.6 MeV (1976LI08). For other polarization measurements see (1965WA02; n_0; $E_p = 6.9$ to 12.3 MeV) and (1979CLZS; 6 MeV). See also (1979BYZZ), (1974LO1B, 1976WA1B, 1979BY1B) and ^{13}N.

31. ^{13}C(p, d)^{12}C $\quad Q_m = -2.7218 \quad E_b = 7.55063$

Analyzing power measurements for ^{12}C*(0, 12.71, 15.11, 16.11) have been measured at $E_{\bar{p}} = 65$ MeV (1979HO1H) and those for ^{12}C*(0, 4.4) are reported at $E_{\bar{p}} = 200$ MeV (1979CA1A). See also (1976AJ04), ^{12}C in (1980AJ01) and (1980MC1C, 1980WH1A).

Table 14.17: Resonances in $^{13}C(p, n)^{13}N$ (1961DA09) [a]

E_p (MeV)	Γ (keV)	$^{14}N^*$ (MeV)
3.76 ± 0.05	100	11.04
3.98 ± 0.02	30	11.24
4.05		11.31
4.15 ± 0.02	40	11.40
4.5 ± 0.1	100	11.7
4.7 ± 0.1	150	11.9
5.03 [b]		12.22
(5.44 ± 0.03)	(60)	(12.60)
5.53 ± 0.03	50	12.68
5.72 ± 0.03	60	12.86
6.20 ± 0.04	70	13.30
6.67 ± 0.13	250	13.74
7.0 ± 0.1	150	14.0
7.3		14.3
7.85 ± 0.08	150	14.83
7.93 ± 0.03	50	14.91
8.03 ± 0.03	50	15.00
8.7 ± 0.2	350	15.6
9.3 ± 0.1	150	16.2
10.2 ± 0.2	400	17.0
11.4 ± 0.3	600	18.1

[a] See also Table 14.9 in (1959AJ76).
[b] (1959GI47).

32. (a) ^{13}C(p, t)^{11}C $\quad Q_m = -15.186 \quad E_b = 7.55063$

(b) ^{13}C(p, ^{3}He)^{11}B $\quad Q_m = -13.1851$

At $E_p = 49.6$ MeV polarization measurements have been carried out for the tritons and ^{3}He ions to the mirror groups ^{11}B*(0, 2.12, 4.45, 5.02, 6.74, 12.91) and ^{11}C*(0, 2.00, 4.32, 4.80, 6.48, 12.50) (1974MA12). See also (1976AJ04) and ^{11}B, ^{11}C in (1980AJ01).

33. ^{13}C(p, α)^{10}B $\quad Q_m = -4.0626 \quad E_b = 7.55063$

Excitation functions have been measured from $E_p = 5.5$ (α_0), 6.0 (α_1), 7.0 (α_2), 8.0 (α_3), 10 (α_4), 11 (α to ^{10}B*(5.11)) to 18 MeV. Total cross sections have also been obtained for the production of ^{6}Li, ^{9}Be and ^{10}B: the latter shows a great deal of structure. The consequences for astrophysical problems are discussed by (1975OB01). The analyzing power for the α_0 group has been measured at $E_{\bar{p}} = 65$ MeV by (1980KA03). See also ^{10}B in (1979AJ01).

34. ^{13}C(d, n)^{14}N $\quad Q_m = 5.3260$

Observed neutron groups are displayed in Table 14.18. Angular distributions have been reported at many energies up to $E_d = 12$ MeV: see (1970AJ04) and Table 14.18. Comparisons of relative spectroscopic factors obtained in this reaction and in reaction 35 are shown in Table 14.23 of (1976AJ04): it appears that S_{rel} for ^{14}N*(2.31) [$T = 1$] is smaller in this reaction than in the (^{3}He, d) reaction although simple DWBA calculations would suggest that the factors would be the same in both proton pickup reactions. The $\tau \cdot \mathbf{T}$ terms appear to be energy dependent: see Table 14.23 (1976AJ04). See also ^{15}N and (1976FOZW).

35. ^{13}C(^{3}He, d)^{14}N $\quad Q_m = 2.0571$

Angular distributions have been studied at $E(^3\text{He}) = 13$ to 17 MeV [see (1976AJ04) and Table 14.18]. At $E(^3\text{He}) = 13$ MeV the angular distributions of deuterons and singlet deuterons to ^{14}N*(0, 2.31, 3.95) have been investigated by (1976JA14): the relative spectroscopic factors for these three states are 1.0, 1.50, 0.43 for deuterons and 1.0, 1.57, 0.41 for singlet deuterons. Spectroscopic factors for these and other states of ^{14}N observed in this reaction and in reaction 34 are displayed in Table 14.23 of (1976AJ04). At $E(^3\text{He}) = 43.6$ MeV ^{14}N*(8.91, 9.51) are strongly populated while ^{14}N*(8.49, 9.13, 9.39) are weakly excited. The $d_{5/2}$ transfer to $T = 0$ states is concentrated in the transitions to ^{14}N*(5.11, 5.83) (1980HA1E). See also (1979MA2K; theor.).

Table 14.18: ^{14}N levels from ^{13}C(d, n)^{14}N and ^{13}C(^{3}He, d)^{14}N

^{14}N* (MeV)	$J^{\pi}; T$	l_p [a]	l_p [b]
g.s.	$1^+; 0$	1	1
2.31	$0^+; 1$	1	1
3.95	$1^+; 0$	1	1
4.92	$0^-; 0$	0	0
5.11	$2^-; 0$	2	2
5.69	$1^-; 0$	0	0
5.83	$3^-; 0$	2	2
6.20	$1^+; 0$	isotropic [c]	1
6.44	$3^+; 0$	1 [c]	1
7.03	$2^+; 0$	1	1
7.97	$2^-; 0$	[d]	1, 2 [g]
8.06	$1^-; 1$	0 [e]	
8.49	$4^-; 0$	(3, 4) [b]	4 [h]
8.62	$0^+; 1$	0 [f], 1 [k]	1 [i]
8.91	$3^-; 1$	2 [c,k]	2 [j]
8.98	$2^+; (0)$	(1, 2, 3)	
9.13	$2^-; 0$	2 [k]	[l]
9.17	$2^+; 1$	(1, 3) [k]	
9.39	$2^-, 3^-; 0$	2 [k]	[l]
9.51	$2^-; 1$	2 [k]	[l]
9.70	$1^+; 0$	1 [k]	

[a] ^{13}C(d, n)^{14}N: E_d = 5.5 and 6 MeV (1966FU10), 4.5, 5.0 and 5.5 MeV (1973BO10), 6.5 MeV (1975BO35).
[b] ^{13}C(^{3}He, d)^{14}N: $E(^{3}\text{He}) = 15$ MeV (1966HO15, 1971FO05).
[c] (1973BO10).
[d] Angular distributions not complete because groups partly masked by contaminant.
[e] (1973BO10) report $l = 1$ in their Table 1: this is a typographical error (see p. 367).
[f] Expected $l = 1$ (1973BO10).
[g] The width obtained for this state in ^{13}C(p, γ): $(2J + 1)\Gamma_p = 12.6 \pm 3.6$ eV implies $l_p = 2$ and therefore odd parity: Γ_p is then 2.5 ± 0.07 eV, based on $J = 2$ (1972BA56).
[h] $\Gamma_p < 9.9 \times 10^{-2}$ eV (1971FO05).
[i] $\Gamma_p < 18$ keV (1971FO05).
[j] $\Gamma_p = 12.1$ keV (1971FO05).
[k] (1975BO35).
[l] Observed (1980HA1E).

36. ^{13}C(α, t)^{14}N $\qquad Q_m = -12.2634$

Angular distributions have been measured at $E_\alpha = 27$ MeV for the α groups to ^{14}N*(0, 2.31, 3.95, 4.92, 5.11). See also (1976AJ04), (1976LE1K) and (1978ZE03, 1980ZE05; theor.).

37. ^{13}C(^{7}Li, ^{6}He)^{14}N $\qquad Q_m = -2.424$

At $E(^7\text{Li}) = 34$ MeV, angular distributions have been obtained for the transitions to ^{14}N*(0, 2.31, 3.95) (1973SC26).

38. ^{13}C(^{11}B, ^{10}Be)^{14}N $\qquad Q_m = -3.678$

See (1976AJ04).

39. ^{14}C(β^-)^{14}N $\qquad Q_m = 0.15648$

See ^{14}C.

40. ^{14}C(p, n)^{14}N $\qquad Q_m = -0.6259$

Angular distributions have been obtained for the n_0, n_1 and n_2 groups in the range $E_p = 6$ to 14 MeV [see (1976AJ04)] and at $E_p = 2.45$ MeV (1977NI03; n_0) and 35 MeV (1979DO14; n_0, n_2). DWBA analysis of the latter results favors the inclusion of an isovector tensor interaction in the transition to $^{14}\text{N}_{\text{g.s.}}$ (1979DO14). See also ^{15}N.

41. ^{14}C(^{3}He, t)^{14}N $\qquad Q_m = 0.1379$

At $E(^3\text{He}) = 44.8$ MeV, triton groups are observed corresponding to all known levels of ^{14}N with $E_x < 7.1$ MeV. Triton groups were also seen to unresolved states with $E_x = 8.0 \rightarrow 9.5$ MeV, to ^{14}N*(10.43) and to excited states with $E_x = 12.49 \pm 0.04$, 12.83 ± 0.05 and 13.70 ± 0.04 MeV. Angular distributions were obtained for nine of the triton groups and analyzed using a local two-body interaction with an arbitrary spin-isospin exchange mixture. Dominant $L = 0$ transitions are found to ^{14}N*(2.31, 3.95, 13.7), $L = 1$ to ^{14}N*(5.11), $L = 2$ to ^{14}N*(0, 7.03, 10.43) and $L = 3$ to ^{14}N*(5.83) (1969BA06). See also reaction 50.

42. (a) ^{14}C(^{6}Li, ^{6}He)^{14}N $Q_{\rm m} = -3.350$
(b) ^{14}C(^{14}C, ^{14}B)^{14}N $Q_{\rm m} = -20.47$
(c) ^{14}C(^{18}O, ^{18}N)^{14}N $Q_{\rm m} = -13.90$

Angular distributions have been studied at $E(^{6}\text{Li}) = 62$ MeV for the transitions to ^{14}N*(0, 3.95, 6.20, 7.03): the $L = 0$ transition to ^{14}N*(3.95) carries at least 90% of the GT strength (1976GO25). For reactions (b) and (c) see (1980NA14).

43. (a) ^{14}N(γ, n)^{13}N $Q_{\rm m} = -10.554$
(b) ^{14}N(γ, p)^{13}C $Q_{\rm m} = -7.55063$
(c) ^{14}N(γ, d)^{12}C $Q_{\rm m} = -10.27240$
(d) ^{14}N(γ, 2n)^{12}N $Q_{\rm m} = -30.617$

The total absorption over the range $E_\gamma = 9$ to 31 MeV is dominated by a single peak at 22.5 MeV [estimated $\sigma \approx 29$ mb, $\Gamma \approx 2 - 3$ MeV] and appreciable strength extending beyond 30 MeV. The cross section cannot be accounted for solely by the (γ, n) and (γ, p_0) processes: particle unstable excited states of ^{13}C, ^{13}N are involved (1969BE92). The combined (γ, n) and (γ, pn) cross section begins to rise rapidly above 18 MeV, reaches its maximum value of 15 mb at 23.3 MeV and exhibits structure at about 19, 20.5 and 26 MeV. The main peak ($\Gamma \approx 3.5$ MeV: see (1970AJ04)) at 23.3 MeV appears to be split into two absorption levels (1970BE54, 1975BE60, 1975BE1F, 1976BE1H: monoenergetic photons) and (1980JU02). Maxima reported in other experiments and "breaks" in the (γ, n) activation curve are listed in (1970AJ04). Most of the photon absorption in the giant resonance region forms $J^\pi = 2^-$ states in ^{14}N which decay by d-wave neutron emission to $^{13}\text{N}_{\text{g.s.}}$. Some evidence is found for the existence of $J^\pi = 0^-$ strength at the peak of the giant resonance. Some evidence exists for a small amount of isospin $T = 0$ mixing near 22.5 MeV (1980JU02).

The (γ, p_0) and (γ, p_2) cross sections and angular distributions have been measured in the giant resonance region by (1972CA34, 1974BA37). The authors infer that the giant dipole states [$(p_{3/2})^{-1}$(2s1d)] which decay by p_0 emission to ^{13}C*(3.68) carry $\approx 90\%$ of the E1 strength and do not contribute substantially to the (γ, p_0) process which is populated by $(p_{1/2})^{-1}$(2s1d) giant dipole states. Above $E_\gamma = 22$ MeV d-wave emission from 2^- states appears to dominate the (γ, p_0) cross section (1972CA34, 1974BA37). See also reaction 30.

For reaction (c) see (1977TA1B); for reaction (d) see (1979WI1A). For spallation reactions see (1970AJ04) and (1976TU05, 1978DI1A). See also (1974BU1A, 1977DA1B) and (1979ME1E, 1980ME12; theor.).

44. ^{14}N(γ, γ)^{14}N

Table 14.19: Gamma widths [a] of some unbound levels of ^{14}N from ^{14}N(γ, γ') and ^{14}N(e, e$'$)

E_x (MeV)	$J^\pi; T$	Γ_{γ_0} (eV)	Mult.	Reaction	Refs.
8.06	$1^-; 1$	10.5 ± 6	E1	(γ, γ)	(1956GR17, 1958GR97)
8.91	$3^-; 1$	$(6.6 \pm 2.2) \times 10^{-3}$	M2	(e, e)	(1968CL05)
9.17	$2^+; 1$	7.7 ± 0.9	M1	(e, e)	(1968CL05)
		6.6 ± 1.3 [A]		(e, e)	(1979EN01)
10.43	$2^+; 1$	12.1 ± 1.5	M1	(e, e)	(1968CL05)
		9.6 ± 1.9 [A]			(1979EN01)
12.54 ± 0.1	$J = 0, 1, 2, 3$	$\frac{14.7\pm3.2}{2J+1}$	(M1, E2)	(e, e)	(1979EN01)
13.27 ± 0.1	$J = 0, 1, 2, 3$		(M1, M2, E2)	(e, e)	(1979EN01)
13.76 ± 0.1	$J = 0, 1, 2$	[b]	(M1, E1)	(e, e)	(1979EN01)
16.11 ± 0.1	$J = 0, 1, 2, 3$		(M2)	(e, e)	(1979EN01)

A = Adopted.

[a] See also Tables 14.11, 14.12 and 14.16, and Table 14.24 in (1976AJ04).

[b] See also (1977FR1M).

See (1976AJ04) and Table 14.19.

45. (a) ^{14}N(e, e$'$)^{14}N

(b) ^{14}N(e, ep)^{13}C $\qquad Q_m = -7.55063$

The r.m.s. radius of ^{14}N is 2.54 ± 0.02 fm: see (1976AJ04). Form factors have been determined at $E_e = 60.7$ to 122.0 MeV for ^{14}N*(2.31, 3.95, 4.92, 5.11, 5.69, 5.83): the reduced transition probabilities for these states, in single-particle units, are, respectively, 0.065 ± 0.020, 1.70 ± 0.14, $(1.1 \pm 0.5) \times 10^{-7}$, 4.1 ± 1.0, $(3.8 \pm 2.1) \times 10^{-8}$ and 6.1 ± 1.3 (1974EN01). E.K. Warburton (private communication) calculates 8.7 ± 0.9 fsec for the τ_m of ^{14}N*(3.95), on the basis of (1974EN01), the branching ratios of Table 14.11, and the δ(E2/M1) of (1967OL02). Inelastic scattering (at $\theta = 180°$) gives evidence for the excitation of states with $E_x = 8.91$ to 16.11 MeV: see Table 14.19. See also Table 14.11.

See also (1977FR1M, 1978VO12), (1977RI1H) and (1976BH1B, 1978FU13, 1979DO1P, 1979DO17, 1979KI1K, 1980ER01; theor.). For reaction (b) see (1978DE32).

46. ^{14}N(n, n$'$)^{14}N*

Angular distributions of elastically and inelastically scattered neutrons are displayed in Table 14.23 of (1970AJ04). See also (1975BE1Y, 1978BE2B). Observed γ-rays are shown in Table 14.25 of (1976AJ04). See also (1979SO1B; applied).

47. (a) ^{14}N(p, p′)^{14}N*
(b) ^{14}N(p, 2p)^{13}C $\qquad Q_{\rm m} = -7.55063$
(c) ^{14}N(p, pd)^{12}C $\qquad Q_{\rm m} = -10.27240$

Angular distributions of elastically and inelastically scattered protons have been studied at a number of energies up to $E_{\rm p} = 155$ MeV: see Tables 14.23 in (1970AJ04) and 14.26 in (1976AJ04) and (1977SA1B; p$_0$; $E_{\rm p} = 5.85$ MeV), (1979AO02; p$_0$, p$_1$; 21 MeV; pol.), (1980FO05; p$_0$, p$_1$, p$_2$ and see Table 14.20; 29.8, 36.6 and 40.0 MeV), (1980FA07; p$_0$; 35.2 MeV), (1980CO05; p$_0$, p$_1$, p$_2$; 122 MeV) and (1980MO01; p$_0$; 144 MeV).

(1980FO05) have analyzed angular distributions to ^{14}N*(2.31) with a microscopic model DWA which included contributions from the knock-on exchange amplitude and from central, tensor and spin-orbit forces. The first were fairly satisfactory. The extracted strengths of the tensor force were $20 - 75\%$ larger than estimates based on the one-pion-exchange potential (1980FO05). See also (1976AJ04).

Observed inelastic groups are exhibited in Table 14.20. At $E_{\rm p} = 800$ MeV, the spectra are dominated by the groups to ^{14}N*(9.17, 10.43) [$J^\pi = 2^+$] (1979MO1E; prelim.).

For reaction (b) see (1976AJ04). For reaction (c) see (1970AJ04). See also (1977BA85), (1979RA1C; astrophys.), (1976DO12, 1977GA22, 1978GO1L, 1978MA34, 1979KI10, 1979MA20; theor.) and ^{15}O.

48. ^{14}N(d, d′)^{14}N*

Angular distributions of elastically and inelastically scattered deuterons have been studied for $E_{\rm d} = 52$ MeV: see Table 14.23 in (1970AJ04), (1976AJ04), (1980KR01; d$_0$; $E_{\vec{\rm d}} = 10$ MeV), and (1976AO01, 1979AO01; d$_0$, d$_1$, d$_2$; $E_{\rm d} = 10.0$, 11.7, 14.8, 17.9 MeV). Inelastic groups are displayed in Table 14.20. The deuteron group to the 0^+, $T = 1$ state ^{14}N*(2.31) is isospin forbidden: its cross section is $1 - 2$ orders of magnitude less than that to ^{14}N*(3.95) [J^π; $T = 1^+$; 0]. It is summarized for $E_{\rm d} = 6$ to 20 MeV by (1979AO01) who find that the observed isospin violation is well accounted for by a direct multistep reaction mechanism which assumes that there is isospin mixing in the intermediate channels. See also (1976AJ04), ^{16}O in (1977AJ02, 1982AJ01) and (1977IZ01, 1977IZ1B, 1978MA34; theor.).

49. ^{14}N(t, t)^{14}N

Table 14.20: ^{14}N levels from ^{14}N(p, p′), (d, d′), (^{3}He, ^{3}He′) and (α, α′)

^{14}N*(MeV ± keV)				L [e]	Dominant config. [n]	$J^\pi; T$
(p, p′) [a]	(d, d′)	(^{3}He, ^{3}He′)	(α, α′)			
2.31	see text	[c]	see text		$(p_{\frac{1}{2}})^2$	$0^+; 1$
3.95	[b]	[c]	[e]	2	$(p_{\frac{1}{2}})^2$+ c.e. [h]	$1^+; 0$
4.91	[b]	[c]	[e]	1, 3	$p_{\frac{1}{2}}s_{\frac{1}{2}}$	$0^-; 0$
5.11	[b]	[c]	[e]	1, 3	$p_{\frac{1}{2}}d_{\frac{5}{2}}$	$2^-; 0$
5.69	[b]	[c]	[e]	1, 3	$p_{\frac{1}{2}}s_{\frac{1}{2}}$	$1^-; 0$
5.83	[b]	[c]	[e]	1, 3	$p_{\frac{1}{2}}d_{\frac{5}{2}}$	$3^-; 0$
6.20	[b]	[c]	[e,f]		$(s_{\frac{1}{2}})^2$	$1^+; 0$
6.44	[b]		[e,f]		$s_{\frac{1}{2}}d_{\frac{5}{2}}$	$3^+; 0$
7.03	[b]	[c]	[e]	2	c.e. [h]	$2^+; 0$
7.97					$p_{\frac{1}{2}}d_{\frac{3}{2}}$	$2^-; 0$
8.06		8.0 → 11.0 [d]			$p_{\frac{1}{2}}s_{\frac{1}{2}}$	$1^-; 1$
8.49						$4^-; 1$
8.62					$(s_{\frac{1}{2}})^2$	$0^+; 1$
8.91					$p_{\frac{1}{2}}d_{\frac{5}{2}}$	$3^-; 0$
9.17					c.e. [h]	$2^+; 1$
9.39						$2^-, 3^-; 0$
9.51					$p_{\frac{1}{2}}d_{\frac{5}{2}}$	$1^+; 0$
9.70					$(p_{\frac{1}{2}})^2$	$1^+; 0$
10.1					$s_{\frac{1}{2}}d_{\frac{5}{2}}$	$2^+, 1^+; 0$
11.2 ± 200	[f,g]	11.22 ± 50 [c]				
12.8 ± 400	[f,g]	12.77 ± 50 [c]				
17						
21.5						

[a] For references see Table 14.27 in (1976AJ04). Angular distributions are reported at $E_p = 29.8$ MeV to all the states with $E_x \leq 8.49$ MeV (1980FO05).
[b] Observed: see (1970AJ04).
[c] Observed: see (1969BA06).
[d] Unresolved structure.
[e] (1966HA19).
[f] Relatively low cross section due to two-nucleon transition.
[g] (1971CU01): pp′.
[h] c.e. = compound elastic.

See (1976AJ04).

50. ^{14}N(^{3}He, ^{3}He$'$)^{14}N*

Angular distributions of elastically and inelastically scattered ^{3}He ions have been measured at E(^{3}He) up to 44.6 MeV: see Table 14.23 in (1970AJ04) and (1976AJ04).

At $E(^3\text{He}) = 44.6$ MeV, twelve ^{3}He groups are reported corresponding to states in ^{14}N: see Table 14.20 (1969BA06). The angular distributions were analyzed using a local two-body interaction with an arbitrary spin-isospin exchange mixture. A comparison of the cross sections of the reactions ^{14}N(^{3}He, t)^{14}O$_{\text{g.s.}}$, ^{14}N(^{3}He, ^{3}He$'$)^{14}N*(2.31) and ^{14}C(^{3}He, t)^{14}N(0) [which all correspond to transitions between identical initial and final states] shows that they are roughly equal, as would be expected from charge independence, once detailed-balance, isospin coupling and phase-space corrections have been applied (1969BA06).

51. (a) ^{14}N(α, α')^{14}N*

(b) ^{14}N(α, ^{8}Be)^{10}B $\qquad Q_{\text{m}} = -11.7051$

Angular distributions of elastically and inelastically scattered α-particles have been measured for $E_\alpha = 7.6$ to 104 MeV: see Table 14.23 in (1970AJ04) and (1976AJ04), (1974CH1T, 1976CH24; α_1; $E_\alpha = 7.6$ to 16.9 MeV), (1977EN01; α_0; 19.8 to 23.1 MeV) and (1976FE12; α_0, $\alpha_{2\to4}$, α_{5+6}, α_{7+8}, α_9, α_{10}; 23.7 MeV). Table 14.20 displays the observed α-groups. Generally the intensity of the α_1 group is weak: see (1976CH24) and ^{18}F in (1978AJ03, 1983AJ01). See also (1976YO02). (1976WO11) find $S_\alpha = 0.75$ for ^{14}N$_{\text{g.s.}}$. See also (1977KN1E), (1976HA1Q, 1977MA2E, 1979KN1F), (1979RA1C; astrophys.) and (1977DM1A; theor.).

52. (a) ^{14}N(^{6}Li, ^{6}Li)^{14}N

(b) ^{14}N(^{7}Li, ^{7}Li)^{14}N

Elastic angular distributions have been measured at $E(^6\text{Li}) = 19.5$ MeV (1977KU06) and 32 MeV (1971GR44) and at $E(^7\text{Li}) = 36$ MeV (1976CO23).

53. ^{14}N(^{9}Be, ^{9}Be)^{14}N

See ^{9}Be in (1974AJ01).

54. (a) ^{14}N(^{10}B, ^{10}B)^{14}N
(b) ^{14}N(^{11}B, ^{11}B)^{14}N

Elastic angular distributions (reaction (a)) have been measured at $E(^{10}\text{B}) = 100$ MeV (1975NA15) and $E(^{14}\text{N}) = 73.9$ and 93.6 MeV (1977MO1A, 1979MO14). The elastic distributions (reaction (b)) have been studied at $E(^{14}\text{N}) = 41$, 77 and 113 MeV (1971LI11). For fusion cross sections see (1977HI01, 1978KO1J, 1978WU1C, 1980OR1C). See also (1978TA1B).

55. ^{14}N(^{12}C, ^{12}C)^{14}N

Elastic angular distributions have been measured in the range $E(^{14}\text{N}) = 21.3$ to 155 MeV: see (1976AJ04). More recently studies are reported at $E(^{14}\text{N}) = 37, 47$ and 58.3 MeV (1978CO20), 53 MeV (1976ZE04) and 78.8 MeV (1977MO1A, 1979MO14). At $E(^{14}\text{N}) = 155$ MeV the selective population of certain ^{14}N states is observed and angular distributions are reported for the transitions to ^{14}N*(0, 8.96, 12.7) (1975NA11).

For fusion cross section measurements see (1976ST12, 1977SW02, 1979GO09, 1979GO11, 1979KO20, 1980WI09) and (1976AJ04). See also (1978DA1E, 1978HA1F), (1976LE1F, 1978TS04, 1979GO1R, 1979NA1G, 1980TA1B), (1978RO1D; astrophys.) and (1976AM01, 1977BA3E, 1977MA11, 1978AV1A, 1978CU1C, 1978CU1E, 1978CU06, 1978FR1N, 1978HO13, 1978KA14, 1978VA1A, 1979MO1J, 1979NA03, 1980LE11, 1980LO02, 1980VA03; theor.).

56. (a) ^{14}N(^{13}C, ^{13}C)^{14}N
(b) ^{14}N(^{14}C, ^{14}C)^{14}N

The elastic angular distribution (reaction (a)) has been measured at $E(^{14}\text{N}) = 19.3$ MeV (1971VO01). For a fusion study see (1980WI09). For reaction (b) see (1976AJ04).

57. ^{14}N(^{14}N, ^{14}N)^{14}N

Elastic angular distributions have been studied for $E(^{14}\text{N}) = 4.99$ to 20.22 MeV (1969JA15). For fusion cross section measurements see (1976ST12, 1976SW02). See also (1976AJ04), (1978RO1D; astrophys.) and (1976RU1B, 1978AV1A, 1979HU1B; theor.).

58. ^{14}N(^{16}O, ^{16}O)^{14}N

Elastic angular distributions have been measured for $E(^{14}\text{N}) = 8.08$ to 155 MeV: see (1976AJ04). Recent work is reported at $E(^{14}\text{N}) = 76.2$ MeV (1979MO14, 1977MO1A) and 155 MeV (1977TO02: see also ^{16}O in (1982AJ01)). For fusion cross section measurements see (1976ST12, 1977SW02, 1977VO08). See also (1976AJ04) and (1978AV1A, 1978VA1A; theor.).

59. ^{14}N(^{19}F, ^{19}F)^{14}N

The elastic scattering has been studied at $E(^{14}\text{N}) = 19.5$ MeV (1977KU06).

60. (a) ^{14}N(^{24}Mg, ^{24}Mg)^{14}N
(b) ^{14}N(^{27}Al, ^{27}Al)^{14}N
(c) ^{14}N(^{28}Si, ^{28}Si)^{14}N
(d) ^{14}N(^{29}Si, ^{29}Si)^{14}N

For reactions (a, b, c) see (1977TH1G). For reactions (b, c) see (1971KO11: $E(^{14}\text{N}) = 65$, 84 and 88 MeV). For reaction (c) see (1977EC04: $E(^{14}\text{N}) = 27$, 30 and 33 MeV). For reaction (d) see (1978PE13: $E(^{14}\text{N}) = 39$ MeV). See also (1977SC1G, 1980TA1B) and (1979KA27; theor.).

61. (a) ^{14}N(^{39}K, ^{39}K)^{14}N
(b) ^{14}N(^{40}Ca, ^{40}Ca)^{14}N
(c) ^{14}N(^{48}Ca, ^{48}Ca)^{14}N

For reaction (a) see (1978BA26; theor.). For reaction (b) see (1978BU10), (1978HO1C) and (1979SA27; theor.). For reaction (c) see (1978HO1C).

62. ^{15}N(γ, n)^{14}N $\qquad Q_{\text{m}} = -10.8334$

Cross sections (integrated to 35 MeV) have been measured for the transitions to ^{14}N*(2.31, 3.95, $5.11 + 5.83$, 7.03) (1976PA22). See also ^{15}N.

63. ^{15}N(p, d)^{14}N $\qquad Q_{\text{m}} = -8.6087$

Angular distributions have been obtained for the deuterons corresponding to ^{14}N*($0 \to 8.06$, 8.62, 8.91, $8.96 + 8.98$, $9.17 \to 10.43$, 10.81, 11.05, $11.24 + 11.29$, $11.36 \to 11.66$, 11.75, 11.95, 12.20, 12.50, 12.61, $12.79 + 12.82$, $13.17 + 13.24$, $13.71 + 13.72$) (1969SN04: $E_p = 39.8$ MeV). Spectroscopic factors were extracted by DWBA analysis of the $l_n = 1$ pickup angular distributions (1969SN04). See also (1976AJ04).

64. ^{15}N(^{3}He, α)^{14}N $\quad Q_m = 9.7445$

Observed states in ^{14}N are displayed in Table 14.28 of (1976AJ04) together with the derived spectroscopic factors.

65. ^{15}N(^{13}C, ^{14}C)^{14}N $\quad Q_m = -2.6568$

At $E(^{15}$N$) = 30$, 32 and 45 MeV the angular distributions involving ^{14}N*(0, 2.31) have been studied: they are symmetric about 90° for the transition to the $T = 1$ analog state ^{14}N*(2.31) (1975GA17, 1976GA37).

66. ^{16}O(π^-, 2n)^{14}N $\quad Q_m = 155.824$

At $E_{\pi^-} = 230$ MeV, γ-rays from the decay of ^{14}N*(2.31, 3.95, 5.11, 5.83) are observed (1974LI15).

67. (a) ^{16}O(γ, d)^{14}N $\quad Q_m = -20.7363$
(b) ^{16}O(p, pd)^{14}N $\quad Q_m = -20.7363$

For reaction (a) see (1979WIZW) and ^{16}O in (1982AJ01). At $E_p = 75$ MeV, angular distributions to ^{14}N*(0, 3.95) have been studied by (1977GR04); ^{14}N*(2.31) is also populated. See also (1976GO1E).

68. ^{16}O(p, ^{3}He)^{14}N $\quad Q_m = -15.2428$

Angular distributions have been measured in the range $E_p = 27$ to 54.1 MeV: see (1976AJ04) and at $E_p = 27.0$ to 30.7 MeV (1978GO04; to ^{14}N*(2.31)). A number of comparisons have been made of the ratio of (p, ^{3}He) to the $T = 1$ state at 2.31 MeV and of (p, t) to the analog ground state of ^{14}O: see e.g. (1978GO04). See also ^{17}F in (1982AJ01) and (1976DA1K).

69. ^{16}O(d, α)^{14}N $\quad Q_m = 3.1104$

Angular distributions have been measured at many energies up to $E_d = 40$ MeV: see Table 14.25 in (1970AJ04), (1976AJ04) and (1973CA30; α_0; $0.98 \rightarrow 1.97$ MeV), (1976LU1A; α_0. α_2; 16 MeV) and (1976VA07: α to ^{14}N*(0, 3.95, 7.03, 11.04; 40 MeV). Analysis with a one-step ZRDWBA is reported by (1976VA07) And S values are derived: ^{14}N*(11.04) probably has $J^\pi = 3^+$.

The yield of the isospin forbidden α_1 group [to ^{14}N*(2.31)] has been studied for $E_d = 2$ to 15 MeV by (1969JO09, 1973JO13): the intensity of the isospin group is strongly dependent on E_d and on the angle of observation. The α_1 reaction appears to proceed almost exclusively by a compound nuclear process and its study leads to the determination of a large number of ^{18}F states: the average isospin impurity in ^{18}F for $10 \leq E_x \leq 20$ MeV is $3 - 10\%$ (1973JO13). At $E_d = 50$ MeV, the intensity of ^{14}N*(2.31) is $0.1 - 0.2\%$ that of ^{14}N$_{g.s.}$ (1975FA06). See also ^{18}F in (1978AJ03, 1983AJ01) and (1976PE08, 1978RI05).

Measurements on the absolute cross sections of this reaction [$E_d = 3.6$ to 5.3 MeV] and its inverse [^{14}N(α, d)^{16}O] are consistent with the principle of detailed balance. An upper limit of 0.2% is assigned to the time-reversal non-invariant part of the reaction amplitudes (1971TH03). See also (1978HI1E, 1978PI15; applications).

70. ^{16}O(α, ^{6}Li)^{14}N $\quad Q_m = -19.2628$

At $E_\alpha = 42$ MeV the transitions involving (^{14}N$_{g.s.}$ and ^{6}Li*(0, 3.56)), (^{14}N*(2.31) + ^{6}Li$_{g.s.}$) and (^{14}N*(3.95) + ^{6}Li$_{g.s.}$) have been studied by (1972RU03).

71. ^{16}O(^{10}B, 3α)^{14}N $\quad Q_m = -2.8236$

See (1978BE1G).

72. ^{16}O(^{11}B, ^{13}C)^{14}N $\quad Q_m = -2.0576$

See (1976AJ04).

73. ^{16}O(^{16}O, ^{18}F)^{14}N $\quad Q_m = -13.2100$

See (1974RO04).

74. ^{17}O(p, α)^{14}N $\qquad Q_m = 1.191$

See (1978SE08) and ^{18}F in (1978AJ03, 1983AJ01).

75. ^{19}F(d, ^{7}Li)^{14}N $\qquad Q_m = -6.1232$

See (1967DE03).

^{14}O

(Figs. 8 and 9)

GENERAL: (See also (1976AJ04).)

Special reactions involving ^{14}O: (1976AB04, 1978AB08).

Astrophysical questions: (1977JO1D, 1977SI1D).

Applied topics: (1978HI1D).

Reactions involving pions: (1976DI10, 1976DI11, 1977HO1B, 1978SH12, 1979LI1H, 1980DE10, 1980SI07).

Other topics: (1976IR1B, 1976ST13, 1976VO1C, 1979KA13).

Mass of ^{14}O: The recent ^{14}N(p, n)^{14}O threshold measurement by (1977WH01) leads to an atomic mass excess of 8007.1 ± 0.4 keV for ^{14}O. See also (1980BA1M). A preliminary measurement of the ^{16}O(p, t) Q-value (P.A. Barker and J.A. Nolen, private communication) leads to 8008.65 ± 0.51 keV, in excellent agreement with the value adopted by (1977WA08) [8008.3 ± 0.5 keV] which we continue to adopt. See also (1980NO1A).

1. ^{14}O(β^+)^{14}N $\qquad Q_{\rm m} = 5.1449$

A recent measurement of the half-life of ^{14}O is 70.613 ± 0.025 sec (1978WI04); [for earlier measurements see (1976AJ04)]. The "best" value of $\tau_{1/2} = 70.606 \pm 0.018$ sec (1978WI04). ^{14}O [$J^\pi = 0^+$; $T = 1$] decays predominantly to the analog state ^{14}N*(2.31): the branching ratio to that state is $(99.332 \pm 0.011)\%$. This value is obtained by adopting $(0.61 \pm 0.01)\%$ (1966SI05) and $(0.058 \pm 0.004)\%$ (1980WI1H) † for the branching ratios to ^{14}N*(0, 3.95) [both 1^+; 0 states]. The ft-value for the $0^+ \to 0^+$ transition to ^{14}N*(2.31) is 3086.5 ± 2.7 sec (1978WI04): [$\log ft = 3.4895 \pm 0.0004$]. For the transition to ^{14}N*(0, 3.95) $\log ft = 7.266 \pm 0.009$ (1980WI1H) and 3.112 ± 0.034 (1980WI1H), respectively. See also the discussion in (1976AJ04).

See also (1977BA2L, 1977WH01), (1976BE1E, 1978WE1J), (1978DA1H, 1978TA1U; astrophys.) and (1976LO01, 1976WI15, 1977GO13, 1977RI08, 1977RY1B, 1977SZ03, 1977TO11, 1977WI04, 1978SZ03, 1978TO02, 1978VA14, 1978WE1J, 1979DE15, 1979FE02, 1979KI1G, 1979SZ07, 1980LO07; theor.).

2. ^{12}C(^{3}He, n)^{14}O $\qquad Q_{\rm m} = -1.1484$

Observed neutron groups are displayed in Table 14.22. Angular distributions have been measured at $E(^3{\rm He}) = 25.4$ MeV [see (1976AJ04, 1970AJ04)] and at 15, 18 and 20 MeV (1978FE03: n_0, n_1, n_{2+3+4}). See also (1976WA1B) and ^{15}O.

† *Note added in proof:* Sum of ϵ_K and β-decay in ratio 6/4 (R.W. Kavanagh, private communication).

Table 14.21: Energy levels of ^{14}O

E_x (MeV ± keV)	$J^\pi; T$	$\tau_{1/2}$ (sec) or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
g.s.	$0^+; 1$	$\tau_{1/2} = 70.606 \pm 0.018$ sec	β^+	1, 2, 5, 8, 9, 10, 11, 13
5.173 ± 10	$1^-; 1$			2, 6, 11, 13
5.920 ± 10	$0^+; 1$	$\Gamma \leq 50$ keV	p	2, 6, 11, 13
6.272 ± 10	$3^-; 1$	103 ± 6	p	2, 3, 4, 5, 6, 11, 13
6.590 ± 10	$2^+; 1$	≤ 60	p	2, 11, 13
(6.79 ± 30)	$\pi = -$			11
7.768 ± 10	$2^+; 1$	76 ± 10	p	2, 10, 11, 13
(8.72 ± 40)				6, 11, 13
9.715 ± 20	$(2^+); 1$			2, 6, 11, 13
9.915 ± 20	$4^+; 1$	100 ± 50		2, 3, 4, 5, 6
10.89 ± 50				11
11.24 ± 50				11
11.97 [a]				11
12.84 ± 50				11
13.01 ± 50				11
14.15 ± 40				11
14.64 ± 60				11
17.40 ± 60				11

[a] Possibly more than one level.

Table 14.22: Levels of ^{14}O from ^{12}C(^{3}He, n)^{14}O

E_x (MeV ± keV) (1972GR39)	$\Gamma_{c.m.}$ (keV) (1973PR08)	L [d]	J^{π} [d]
0		0	0^+
5.173 ± 10		1	1^-
5.930 ± 15 [a]	≤ 47	0	0^+
6.272 ± 10	103 ± 6	3	3^-
6.596 ± 10 [b]	≤ 56	(2)	2^+ [e]
7.768 ± 10	76 ± 10	2	2^+
9.705 ± 25		(2)	(2^+)
9.915 ± 20 [c]	100 ± 50 [c]	4	4^+

[a] (1961TO03, 1968TO09) report $E_x = 5.905 \pm 0.012$ MeV.
[b] (1970AD01) report $E_x = 6.585 \pm 0.005$ MeV.
[c] (1972BR60) report $E_x = 9.95 \pm 0.043$ MeV; $J^{\pi} = 3^-$.
[d] See Table 14.30 in (1976AJ04).
[e] $J = 2$ follows from the np coincidence study of (1973PR08). The J shown for ^{14}O*(5.92, 6.27, 7.77) are in accord with this work.

3. ^{12}C(^{10}B, ^{8}Li)^{14}O $\qquad Q_m = -16.904$

At $E(^{10}\text{B}) = 100$ MeV the angular distributions of the transitions to ^{14}O*(6.27, 9.92) [$J^{\pi} = 3^-, 4^+$], the states preferentially excited, have been studied by (1978HA10).

4. ^{12}C(^{11}B, ^{9}Li)^{14}O $\qquad Q_m = -24.296$

At $E(^{11}\text{B}) = 114$ MeV, ^{14}O*(6.27, 9.9) [$J^{\pi} = 3^-, 4^+$] are populated: see (1974AN36).

5. ^{12}C(^{12}C, ^{10}Be)^{14}O $\qquad Q_m = -20.6159$

At $E(^{12}\text{C}) = 114$ MeV, the population of ^{14}O*(0, 6.27, 9.9) is reported: it is suggested that ^{14}O*(9.9) has a $(d_{5/2})^2_{4^+;1}$ configuration (1972SC21, 1974AN36). $^{14}\text{O}_{\text{g.s.}}$ is weakly populated (1974AN36).

6. ^{12}C(^{14}N, ^{12}B)^{14}O $\quad Q_m = -18.514$

At $E(^{14}N) = 118$ MeV, the population of ^{14}O*(6.27, 9.9) is reported (1974AN36). At $E(^{14}N) = 155$ MeV there is some evidence for the excitation of ^{14}O*(5.17, 5.92, 6.27, 8.72, 9.72) (1975NA11). See also (1979NA1G).

7. ^{12}C(^{16}O, ^{14}C)^{14}O $\quad Q_m = -15.7652$

See ^{14}C (1979PR07).

8. ^{12}C(^{20}Ne, ^{18}O)^{14}O $\quad Q_m = -14.2683$

See (1979OR01: $E(^{20}Ne) = 150$ to 294 MeV).

9. ^{13}C(p, π^-)^{14}O $\quad Q_m = -137.161$

At $E_p = 200$ MeV the angular distributions of π^- and π^+ to the ground states of ^{14}O and ^{14}C are very different (1979HO1F). See also (1979JO1C) and (1976NO1D, 1976PO1D; theor.).

10. ^{14}N(p, n)^{14}O $\quad Q_m = -5.9273$

$E_{thresh.} = 6355.6 \pm 1.6$ keV (1976FR1D);
$E_{thresh.} = 6353.6 \pm 0.4$ keV (1977WH01) ‡ ;
$E_{thresh.} = 6353.99 \pm 0.1$ keV (1980BA1M; prelim.).

Ground state angular distributions have been measured at $E_p = 35$ MeV (1979TAZW) and 144 MeV ((1980MO10) and to ^{14}O*(7.77)). See also (1976AJ04).

11. ^{14}N(^{3}He, t)^{14}O $\quad Q_m = -5.1635$

‡ See also the "*Mass of ^{14}O*" section in ^{14}O here.

Triton groups have been observed at $E(^3\mathrm{He}) = 44.6$ MeV to the first six states shown in Table 14.21 and to levels with $E_\mathrm{x} = 6.79 \pm 0.03$, 8.74 ± 0.06, 9.74 ± 0.03, 10.89 ± 0.05, 11.24 ± 0.05, 11.97 (unresolved), 12.84 ± 0.05, 13.01 ± 0.05, 14.15 ± 0.04, 14.64 ± 0.06 and 17.40 ± 0.06 MeV (1967BA13, 1969BA06). See also reaction 50 in ^{14}N. [The states at 6.79 and 8.74 MeV reported in this reaction are relatively weakly excited and are not observed in reaction 2.]

12. ^{16}O(γ, 2n)^{14}O $\qquad Q_\mathrm{m} = -28.8882$

See (1977JO02).

13. ^{16}O(p, t)^{14}O $\qquad Q_\mathrm{m} = -20.4062$

Angular distributions of ground state tritons have been studied to $E_\mathrm{p} = 54.1$ MeV [see (1976AJ04)] and at 28.9, 29.8 and 30.7 MeV (1978GO04). For comparison with the (p, ^{3}He) results see reaction 68 in ^{14}N.

Triton groups have also been observed to states with $E_\mathrm{x} = 5.21 \pm 0.04$, 5.92 ± 0.06, 6.28 ± 0.05, 6.59, 7.77, 8.69 ± 0.06 [weak, not observed in reaction 2], and 9.65 ± 0.06 MeV (1971FL04). Angular distributions have been studied with polarized protons at $E_\mathrm{p} = 43.8$ MeV to ^{14}O*(0, 5.17, 6.27, 6.59, 7.77, 9.72) (1974MA12). See also (1977BA2L, 1979NOZZ), (1976DA1K) and (1978PI1B, 1978PI10; theor.).

14. ^{16}O(α, ^{6}He)^{14}O $\qquad Q_\mathrm{m} = -27.914$

See (1975VA01, 1975VA1F).

15. ^{18}O(α, ^{8}He)^{14}O $\qquad Q_\mathrm{m} = -37.962$

See (1975JA10).

^{14}F
(Not illustrated)

^{14}F has not been observed: its atomic mass excess is predicted to be 32.98 MeV (1978GU10) which would make it unstable with respect to decay into ^{13}O+p by 2.58 MeV. See also (1976AJ04).

^{14}Ne
(Not illustrated)

^{14}Ne has not been observed. See (1976BE1V; theor.).

References

(Closed 01 August 1980)

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.

1953WO41 H.H. Woodbury, R.B. Day and A.V. Tollestrup, Phys. Rev. 92 (1953) 1199

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

1955AL16 H.R. Allan and N. Sarma, Proc. Phys. Soc. A68 (1955) 535

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

1956GR17 G.M. Griffiths, Can. J. Phys. 34 (1956) 339

1957WI27 D.H. Wilkinson and S.D. Bloom, Phil. Mag. 2 (1957) 63

1958GR97 G.M. Griffiths, Proc. Phys. Soc. A72 (1958) 337

1958WA02 E.K. Warburton and H.J. Rose, Phys. Rev. 109 (1958) 1199

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

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

1959HO01 H.D. Holmgren, E.A. Wolicki and R.L. Johnston, Phys. Rev. 114 (1959) 1281

1959WA04 E.K. Warburton, H.J. Rose and E.N. Hatch, Phys. Rev. 114 (1959) 214

1959WA16 E.K. Warburton, Phys. Rev. 113 (1959) 595

1960HE14 D.F. Hebbard and J.L. Vogl, Nucl. Phys. 21 (1960) 652

1960RO23 H.J. Rose, F. Riess and W. Trost, Nucl. Phys. 21 (1960) 367

1961CO05 H.O. Cohn, J.K. Bair and H.B. Willard, Phys. Rev. 122 (1961) 534

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

1961HE02 R.E. Hester and W.A.S. Lamb, Phys. Rev. 121 (1961) 584

1961KA04 E. Kashy, R.R. Perry, R.L. Steele and J.R. Risser, Phys. Rev. 122 (1961) 884

1961TO03 J.H. Towle and B.E.F. Macefield, Proc. Phys. Soc. 77 (1961) 399

1962RO21 H.J. Rose, F. Uihlein, F. Riess and W. Trost, Nucl. Phys. 36 (1962) 583

1963RO17 H.J. Rose, W. Trost and F. Riess, Nucl. Phys. 44 (1963) 287

1964DZ1A Dzubay and Blair, Phys. Rev. 134 (1964) B586

1964RO03 H.J. Rose, F. Riess and W. Trost, Nucl. Phys. 52 (1964) 481

1965FO06 P.D. Forsyth, I.J. Taylor and R.R. Perry, Nucl. Phys. 66 (1965) 376

1965NE06 J.O. Newton, R.S. Blake, D.J. Jacobs and J.P. Schapira, Nucl. Phys. 71 (1965) 113

1965WA02 B.D. Walker, C. Wong, J.D. Anderson, J.W. McClure and R.W. Bauer, Phys. Rev. 137 (1964) B347

1966AL10 D.E. Alburger, A. Gallmann, J.B. Nelson, J.T. Sample and E.K. Warburton, Phys. Rev. 148 (1966) 1050

1966DI04 G.U. Din and J.L. Weil, Nucl. Phys. 86 (1966) 509

1966FU10 H. Fuchs, K. Grabisch, P. Kraaz and G. Roschert, Phys. Lett. 23 (1966) 363

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

1966HO15 C.H. Holbrow, R. Middleton and B. Rosner, Phys. Rev. 152 (1966) 970

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

1966SI05 G.S. Sidhu and J.B. Gerhart, Phys. Rev. 148 (1966) 1024

1966SW01 C.P. Swann, Phys. Rev. 148 (1966) 1119

1966YO1A Young et al., Nucl. Instrum. Meth. Phys. Res. 44 (1966) 109

1967BA13 G.C. Ball and J. Cerny, Phys. Rev. 155 (1967) 1170

1967CH19 C. Chasman, K.W. Jones, R.A. Ristinen and D.E. Alburger, Phys. Rev. 159 (1967) 830

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

1967GA12 A. Gallmann, F. Haas and B. Heusch, Phys. Rev. 164 (1967) 1257

1967OL02 J.W. Olness, A.R. Poletti and E.K. Warburton, Phys. Rev. 154 (1967) 971

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

1967YO02 F.C. Young, P.D. Forsyth and J.B. Marion, Nucl. Phys. A91 (1967) 209

1968AL12 K.W. Allen, T.K. Alexander and D.C. Healey, Can. J. Phys. 46 (1968) 1575

1968BE30 R.A.I. Bell, R.D. Gill, B.C. Robertson, J.S. Lopes and H.J. Rose, Nucl. Phys. A118 (1968) 481

1968CL05 H.-G. Clerc and E. Kuphal, Z. Phys. 211 (1968) 452

1968MA29 N.F. Mangelson, B.G. Harvey and N.K. Glendenning, Nucl. Phys. A117 (1968) 161

1968ME10 K. Meier-Ewert, K. Bethge and K.-O. Pfeiffer, Nucl. Phys. A110 (1968) 142

1968RO1C Rose, Hausser and Warburton, Rev. Mod. Phys. 40 (1968) 591

1968TO09 J.H. Towle and G.J. Wall, Nucl. Phys. A118 (1968) 500

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

1969BE92 N. Bezic, D. Brajnik, D. Jamnik and G. Kernel, Nucl. Phys. A128 (1969) 426
1969CA1A R.R. Carlson and H.W. Wyborny, Phys. Rev. 178 (1969) 1529
1969HO23 C.H. Holbrow, R. Middleton and W. Focht, Phys. Rev. 183 (1969) 880
1969JA15 L.A. Jacobson, Phys. Rev. 188 (1969) 1509
1969JO09 J. Jobst, S. Messelt and H.T. Richards, Phys. Rev. 178 (1969) 1663
1969SN02 F.D. Snyder and M.A. Waggoner, Phys. Rev. 186 (1969) 999
1969SN04 J.L. Snelgrove and E. Kashy, Phys. Rev. 187 (1969) 1259
1969TH01 M.J. Throop, Phys. Rev. 179 (1969) 1011
1970AD01 E.G. Adelberger, A.V. Nero and A.B. McDonald, Nucl. Phys. A143 (1970) 97
1970AJ04 F. Ajzenberg-Selove, Nucl. Phys. A152 (1970) 1
1970BE54 B.L. Berman, S.C. Fultz, J.T. Caldwell, M.A. Kelly and S.S. Dietrich, Phys. Rev. C2 (1970) 2318
1970BL10 J.L. Black, W.J. Caelli, W.F. Davidson and R.B. Watson, Nucl. Phys. A153 (1970) 233
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
1971AL09 B.J. Allen and R.L. Macklin, Phys. Rev. C3 (1971) 1737
1971BA68 P.H. Barker, P.M. Cockburn, A. Huber, H. Knoth, U. Matter, H.-P. Seiler and P. Marmier, Ann. Phys. 66 (1971) 705
1971CO32 J. Coudurier, F. Merchez and C. Perrin, Lett. Nuovo Cim. 2 (1971) 1117
1971CU01 T.H. Curtis, H.F. Lutz, D.W. Heikkinen and W. Bartolini, Nucl. Phys. A165 (1971) 19
1971DU03 J.R. Duray and C.P. Browne, Phys. Rev. C3 (1971) 1867
1971FL04 D.G. Fleming, J.C. Hardy and J. Cerny, Nucl. Phys. A162 (1971) 225
1971FO05 H.T. Fortune, R. Middleton, J.D. Garrett and C.H. Holbrow, Phys. Rev. C3 (1971) 1441
1971GO40 N.B. Gove and M.J. Martin, Nucl. Data Tables A10 (1971) 205
1971GR44 K.O. Groeneveld, A. Richter, U. Strohbusch and B. Zeidman, Phys. Rev. Lett. 27 (1971) 1806
1971KA35 G. Kaschl, G. Mairle, H. Mackh, D. Hartwig and U. Schwinn, Nucl. Phys. A178 (1971) 275
1971KO11 I. Kohno, S. Nakajima, T. Tonuma and M. Odera, J. Phys. Soc. Jpn. 30 (1971) 910
1971LI11 M. Liu, W. von Oertzen, J.C. Jacmart, F. Pougheon, M. Riou, J.C. Roynette and C. Stephan, Nucl. Phys. A165 (1971) 118
1971MA46 K. Maluszynska, M. Przytula and I.V. Sizov, Acta Phys. Pol. B2 (1971) 183

1971RI13 F. Riess, W.J. O'Connell and P. Paul, Nucl. Phys. A175 (1971) 462

1971RI15 H.T. Richards and H.V. Smith, Jr., Phys. Rev. Lett. 27 (1971) 1735

1971TH03 S.T. Thornton, C.M. Jones, J.K. Bair, M.D. Mancusi and H.B. Willard, Phys. Rev. C3 (1971) 1065

1971VO01 W. Von Oertzen, G. Bohlen, B. Gebauer, E.E. Habib and N. Marquardt, Phys. Lett. B34 (1971) 51

1971WY01 H.W. Wyborny and R.R. Carlson, Phys. Rev. C3 (1971) 2185

1972BA56 D.P. Balamuth and J.W. Noe, Phys. Rev. C6 (1972) 30

1972BO68 H.G. Bohlen, M. Feil, A. Gamp, B. Kohlmeyer, N. Marquardt and W. Von Oertzen, Phys. Lett. B41 (1972) 425

1972BR60 O.D. Brill, A.D. Vongai, K.A. Gridnev and A.R. Faiziev, Yad. Fiz. 16 (1972) 640; Sov. J. Nucl. Phys. 16 (1973) 359

1972CA34 R.W. Carr, J.E.E. Baglin and E.J. Bentz, Jr., Phys. Rev. C6 (1972) 2032

1972CO01 J.A. Cookson, Nucl. Phys. A180 (1972) 89

1972CRZN H. Crannell, P.L. Hallowell, J.T. O'Brien, J.M. Finn, F.J. Kline, S. Penner, J.W. Lightbody, Jr. and S.P. Fivozinsky, in Sedai (1972) 375

1972DE1D Denisov, Kulchitskii and Chubukov, Sov. J. Nucl. Phys. 14 (1972) 497

1972GR39 M.B. Greenfield, C.R. Bingham, E. Newman and M.J. Saltmarsh, Phys. Rev. C6 (1972) 1756

1972KE08 R.M. Keyser, R.A. Blue and H.R. Weller, Nucl. Phys. A186 (1972) 528

1972NO08 J.W. Noe, D.P. Balamuth and R.W. Zurmuhle, Phys. Rev. C6 (1972) 780

1972OE01 H. Oeschler, H. Schroter, H. Fuchs, L. Baum, G. Gaul, H. Ludecke, R. Santo and R. Stock, Phys. Rev. Lett. 28 (1972) 694

1972RE10 M.J. Renan, J.P.F. Sellschop, R.J. Keddy and D.W. Mingay, Nucl. Phys. A193 (1972) 470

1972RU03 C. Rudy, R. Vandenbosch, P. Russo and W.J. Braithwaite, Nucl. Phys. A188 (1972) 430.

1972SC21 D.K. Scott, P.N. Hudson, P.S. Fisher, C.U. Cardinal, N. Anyas-Weiss, A.D. Panagiotou and P.J. Ellis, Phys. Rev. Lett. 28 (1972) 1659

1972SM07 H.V. Smith,Jr., Phys. Rev. C6 (1972) 441

1973AJ01 F. Ajzenberg-Selove, H.G. Bingham and J.D. Garrett, Nucl. Phys. A202 (1973) 152

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

1973BI1B Biro, Sudar, Csikai and Dezho, Neitronnaya Fiz., Pt. III, 1973 (1974) 85

1973BO10 J.R. Bobbitt, III, M.P. Etten and G.H. Lenz, Nucl. Phys. A203 (1973) 353

1973CA30 S. Cavallaro, A. Cunsolo, R. Potenza and A. Rubbino, Nuovo Cim. A14 (1973) 692

1973DA37 S. Dahlgren, P. Grafstrom, B. Hoistad and A. Asberg, Phys. Lett. B47 (1973) 439

1973JO13 P.L. Jolivette, Phys. Rev. C8 (1973) 1230

1973KL12 F.J. Kline, H. Crannell, J.T. O'Brien, J. McCarthy and R.R. Whitney, Nucl. Phys. A209 (1973) 381

1973MO15 T. Mo and H.R. Weller, Phys. Rev. C8 (1973) 972

1973MU14 S.F. Mughabghab and D.I. Garber, BNL 325, 3rd Edition, Vol. 1 (1973)

1973OE01 H. Oeschler, H. Fuchs and H. Schroter, Nucl. Phys. A202 (1973) 513

1973PR08 J.G. Pronko, R.G. Hirko and D.C. Slater, Phys. Rev. C7 (1973) 1382

1973SC26 P. Schumacher, N. Ueta, H.H. Duhm, K.-I. Kubo and W.J. Klages, Nucl. Phys. A212 (1973) 573

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

1974AL07 T.K. Alexander, G.J. Costa, J.S. Forster, O. Hausser, A.B. McDonald, A. Olin and W. Witthuhn, Phys. Rev. C9 (1974) 1748

1974AL11 D.E. Alburger and D.R. Goosman, Phys. Rev. C10 (1974) 912

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

1974BA37 J.E.E. Baglin, E.J. Bentz and R.W. Carr, Phys. Rev. C10 (1974) 24

1974BU1A Bulow and Forkman, IAEA, STI/DOC/10/156 (1974) 475

1974CH1T Chen, Thesis, Univ. Wisconsin (1974)

1974DA06 N.E. Davison, P. Fintz and A. Gallmann, Nucl. Phys. A220 (1974) 166

1974DE25 C. Detraz, F. Pougheon, M. Bernas, M. Langevin, P. Roussel and J. Vernotte, Nucl. Phys. A228 (1974) 39

1974EN01 N. Ensslin, W. Bertozzi, S. Kowalski, C.P. Sargent, W. Turchinetz, C.F. Williamson, S.P. Fivozinsky, J.W. Lightbody, Jr. and S. Penner, Phys. Rev. C9 (1974) 1705

1974FI1D D. Fick, Nukleonika 19 (1974) 693

1974GM01 K. Gmur and H.H. Muller, Helv. Phys. Acta 46 (1974) 807

1974JO01 P.L. Jolivette, Phys. Rev. C9 (1974) 16

1974KL12 F.J. Kline, H. Crannell, J.M. Finn, P.L. Hallowell, J.T. O'Brien, C.W. Werntz, S.P. Fivozinsky, J.W. Lightbody and Jr., S. Penner, Nuovo Cim. A23 (1974) 137

1974LI15 B.J. Lieb and H.O. Funsten, Phys. Rev. C10 (1974) 1753

1974LO1B Lorenzen and Brune, IAEA, STI/DOC/10/156 (1974) 325

1974MA12 J.A. Macdonald, J. Cerny, J.C. Hardy, H.L. Harney, A.D. Bacher and G.R. Plattner, Phys. Rev. C9 (1974) 1694

1974NO01 J.W. Noe, D.P. Balamuth and R.W. Zurmuhle, Phys. Rev. C9 (1974) 132

1974RO04 H.H. Rossner, G. Hinderer, A. Weidinger and K.A. Eberhard, Nucl. Phys. A218 (1974) 606

1974SH1E Sher, IAEA, STI/DOC/10/156 (1974) 1

1974TH01 C. Thibault and R. Klapisch, Phys. Rev. C9 (1974) 793

1975BA1W Batusov et al., An. Stiint. “Al. I. Cuza” Iasi (Ser. Noua) I.B. (Romania) 21 (1975) 7

1975BA40 Y.A. Batusov, S.A. Bunyatov, L. Vizireva, G.R. Gulkanyan, F. Mirsalikhova, V.M. Sidorov and K. Chernev, Yad. Fiz. 21 (1975) 1215; Sov. J. Nucl. Phys. 21 (1975) 627

1975BA52 H.W. Baer, J.A. Bistirlich, N. de Botton, S. Cooper, K.M. Crowe, P. Truol and J.D. Vergados, Phys. Rev. C12 (1975) 921

1975BE1F Berman and Fultz, Rev. Mod. Phys. 47 (1975) 713

1975BE1Y Bernard and Taylor, Nucl. Cross Sections and Tech., Pt. II, Washington, D.C., 1975 (1975) 938

1975BE60 B.L. Berman, At. Data Nucl. Data Tables 15 (1975) 319

1975BO35 J. Bommer, M. Ekpo, H. Fuchs, K. Grabisch and H. Kluge, Nucl. Phys. A251 (1975) 257

1975BO58 V.I. Borovlev and I.D. Lopatko, Izv. Akad. Nauk SSSR Ser. Fiz. 39 (1975) 1758; Bull. Acad. Sci. USSR Phys. Ser. 39 (1975) 162

1975CE04 F.E. Cecil, J.R. Shepard, R.E. Anderson, R.J. Peterson and P. Kaczkowski, Nucl. Phys. A255 (1975) 243

1975FA06 W.R. Falk, A. Djaloeis, H.H. Wolter and H. Kelleter, Z. Phys. A273 (1975) 265

1975FE1A Feather, Commun. Roy. Soc. Edinburgh (Phys. Sci.) 2 (1975) 19

1975FO01 H.T. Fortune, H.G. Bingham, D.J. Crozier and J.N. Bishop, Phys. Rev. C11 (1975) 302

1975GA17 A. Gamp, P. Braun-Munzinger, C.K. Gelbke, H.L. Harney, H.G. Bohlen, W. Bohne, K.D. Hildenbrand, J. Kuzminski, W. Von Oertzen and I. Tserruya, Nucl. Phys. A250 (1975) 341

1975GE1E Gershtein, Folomeshkin, Khlopov and Eramzhyan, Yad. Fiz. 22 (1975) 157

1975HE02 H.T. Heaton, II, J.L. Menke, R.A. Schrack and R.B. Schwartz, Nucl. Sci. Eng. 56 (1975) 27

1975JA10 J. Janecke, F.D. Becchetti, L.T. Chua and A.M. VanderMolen, Phys. Rev. C11 (1975) 2114

1975KA1G P.J. Karol, M.V. Yester, R.L. Klobuchar and A.A. Caretto, Phys. Lett. B58 (1975) 489

1975KO1F Kozodaeva et al., Yad. Fiz. 22 (1975) 730

1975KO25 V.F. Kosmach, A.G. Martirosova and V.I. Ostroumov, Yad. Fiz. 22 (1975) 453; Sov. J. Nucl. Phys. 22 (1976) 233

1975LI11 D.A. Lind, R.J. Peterson and H.W. Fielding, Phys. Rev. C11 (1975) 2099

1975MA1M Maslennikova and Tret'yakova, Yad. Fiz. 22 (1975) 687

1975MI12 D.J. Millener and D. Kurath, Nucl. Phys. A255 (1975) 315

1975MU07 J.J. Murphy II, Y.M. Shin and D.M. Skopik, Nucl. Phys. A246 (1975) 221

1975NA11 K.G. Nair, C.W. Towsley, R. Hanus, M. Hamm and K. Nagatani, Phys. Rev. Lett. 35 (1975) 838

1975NA15 K.G. Nair, H. Voit, C.W. Towsley, M. Hamm, J.D. Bronson and K. Nagatani, Phys. Rev. C12 (1975) 1575

1975OB01 D.L. Oberg, D. Bodansky, D. Chamberlin and W.W. Jacobs, Phys. Rev. C11 (1975) 410

1975PA18 P. Paul, H.S. Kuan and E.K. Warburton, Nucl. Phys. A254 (1975) 1

1975PO10 J.E. Poth, M.W. Sachs and D.A. Bromley, Nuovo Cim. A28 (1975) 215

1975RA22 V.K. Rasmussen and F.R. Metzger, Phys. Rev. C12 (1975) 706

1975SC35 W.F.W. Schneider, B. Kohlmeyer, F. Puhlhofer and R. Bock, Nucl. Phys. A251 (1975) 331

1975SE04 H.P. Seiler, R. Kulessa, P.M. Cockburn, P. Marmier and P.H. Barker, Nucl. Phys. A241 (1975) 159

1975SE1J J.P.F. Sellschop, R.J. Keddy, D.W. Mingay, M.J. Renan and D.G. Schuster, Int. J. Appl. Rad. Isotopes 26 (1975) 640

1975SO1E Sokol. Thesis, Univ. Notre Dame (1975)

1975SP04 J. Spuller, M.D. Hasinoff, S.T. Lim, D.F. Measday and T.J. Mulligan, Nucl. Phys. A248 (1975) 276

1975VA01 A. Vander Molen, F.D. Becchetti, J. Janecke and L. Chua, Phys. Rev. C11 (1975) 734

1975VA19 O.I. Vasileva, V.M. Lebedev, A.V. Spasskii, I.B. Teplov and L.N. Fateeva, Yad. Fiz. 22 (1975) 446; Sov. J. Nucl. Phys. 22 (1976) 229

1975VA1F Vander Molen, Thesis, Univ. Michigan (1975)

1975WI04 S.J. Wilson, Phys. Rev. C11 (1975) 1071

1975ZI1A Zimmerman, Fowler and Caughlan, OAP-399 (1975)

1976AB04 A. Abul-Magd and J. Hufner, Z. Phys. A277 (1976) 379

1976AJ04 F. Ajzenberg-Selove, Nucl. Phys. A268 (1976) 1

1976AM01 H. Amakawa and K.-I. Kubo, Nucl. Phys. A266 (1976) 521

1976AO01 Y. Aoki, S. Kato, J. Kawa, K. Okada and T. Izumoto, Phys. Lett. B61 (1976) 437

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

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

1976BA08 R. Babinet, L.G. Moretto, J. Galin, R. Jared, J. Moulton and S.G. Thompson, Nucl. Phys. A258 (1976) 172

1976BA41 K. Bangert, U.E.P. Berg, K. Wienhard and H. Wolf, Z. Phys. A278 (1976) 295

1976BA54 B. Bassalleck, H.D. Engelhardt, E.L. Haase, W.-D. Klotz, C.W. Lewis, F. Takeutchi, H. Ullrich and M. Furic, Phys. Lett. B65 (1976) 128

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

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

1976BE1H Berman, Preprint UCRL-78482 (1976)

1976BE1M Bentheim et al., Z. Phys. A279 (1976) 163

1976BE1U V. Bechtold, L. Friedrich, J. Bialy, M. Junge, F.K. Schmidt and G. Strassner, Polarization, Zurich, 1975 (1976) 723

1976BE1V Beiner, Lombard and Mas, Cargese Conf., CERN 76-13 (1976) 212

1976BH1B Bhalerao and Dhavale, Prog. Theor. Phys. 56 (1976) 1497

1976BO1M Bouvier and Weibel, Arch. Sci. (Geneva) 29 (1976) 163

1976BO1Q Borcvlev, Lopatko, Slabcspitsky and Chegoryan, Polarization, Zurich, 1975 (1976) 599

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

1976BR1H Brown, Starrfield and Waller, Bull. Amer. Phys. Soc. 21 (1976) 587

1976BU16 M. Buenerd, C.K. Gelbke, B.G. Harvey, D.L. Hendrie, J. Mahoney, A. Menchaca-Rocha, C. Olmer and D.K. Scott, Phys. Rev. Lett. 37 (1976) 1191

1976BU21 N.T. Burtevaev, A.D. Vongai, Y.A. Glukhov, A.D. Duisebaev, G.N. Ivanov, V.I. Kanashevich, S.V. Laptev, A.A. Ogloblin, S.B. Sakuta, A.V. Spasskii et al., Yad. Fiz. 24 (1976) 873; Sov. J. Nucl. Phys. 24 (1976) 457

1976CE1E Cerny, Cargese Conf., CERN 76-13 (1976) 225

1976CH1N Chyi, Bull. Amer. Phys. Soc. 21 (1976) 1331

1976CH1P Chatterjee, Tobias and Lyman, Spallation Nucl. Reactions and Their Applications; Eds., Shen and Merker (1976) 169

1976CH24 L.C. Chen, Phys. Rev. C14 (1976) 2069

1976CH28 A. Chevarier, N. Chevarier, A. Demeyer, P. Martin and P. de Saintignon, Nucl. Phys. A274 (1976) 223

1976CO1R H.T. Coelho, R.M. Dreizler, W. Berger and H. W. Galbraith, Nucl. Phys. A259 (1976) 231

1976CO23 M.E. Cobern, D.J. Pisano and P.D. Parker, Phys. Rev. C14 (1976) 491

1976DA06 R.A. Dayras, Z.E. Switkowski and T.A. Tombrello, Nucl. Phys. A261 (1976) 365

1976DA1K Darden and Haeberli, Polarization, Zurich, 1975 (1976) 229

1976DE1G Despain, OAP-459 (1976)

1976DI10 M. Dillig and M.G. Huber, Lett. Nuovo Cim. 16 (1976) 293

1976DI11 M. Dillig and M.G. Huber, Lett. Nuovo Cim. 16 (1976) 299

1976DI1F Dickens and Bell, Astrophys. J. 207 (1976) 506

1976DO12 G.A. Doskeev, M.A. Zhusupov and V.I. Markov, Izv. Akad. Nauk SSSR Ser. Fiz. 40 (1976) 742; Bull. Acad. Sci. USSR Phys. Ser. 40 (1976) 45

1976DW1A Dwyer and Meyer, Bull. Amer. Phys. Soc. 21 (1976) 540

1976EA1A Earwacker and Walker, Lowell CONF-760715-P2 (1976)

1976EC1B Economou and Turkevich, Nucl. Instrum. Meth. 134 (1976) 391

1976EG02 R. Eggers, M.N. Namboodiri, P. Gonthier, K. Geoffroy and J.B. Natowitz, Phys. Rev. Lett. 37 (1976) 324

1976EN02 H.D. Engelhardt, C.W. Lewis and H. Ullrich, Nucl. Phys. A258 (1976) 480

1976EP1A Epsteain, Arnett and Schramm, Astrophys. J. Suppl. 31 (1976) 111

1976FE12 G.A. Feofilov, A.E. Denisov, R.P. Kolalis and V.S. Sadkovskii, Izv. Akad. Nauk SSSR Ser. Fiz. 40 (1976) 2210; Bull. Acad. Sci. USSR Phys. Ser. 40 (1976) 158

1976FI1E Fisher et al., Atstrophys. J. 205 (1976) 938

1976FOZW H.T. Fortune, M.E. Cobern and G.E. Moore, Bull. Amer. Phys. Soc. 21 (1976) 514, AF10

1976FR1D Freeman et al., At. Masses and Fund. Constants; Eds., Sanders and Wapstra (1976) 126

1976GA37 A. Gamp, P. Braun-Munziger, C.K. Gelbke and H.L. Harney, Nukleonika 21 (1976) 753

1976GAYV D.I. Garber and R.R. Kinsey, BNL 325, 3rd Edition, Vol. 2 (1976)

1976GE20 H. Gemmeke, D. Baumgartner, A. Richter and L. Lassen, Z. Phys. A279 (1976) 425

1976GI1C Ginzburg and Ptjskin, Rev. Mod. Phys. 48 (1976) 161

1976GO1E N.F. Golovanova, I.M. Il'in, V.G. Neudatchin, Yu.F. Smirnov and Yu.M. Tchuvilsky, Nucl. Phys. A262 (1976) 444

1976GO25 C.D. Goodman, W.R. Wharton and D.C. Hensley, Phys. Lett. B64 (1976) 417

1976GR02 H. Grawe, J. Herholz and K. Kandler, Z. Phys. A276 (1976) 351

1976GR1F Griggs et al., Bull. Amer. Phys. Soc. 21 (1976) 514

1976HA1Q Hanna, Proc. Dubna Conf., JINR D-9920, Vol. II (1976) 195

1976HI05 M.D. High and B. Cujec, Nucl. Phys. A259 (1976) 513

1976IR1B Irvine et al., Ann. Phys. 102 (1976) 129

1976JA13 R. Jahn, G.J. Wozniak, D.P. Stahel and J. Cerny, Phys. Rev. Lett. 37 (1976) 812

1976JA14 U. Janetzki, Q.K.K. Liu, D. Hahn, H. Homeyer and J. Scheer, Nucl. Phys. A267 (1976) 285

1976JA1G Jacobs, Clegg, Ikossi and Ludwig, Polarization, Zurich, 1975 (1976) 697

1976JA1H Jacobs, Clegg, Ludwig and Tonsfeldt, Bull. Amer. Phys. Soc. 21 (1976) 638

1976KA04 T. Kammuri, Nucl. Phys. A259 (1976) 343

1976KI1D King et al., Lowell Conf., CONF-760715-P2 (1976) 1344

1976KR1A Krone, Goldberg and Raymer, Bull. Amer. Phys. Soc. 21 (1976) 795

1976KR1B Krammer, Drenokhahn, Finokh and Niewisch, Polarization, Zurich, 1975 (1976) 651

1976KU1D Kuehner et al., Polarization, Zurich, 1975 (1976) 695

1976LE1F Lefort, Rept. Prog. 39 (1976) 129

1976LE1K Lebedev et al., Contrib. to Dubna Conf. on Slected Topics in Nucl. Struct., Vol. 1, JINR D-9682 (1976) 98

1976LE1Q L'ecuyer et al., Bull. Amer. Phys. Soc. 21 (1976) 1344

1976LI08 P.W. Lisowski, R.L. Walter, C.E. Busch and T.B. Clegg, Nucl. Phys. A264 (1976) 188

1976LI1K Lingenfelter, Spallation Nucl. Reactions and Thier Applications; Eds., Shen and Merker (1976) 193

1976LI26 E. Lipparini, S. Stringari and M. Traini, Nuovo Cim. A34 (1976) 48

1976LO01 B.A. Logan and A. Ljubicic, Phys. Rev. C13 (1976) 361

1976LU1A Ludwig, Clegg, Ikossi and Jacobs, Polarization, Zurich, 1975 (1976) 687

1976ME1H Mewaldt, Stone, Vidor and Vogt, Astrophys. J. 205 (1976) 931

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

1976NO1C Norgaard and Fricke, Astron. Astrophys. 49 (1976) 337

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

1976OS1E Osmer, Astrophys. J. 202 (1976) 352

1976PA22 B.H. Patrick, E.M. Bowey and E.G. Muirhead, J. Phys. (London) G2 (1976) 751

1976PE08 D.T. Petty, J.A. Kuehner, J. Szucs, P.W. Green and G.D. Jones, Phys. Rev. C14 (1976) 12

1976PO1D Powers, Meson-Nucl. Phys., 1976 (1976) 552

1976QU1A Querci and Querci, Astron. Astrophys. 49 (1976) 443

1976RA1J Randle, Green and Earwaker, Lowell Conf., CONF-760715-P2 (1976) 1269

1976RO14 C. Rogers, Nucl. Phys. A271 (1976) 447

1976RO1J Ross and Aller, Science 191 (1976) 1223

1976RU1B H.M. Ruck and W. Greiner, Phys. Lett. B61 (1976) 327

1976SA04 F.D. Santos, Phys. Rev. C13 (1976) 1145

1976SI07 W.L. Sievers, J.A. Pintar, R.L. Boudrie, F.W. Prosser, Jr. and P. Goldhammer, Phys. Rev. C13 (1976) 2546

1976SI1D Silberberg, Tsao and Shapiro, Spallation Nucl. Reactions and Their Applications; Eds., Shen and Mercer (1976) 49

1976SI1G Simons, Land, Brown and Brennan, Bull. Amer. Phys. Soc. 21 (1976) 1344

1976ST12 R.G. Stokstad, Z.E. Switkowski, R.A. Dayras and R.M. Wieland, Phys. Rev. Lett. 37 (1976) 888

1976ST13 S. Stringari, R. Leonardi and D.M. Brink, Nucl. Phys. A269 (1976) 87

1976ST1H Standing and Cohan, Bull. Amer. Phys. Soc. 21 (1976) 1344

1976SU1E Sundqvist et al., Int. J. Appl. Rad. Isotopes 27 (1976) 273

1976SW02 Z.E. Switkowski, R.G. Stokstad and R.M. Wieland, Nucl. Phys. A274 (1976) 202

1976TE03 R.K. Tenhaken and P.A. Quin, Nucl. Phys. A271 (1976) 173

1976TR1C T.A. Trainor, N.L. Back, J.E. Bussoletti and L.D. Knutson, Polarization, Zurich, 1975 (1976) 632

1976TU05 M. Turk, Fizika 8 (1976) 173

1976VA07 A. van der Woude and R.J. de Meijer, Nucl. Phys. A258 (1976) 199

1976VA1D Van Paradijs and Kester, Astron. Astrophys. 53 (1976) 1

1976VI1B Vigroux, Audouze and Lequeux, Astron. Astrophys. 52 (1976) 1

1976VO1C Voinova, INDC(CCP)-93/N (1976)

1976WA1B Walter, Polarization, Zurich, 1975 (1976) 377

1976WA1L Walter et al., Polarization, Zurich, 1975 (1976) 649

1976WE05 M.P. Webb, R. Vandenbosch, K.A. Eberhard, K.G. Bernhardt and M.S. Zisman, Phys. Rev. Lett. 36 (1976) 779

1976WE09 R.B. Weisenmiller, N.A. Jelley, K.H. Wilcox, G.J. Wozniak and J. Cerny, Phys. Rev. C13 (1976) 1330

1976WI15 D.H. Wilkinson, Phys. Lett. B65 (1976) 9

1976WO11 G.J. Wozniak, D.P. Stahel, J. Cerny and N.A. Jelley, Phys. Rev. C14 (1976) 815

1976YO02 D.H. Youngblood, J.M. Moss, C.M. Rozsa, J.D. Bronson, A.D. Bacher and D.R. Brown, Phys. Rev. C13 (1976) 994

1976ZA1B Zaika et al., Polarization, Zurich, 1975 (1976) 665

1976ZE04 A.F. Zeller, M.E. Williams-Norton, R.J. Puigh, G.E. Moore, K.W. Kemper and G.M. Hudson, Phys. Rev. C14 (1976) 2162

1977AJ02 F. Ajzenberg-Selove, Nucl. Phys. A281 (1977) 1

1977AN21 I. Angeli and M. Csatlos, Nucl. Phys. A288 (1977) 480

1977AR06 A.G. Artukh, G.F. Gridnev, V.L. Mikheev and V.V. Volkov, Nucl. Phys. A283 (1977) 350

1977AU1B Austin, MSUCL-254 (1977)

1977AU1E Audouze, CNO Isotopes in Astrophys.; Ed., J. Audouze (1977) 3

1977AU1F Audouze, Lequeux, Rocca-Volmerange and Vigroux, CNO Isotopes in Astrophys.; Ed., J. Audouze (1977) 155

1977AU1J Auer and Demarque, CNO Isotopes in Astrophys.; Ed., J. Audouze (1977) 25

1977BA1P Batusov and Eramzhyan, Fiz. Elem. Chastits At. Yad. (USSR) 8 (1977) 229

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

1977BA3E R. Bass, Phys. Rev. Lett. 39 (1977) 265

1977BA85 O.E. Badawy, K.M. Abdo and M. Tawfik, Acta Phys. (Hungary) 43 (1977) 269

1977BE2J Bell, Clegg and Powell, Monthly Notice Roy. Astron. Soc. 181 (1977) 31

1977BI07 M. Bister, A. Anttila and J. Keinonen, Phys. Rev. C16 (1977) 1303

1977BR1N Brown and Hughes, Nature 268 (1977) 512

1977CA1J Carbon, Butler, Kraft and Nocar, CNO Isotopes in Astrophys.; Ed., J. Audouze (1977) 33

1977CA1K Caughlan, CNO Isotopes in Astrophys.; Ed., J. Audouze (1977) 121

1977CA1N Casse and Goret, OAP-499 (1977)

1977CH22 R. Chechik, Z. Fraenkel, H. Stocker and Y. Eyal, Nucl. Phys. A287 (1977) 353

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

1977CL1C Clayton, CNO Isotopes in Astrophys.; Ed., J. Audouze (1977) 15

1977CL1E Clegg, Monthly Notice Roy. Astron. Sci. 181 (1977) 1

1977CO14 T.M. Cormier, P. Braun-Munzinger, P.M. Cormier, J.W. Harris and L.L. Lee, Jr., Phys. Rev. C16 (1977) 215

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

1977CO1U Cowan and Rose, Astrophys. J. 212 (1977) 149

1977CO1W Cowan and Rose, Astrophys. J. 217 (1977) 51

1977CR02 H. Crannell, J.M. Finn, P. Hallowell, J.T. O'Brien, N. Ensslin, L.W. Fagg, E.C. Jones,Jr. and W.L. Bendel, Nucl. Phys. A278 (1977) 253

1977DA18 J.R. Davis and G.U. Din, Aust. J. Phys. 30 (1977) 167

1977DA1B Davydov, Naumov and Shcherbachenko, INDC(CCP)-104/LN (1977)

1977DE1N Dearborn, CNO Isotopes in Astrophys.; Ed., J. Audouze (1977) 39

1977DM1A Dmitrieva, Lebedev and Matusevich, Izv. Akad. Nauk SSSR Ser. Fiz. 41 (1977) 143

1977DO06 G.E. Dogotar, R.A. Eramzhyan, H.R. Kissener and R.A. Sakaev, Nucl. Phys. A282 (1977) 474

1977DR1F Drenckhahn et al., in Tokyo (1977) 540

1977EC04 J.S. Eck, T.J. Gray and R.K. Gardner, Phys. Rev. C16 (1977) 1873

1977EN01 J.B.A. England, E. Casal, A. Garcia, T. Picazo, J. Aguilar and H.M. Sen Gupta, Nucl. Phys. A284 (1977) 29

1977FO1E Fortune, Proc. Int. Conf. Nucl. Struct., Tokyo (1977); J. Phys. Soc. Jpn. Suppl. 44 (1978) 99

1977FR12 V. Franco and A. Tekou, Phys. Rev. C16 (1977) 658

1977FR1M Frey et al., in Tokyo (1977) 172

1977GA22 A. Gabric and K. Amos, Aust. J. Phys. 30 (1977) 287

1977GE08 C.K. Gelbke, D.K. Scott, M. Bini, D.L. Hendrie, J.L. Laville, J. Mahoney, M.C. Mermaz and C. Olmer, Phys. Lett. B70 (1977) 415

1977GI14 Y.R. Gismatullin, I.A. Lantsev and V.I. Ostroumov, Yad. Fiz. 26 (1977) 243; Sov. J. Nucl. Phys. 26 (1977) 126

1977GO07 J. Gosset, H.H. Gutbrod, W.G. Meyer, A.M. Poskanzer, A. Sandoval, R. Stock and G.D. Westfall, Phys. Rev. C16 (1977) 629

1977GO13 B. Goulard, B. Lorazo, H. Primakoff and J.D. Vergados, Phys. Rev. C16 (1977) 1999

1977GO1H G.J. Gounaris and J.D. Vergados, Phys. Lett. B71 (1977) 35

1977GR04 J.Y. Grossiord, M. Bedjidian, A. Guichard, M. Gusakow, J.R. Pizzi, T. Delbar, G. Gregoire and J. Lega, Phys. Rev. C15 (1977) 843

1977HA1L Hagen, Fisher and Ormes, Astrophys. J. 212 (1977) 262

1977HA1P Haeberli, Proc. Int. Conf. Nucl. Struct., Tokyo (1977); J. Phys. Soc. Jpn. Suppl. 44 (1978) 435

1977HE04 B. Heusch, F. Haas, R.M. Freeman and A. Gallmann, Phys. Rev. C15 (1977) 1196

1977HI01 M.D. High and B. Cujec, Nucl. Phys. A278 (1977) 149

1977HO1B Hoistad, High Energy Phys. Nucl. Struct., Zurich, 1977 (1977) 215

1977IK1B Ikuta, Yoshihara and Shickawa, Radiochem. Radioanal. Lett. (Switzerland) 28 (1977) 435

1977IZ01 T. Izumoto, Nucl. Phys. A275 (1977) 342

1977IZ1B Izumoto, INS Rept. 300 (1977)

1977JO02 B. Johnsson, M. Nilsson and K. Lindgren, Nucl. Phys. A278 (1977) 365

1977JO1D Joss, Nature 270 (1977) 310

1977JU1C Juric, Proc., Zurich-Sin (1977) 296

1977KA26 D. Kalinsky, D. Melnik, U. Smilansky, N. Trautner, S. Weisrose and O. Dietzsch, Nucl. Phys. A293 (1977) 509

1977KI1M Kidd et al., Bull. Amer. Phys. Soc. 22 (1977) 567

1977KN1E Knopfle et al., Bull. Amer. Phys. Soc. 22 (1977) 541

1977KO1N Kostin, Kopanets and Koval, Izv. Akad. Nauk SSSR Ser. Fiz. 41 (1977) 153

1977KO25 D.S. Koltun and F. Myhrer, Z. Phys. A283 (1977) 397

1977KO27 W. Kohler, G. Gruber, A. Steinhauser and K. Bethge, Nucl. Phys. A290 (1977) 233

1977KU06 H. Kumpf, J. Mosner, W. Neubert and G. Schmidt, Yad. Fiz. 25 (1977) 481; Sov. J. Nucl. Phys. 25 (1977) 259

1977KU1D R. Kullberg, K. Kristiansson, B. Lindkvist and I. Otterlund, Nucl. Phys. A280 (1977) 491

1977KU1J Kuiper, Kuiper, Zuckerman and Kakan, Astrophys. J. 214 (1977) 394

1977LA1G Lambert and Ries, Astrophys. J. 217 (1977) 508

1977LE1J Leach, Thomas and Vartsky, Int. J. Appl. Rad. Isotopes 28 (1977) 263

1977LO1J Lombaard and Meyer, Nucl. Instrum. Meth. 145 (1977) 347

1977MA11 V. Maruhn-Rezwani, K.T.R. Davies and S.E. Koonin, Phys. Lett. B67 (1977) 134

1977MA1F Madey et al., Int. J. Radiat. Oncology Biol. Phys. (GB) 3 (1977) 325

1977MA1M Mausner et al., Bull. Amer. Phys. Soc. 22 (1977) 547

1977MA1T Maltia, Astron. Astrophys. 60 (1977) 195

1977MA2E Mayer-Boricke, Nukleonika 22 (1977) 1131

1977MA35 V.B. Mandelzweig, Nucl. Phys. A292 (1977) 333

1977ME1D Meeks et al., MSUCL-228 (1977)

1977MO1A T. Motobayashi, Rept. Inst. Phys. Chem. Res. 53 (1977) 81

1977MU1A Mukhopadhyay, Phys. Rept. C30 (1977) 1

1977MU1B Muller, Science 196 (1977) 489

1977NA03 J.B. Natowitz, M.N. Namboodiri, R. Eggers, P. Gonthier, K. Geoffroy, R. Hanus, C. Towsley and K. Das, Nucl. Phys. A277 (1977) 477; Erratum Nucl. Phys. A285 (1977) 532

1977NI03 M. Niecke, M. Niemeier, R. Weigel and H. Wirzba-Lorenz, Nucl. Phys. A289 (1971) 408

1977PE07 G. Perrin, Nguyen Van Sen, J. Arvieux, R. Darves-Blanc, J.L. Durand, A. Fiore, J.C. Gondrand, F. Merchez and C. Perrin, Nucl. Phys. A282 (1977) 221

1977PR05 P.B. Price, J. Stevenson and K. Frankel, Phys. Rev. Lett. 39 (1977) 177

1977PR1E Prialnick, Shara and Shavin, CNO Isotopes in Atsrophys.; Ed., J. Audouze (1977) 63

1977RI08 W.A. Richter and P.R. de Kock, Z. Phys. A282 (1977) 207

1977RI1H Richter, Contrib. Paper, 4th Seminar on Electromagnetic Interactions of Nuclei at Low and Medium Energies, Moscow, 1977; IKDA 78/3 (1977)

1977RY1A Ryman, Powell and Ryle, Int. J. Appl. Rad. Isotopes 28 (1977) 436

1977RY1B Ryder, Phys. Rept. 34 (1977) 55

1977SA1B Sadkovskii, Feofilov, Denisov and Kolalis, Yad. Fiz. 26 (1977) 1200

1977SC1G Schroder and Huizenga, Ann. Rev. Nucl. Sci. 27 (1977) 465

1977SE09 F. Seiler, Nucl. Phys. A286 (1977) 1

1977SE1C F. Seiler and H.W. Roser, Phys. Lett. B69 (1977) 411

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

1977SI1D Silberberg and Tsao, Astrophys. J. Suppl. 35 (1977) 129

1977ST09 C.E. Stronach, W.J. Kossler, H.O. Funsten, W.F. Lankford and B.J. Lieb, Phys. Rev. C15 (1977) 984

1977ST1G Steiner, High Energy Phys. Nucl. Struct., Zurich (1977) 261

1977ST1H Starrfield, Trjran and Sparks, CNO Isotopes in Astrophys.; Ed., J. Audouze (1977) 49

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

1977SW02 Z.E. Switkowski, R.G. Stokstad and R.M. Wieland, Nucl. Phys. A279 (1977) 502

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

1977TA1B Taneichi, Ueno and Shoda, in Tokyo (1977) 141

1977TH1G Theisen et al., Bull. Amer. Phys. Soc. 22 (1977) 627

1977TO02 C.W. Towsley, P.K. Bindal, K.-I. Kubo, K.G. Nair and K. Nagatani, Phys. Rev. C15 (1977) 281; Erratum Phys. Rev. C15 (1977) 1607

1977TO11 I.S. Towner, J.C. Hardy and M. Harvey, Nucl. Phys. A284 (1977) 269

1977TO1E Toyama, Proc. Int. Conf. Nucl. Struct., Tokyo (1977); J. Phys. Soc. Jpn. Suppl. 44 (1978) 450

1977TO1G Toneev and Gudima, Proc., Zurich-Sin (1977) 181

1977TR1D Truran, CNO Isotopes in Astrophys.; Ed., J. Audouze (1977) 145

1977VI1A Vilaithong et al., Bull. Amer. Phys. Soc. 22 (1977) 1007

1977VO08 C. Volant, M. Conjeaud, S. Harar and E.F. da Silveira, J. Phys. (Paris) 38 (1977) 1179

1977WA08 A.H. Wapstra and K. Bos, At. Data Nucl. Data Tables 19 (1977) 175; Erratum At. Data Nucl. Data Tables 20 (1977) 1

1977WA1H Walter, High Energy Phys. Nucl. Struct., Zurich, 1977 (1977) 225

1977WA1P Wannier, CNO Isotopes in Astrophys.; Ed., J. Audouze (1977) 71

1977WE08 M.F. Werby, Phys. Rev. C16 (1977) 1882

1977WE1B R.B. Weisenmiller, Thesis, Univ. of California, Berkeley (1976); LBL-5077 (1977)

1977WE1E Welsh, High Energy Phys. Nucl. Struct., Zurich, 1977 (1977) 95

1977WH01 R.E. White and H. Naylor, Nucl. Phys. A276 (1977) 333

1977WI04 D.H. Wilkinson, Phys. Lett. B67 (1977) 13

1977YO02 R.C. York and R.T. Carpenter, Nucl. Phys. A282 (1977) 351

1977YO1D Yoro and Arima, in Tokyo (1977) 170

1977YO1F Young, Golden and Kapetanakos, Rev. Sci. Instrum. 48 (1977) 432

1977YO1G Young, Stephanakis and Mosher, J. Appl. Phys. 48 (1977) 3642

1978AB08 A.Y. Abul-Magd and J. Hufner, Nucl. Phys, A308 (1978) 429

1978AI1A M.J. Aitken, Phys. Rept. C40 (1978) 277

1978AJ02 F. Ajzenberg-Selove, E.R. Flynn and O. Hansen, Phys. Rev. C17 (1978) 1283

1978AJ03 F. Ajzenberg-Selove, Nucl. Phys. A300 (1978) 1

1978AL19 D.E. Alburger, Phys. Rev. C18 (1978) 576

1978AL1T Alexander and Forster, Advances in Nucl. Phys. 10 (1978) 197

1978AN07 I. Angeli and M. Csatlos, Atomki Kozlem. 20 (1978) 1

1978AR01 K.P. Artemov, V.Z. Goldberg, I.P. Petrov, V.P. Rudakov, I.N. Serikov and V.A. Timofeev, Yad. Fiz. 27 (1978) 3; Sov. J. Nucl. Phys. 27 (1978) 1

1978AT01 M. Atarashi, K. Hira and H. Narumi, Prog. Theor. Phys. 60 (1978) 209

1978AV1A Avishai, Z. Phys. A285 (1978) 333

1978AZ1E L.S. Azhgirey, M.A. Ignatenko, V.V. Ivanov, A.S. Kuznetsov, M.G. Mescheryakov, S.V. Razin, G.D. Stoletov, I.K. Vzorov and V.N. Zhmyrov, Nucl. Phys. A305 (1978) 404; Sov. J. Nucl. Phys. 27 (1978) 544

1978BA1M Bading and Maxson, Bull. Amer. Phys. Soc. 23 (1978) 525

1978BA26 B.F. Bayman, A. Dudek-Ellis and P.J. Ellis, Nucl. Phys. A301 (1978) 141

1978BE1G Berezhnoi, Klyucharev and Rutkevich, Ukr. Fiz. Zh. 23 (1978) 1841

1978BE1H Becchetti, AIP Conf. Proc. 47 (1978) 308

1978BE27 Y.A. Berdnikov, Y.R. Gismatullin, A.G. Kalimov and V.I. Ostroumov, Yad. Fiz. 27 (1978) 599; Sov. J. Nucl. Phys. 27 (1978) 320

1978BE2B Benenson and Williams, Bull. Amer. Phys. Soc. 23 (1978) 636

1978BE2C K.G. Bernhardt, H. Bohn, K.A. Eberhard and R. Vandenbosch, Proc. Int. Conf. on Resonances in Heavy Ion Reactions, Hvar, 1977 (1978) 367

1978BE2D Bennett et al., Science 201 (1978) 345

1978BH03 R.K. Bhowmik, E.C. Pollacco, N.E. Sanderson, J.B.A. England and G.C. Morrison, Phys. Lett. B80 (1978) 41

1978BI03 R. Billerey, C. Cerruti, A. Chevarier, N. Chevarier and A. Demeyer, Z. Phys. A284 (1978) 319

1978BO1M Bogard and Gibson, Nature 271 (1978) 150

1978BO25 A.I. Boiko, Y.R. Gismatullin and I.A. Lantsev, Yad. Fiz. 27 (1978) 1439; Sov. J. Nucl. Phys. 27 (1978) 759

1978BU10 M. Buenerd, D. Lebrun, J. Chauvin, Y. Gaillard, J.M. Loiseaux, P. Martin, G. Perrin and P. de Saintignon, Phys. Rev. Lett. 40 (1978) 1482

1978BU1B Buffington, Orth and Mast, Astrophys. J. 226 (1978) 355

1978BU1H Butler, Newman and Talbot, Science 201 (1978) 522

1978CH16 R. Chechik, Z. Fraenkel, Y. Eyal and H. Stocker, Nucl. Phys. A304 (1978) 243

1978CL1F Clayton, Ann. Rev. Nucl. Part. Sci. 28 (1978) 501

1978CO13 J.D. Cossairt, S.B. Talley, D.P. May, R.E. Tribble and R.L. Spross, Phys. Rev. C18 (1978) 23

1978CO20 M. Conjeaud, S. Gary, S. Harar and J.P. Wieleczko, Nucl. Phys. A309 (1978) 515

1978CR1B Crawford et al., Bull. Amer. Phys. Soc. 23 (1978) 27

1978CU06 R.Y. Cusson, J.A. Maruhn and H.W. Meldner, Phys. Rev. C18 (1978) 2589

1978CU1C Cusson and Gomez Del Campo, Bull. Amer. Phys. Soc. 23 (1978) 537

1978CU1E Cusson, Gomez Del Campo and Meldner, AIP Conf. Proc. 47 (1978) 35

1978DA17 S.K. Datta, G.P.A. Berg and P.A. Quin, Nucl. Phys. A312 (1978) 1

1978DA1A Dalitz and Gal, Ann. Phys. 116 (1978) 167

1978DA1E Dayras et al., Bull. Amer. Phys. Soc. 23 (1978) 503

1978DA1H Davids, Bull. Amer. Phys. Soc. 23 (1978) 1023

1978DE15 P. Desgrolard, P.A.M. Guichon and J. Joseph, Nuovo Cim. A43 (1978) 475

1978DE1R Deming, Astrophys. J. 223 (1978) L31

1978DE32 S.V. Dementii, V.I. Ogurtsovm and N.G. Afanasev, Yad. Fiz. 28 (1978) 865; Sov. J. Nucl. Phys. 28 (1978) 443

1978DI1A Di Napoli et al., J. Inorg. Nucl. Chem. 40 (1978) 1973

1978DI1D Dietrich and Simpson, Astrophys. J. 225 (1978) L41

1978DO1G Doucas et al., Nature 276 (1978) 253

1978DU1B Dubna-Warsaw-Leningrad Collaboration, Yad. Fiz. 27 (1978) 1246

1978DW1A Dwek, Astrophys. J. 225 (1978) L149

1978DW1B Dwyer, Astrophys. J. 224 (1978) 691

1978EN1C T. Encrenaz, M. Combes and Y. Zeau, Astron. Astrophys. 70 (1978) 29

1978FE03 D.H. Feng, K.N. Geller and N. Klein, Phys. Rev. C18 (1978) 33

1978FO06 H.T. Fortune, M.E. Cobern, S. Mordechai, G.E. Moore, S. Lafrance and R. Middleton, Phys. Rev. Lett. 40 (1978) 1236

1978FR1N Frahn and Rehm, Phys. Rept. C37 (1978) 1

1978FU13 A.V. Fursaev, V.K. Tartakovskij and A.A. Pasichny, Ukr. Fiz. Zh. 23 (1978) 827

1978GA1C Gal, Soper and Dalitz, Ann. Phys. 113 (1978) 79

1978GE1C Gelbke et al., Phys. Rept. C42 (1978) 311

1978GI05 Y.S. Gismatullin, V.F. Kosmach, A.G. Martirosova and V.I. Ostroumov, Yad. Fiz. 27 (1978) 37; Sov. J. Nucl. Phys. 27 (1978) 19

1978GL1E Gloeckler et al., Bull. Amer. Phys. Soc. 23 (1978) 510

1978GO04 C.D. Goodman, D.L. Hanson, D.C. Hensley and R.G. Stokstad, Phys. Rev. C17 (1978) 493

1978GO1L Golovanova, Ibraev and Neudatchin, Prog. Theor. Phys. 59 (1978) 127

1978GO1Q G.J. Gounaris and J.D. Vergados, Phys. Rev. C17 (1978) 1155

1978GR1F Green and Korteling, Proc., Cluster, Winnipeg (1978) 89

1978GU10 K. Gul, J. Phys. Soc. Jpn. 44 (1978) 353

1978HA10 M. Hamm and K. Nagatani, Phys. Rev. C17 (1978) 586; Erratum Phys.Rev. C17, 2258 (1978)

1978HA1F Haas et al., Proc. Int. Conf. on Res. in Heavy Ion Reactions, Hvar, 1977 (1978) 349

1978HA1Q Han, Chuang and He, Phys. Energ. Fortis Phys. Nucl. (China) 2 (1978) 249

1978HE1C Hendrie, AIP Conf. Proc. 47 (1978) 402

1978HE1D Heitzmann, Atomkernenergie 31 (1978) 262

1978HE1J H.H. Heckman, D.E. Greiner, P.J. Lindstrom and H. Shwe, Phys. Rev. C17 (1978) 1735

1978HE1M Hedges and Moore, Nature 276 (1978) 255

1978HI1D Hichwa and Nickles, Bull. Amer. Phys. Soc. 23 (1978)1032

1978HI1E Hirvonen and Lucke, Nucl. Instrum. Meth. 149 (1978) 295

1978HO08 W.-S. Hou, C.-S. Lin, M. Wen, H.-H. Hsu and J.-C. Chou, Nucl. Sci. Eng. 66 (1978) 188

1978HO13 D. Horn and A.J. Ferguson, Phys. Rev. Lett. 41 (1978) 1529

1978HO1C Hodgson, Riv. Nuovo Cim. 1 (1978) 1

1978IB1A Iben and Truran, Astrophys. J. 220 (1978) 980

1978IZ02 T. Izumoto, Nucl. Phys. A301 (1978) 448

1978JA10 R. Jahn, D.P. Stahel, G.J. Wozniak, R.J. de Meijer and J. Cerny, Phys. Rev. C18 (1978) 9

1978JA16 J. Jaros, A. Wagner, L. Anderson, O. Chamberlain, R.Z. Fuzesy, J. Gallup, W. Gorn, L. Schroeder, S. Shannon, G. Shapiro et al., Phys. Rev. C18 (1978) 2273

1978KA14 T. Kammuri, T. Motobayashi, I. Kohno, S. Nakajima, M. Yoshie, K. Katori, T. Mikumo and H. Kamitsubo, J. Phys. (London) G4 (1978) L93

1978KA1R Kaler, Iben and Becker, Astrophys. J. 224 (1978) L63

1978KA23 T. Kammuri, Z. Phys. A287 (1978) 85

1978KE01 J. Keinonen, A. Anttila and R. Hentela, Phys. Rev. C17 (1978) 414

1978KE03 J. Keinonen, A. Anttila and M. Bister, Nucl. Phys. A294 (1978) 1

1978KI08 H.R. Kissener, G.E. Dogotar, R.A. Eramzhyan and R.A. Sakaev, Nucl. Phys. A302 (1978) 523

1978KI13 H.R. Kissener, G.E. Dogotar, R.A. Eramzhyan and R.A. Sakaev, Nucl. Phys. A312 (1978) 394

1978KO01 D.G. Kovar, W. Henning, B. Zeidman, Y. Eisen, J.R. Erskine, H.T. Fortune, T.R. Ophel, P. Sperr and S.E. Vigdor, Phys. Rev. C17 (1978) 83

1978KO1J Kolata, Malman, Grant and Rising, Bull. Amer. Phys. Soc. 23 (1978) 502

1978KW1A Y.R. Kwon and F. Tabakin, Phys. Rev. C18 (1978) 932

1978LA1H Lane, White, Knox and Auchampaugh, Bull. Amer. Phys. Soc. 23 (1978) 501

1978LA1K Lattimer, Schramm amd Grossman, Astrophys. J. 219 (1978) 230

1978LE15 R.D. Levine, S.G. Steadman, J.S. Karp and Y. Alhassid, Phys. Rev. Lett. 41 (1978) 1537

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

1978LU1C Luck, Astrophys. J. 219 (1978) 148

1978MA13 M. Makowska-Rzeszutko, P. Egelhof, D. Kassen, E. Steffens, W. Weiss, D. Fick, W. Dreves, K.-I. Kubo and T. Suzuki, Phys. Lett. B74 (1978) 187

1978MA1P Markham, Austin and Stya, MSUCL-276 (1978)

1978MA34 B.S. Mazitov, G.A. Radyuk, E.N. Rasulov and R. Yarmukhamedov, Yad. Fiz. 28 (1978) 67; Sov. J. Nucl. Phys. 28 (1978) 33

1978ME1D Meyer, Nature 272 (1978) 675

1978ME20 J. Meyer, R.S. Nahabetian and E. Elbaz, J. Phys. Lett. 39 (1978) L-158

1978MO07 S. Mordechai, H.T. Fortune, G.E. Moore, M.E. Cobern, R.V. Kollarits and R. Middleton, J. Phys. (London) G4 (1978) 407

1978MO08 S. Mordechai, H.T. Fortune, G.E. Moore, M.E. Cobern, R.V. Kollarits and R. Middleton, Nucl. Phys. A301 (1978) 463

1978MO1N Moorhouse et al., Hyperfine Interactions 4 (1978) 179

1978MO27 T.J. Moorhouse, J. Asher, D.W. Bennett, H.A. Doubt, M.A. Grace, P.D. Johnston, W.L. Randolph and P.M. Rowe, J. Phys. (London) G4 (1978) 1593

1978MU1E Muller, Stephenson and Mast, Science 201 (1978) 347

1978NA07 R. Nayak and L. Satpathy, Nucl. Phys. A304 (1978) 64

1978NE1A Needham et al., Bull. Amer. Phys. Soc. 23 (1978) 943

1978NE1B Needham et al., Bull. Amer. Phys. Soc. 23 (1978) 14

1978NO1F Norveck, Strathman, Fox and Wu, Bull. Amer. Phys. Soc. 23 (1978) 932

1978OR1A Orth, Buffington, Smoot and Mast, Astrophys. J. 226 (1978) 1147

1978OS06 V.M. Osadchiev, Yad. Fiz. 27 (1978) 958; Sov. J. Nucl. Phys. 27 (1978) 507

1978OX1A Oxby et al., Int. J. Appl. Rad. Isotopes 29 (1978) 205

1978PE13 J.C. Peng, B.T. Kim, M.C. Mermaz, A. Greiner and N. Lisbona, Phys. Rev. C18 (1978) 2179

1978PI10 W.T. Pinkston, M. Vallieres and D.H. Feng, Phys. Rev. C18 (1978) 1011

1978PI15 S.T. Picraux, Nucl. Instrum. Meth. 149 (1978) 289

1978PI1B W.T. Pinkston, Nucl. Phys. A295 (1978) 345

1978PO02 H. Poth, G. Backenstoss, I. Bergstrom, P. Blum, J. Egger, W. Fetscher, R. Guigas, R. Hagelberg, N. Hassler, C.J. Herrlander et al., Nucl. Phys. A294 (1978) 435

1978PO1A B. Povh, Ann. Rev. Nucl. Part. Sci. 28 (1978) 1

1978PO1B Podosek, Ann. Rev. Astron. Astrophys. 16 (1978) 293

1978RI05 S. Riedhauser, Phys. Rev. C18 (1978) 1547

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

1978SE08 J.C. Sens, S.M. Refaei and A. Pape, Phys. Rev. C18 (1978) 2007

1978SH12 K. Shimizu and A. Faessler, Z. Phys. A287 (1978) 299

1978SH16 K. Shimizu and A. Faessler, Nucl. Phys. A306 (1978) 311

1978SM02 Y.F. Smirnov and G.F. Filippov, Yad. Fiz. 27 (1978) 73; Sov. J. Nucl. Phys. 27 (1978) 39

1978SN1A Sneden, Lambert, Tomkin and Peterson, Astrophys. J. 222 (1978) 585

1978SO01 J.P. Sokol and C.P. Browne, Phys. Rev. C17 (1978) 388

1978SO1A Sokol, Izv. Akad. Nauk SSSR Ser. Fiz. 42 (1978) 1829

1978ST1C Starrfield, Truran and Sparks, Astrophys. J. 226 (1978) 186

1978SZ03 L. Szybisz, Z. Phys. A285 (1978) 223

1978TA09 T. Takemasa and H. Yoshida, Nucl. Phys. A304 (1978) 229

1978TA1B Taras, AIP Conf. Proc. 47 (1978) 234

1978TA1U R.E. Taam and R.E. Picklum, Astrophys. J. 224 (1978) 210

1978TO02 I.S. Towner and J.C. Hardy, Phys. Lett. B73 (1978) 20

1978TO1C Tomkin and Lambert, Astrophys. J. 223 (1978) 937

1978TR1C Truran, Cowan and Cameron, Astrophys. J. 222 (1978) L63

1978TS04 I. Tserruya, Y. Eisen, D. Pelte, A. Gavron, H. Oeschler, D. Berndt and H.L. Harney, Phys. Rev. C18 (1978) 1688

1978TU06 P.P. Tung, K.A. Erb, M.W. Sachs, G.B. Sherwood, R.J. Ascuitto and D.A. Bromley, Phys. Rev. C18 (1978) 1663

1978VA14 J. van Klinken, F.W.J. Koks and H. Behrens, Phys. Lett. B79 (1978) 199

1978VA1A L.C. Vaz and J.M. Alexander, Phys. Rev. C18 (1978) 2152

1978VA1H Vartsky, Ellis and Cohn, Symp. on Neutron Capture Gamma-Ray Spectroscopy ,1978; BNL (1978) Paper 82

1978VO12 B.B. Voitsekhovskii, V.G. Zelevinskii, S.G. Popov and D.M. Nikolenko, Izv. Akad. Nauk SSSR Ser. Fiz. 42 (1978) 2413; Bull. Acad. Sci. USSR Phys. Ser. 42 (1978) 170

1978WE13 H.R. Weller, J. Szucs, P.G. Ikossi, J.A. Kuehner, D.T. Petty and R.G. Seyler, Phys. Rev. C18 (1978) 1120

1978WE1H C. Werntz, Phys. Rev. Lett. 41 (1978) 1030

1978WE1J Weinberg, Proc. 19th Int. Conf. High Energy Phys., Tokyo (1978) 907

1978WI04 D.H. Wilkinson, A. Gallmann and D.E. Alburger, Phys. Rev. C18 (1978) 401

1978WU1C Wu, Overley, Barnes and Switkowski, LAP-164 (1978)

1978ZA1D Zalm, Van Hienen and Glaudemans, Z. Phys. A287 (1978) 255

1978ZE03 N.S. Zelenskaya, V.M. Lebedev and T.A. Yushchenko, Yad. Fiz. 28 (1978) 90; Sov. J. Nucl. Phys. 28 (1978) 44

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

1979AL1M Alder et al., 1978 RPI Symp. Photopion Nucl. Phys. (1979) 101

1979AL22 Y. Alhassid, R.D. Levine, J.S. Karp and S.G. Steadman, Phys. Rev. C20 (1979) 1789

1979AMZY J.F. Amann, P.D. Barnes, B. Bassalleck, N.J. Colella, K.G.R. Doss, S.A. Dytman, R.A. Eisenstein, R. Grace, D.R. Marlow, R.J. Rieder, et al., Bull. Amer. Phys. Soc. 24 (1979) 819, AD6

1979AN1L Anderson, Failey, Zoller and Gordon, Proc. 3rd Symp. on Neutron Capture Gamma Rays, 1978 (1979) 546

1979AO01 Y. Aoki, J. Sanada, K. Yagi, S. Kunori, Y. Higashi, S. Kato, J. Kawa, K. Okada and T. Izumoto, Nucl. Phys. A322 (1979) 117

1979AO02 Y. Aoki, K. Nagano, S. Kunori and K. Yagi, J. Phys. Soc. Jpn. 47 (1979) 329

1979AU07 G.F. Auchampaugh, S. Plattard and N.W. Hill, Nucl. Sci. Eng. 69 (1979) 30

1979BA16 B. Bassalleck, H.-D. Engelhardt, W.D. Klotz, F. Takeutchi, H. Ullrich and M. Furic, Nucl. Phys. A319 (1979) 397

1979BA2J Bassalleck et al., AIP Conf. Proc. 54 (1979) 174

1979BE2J C.L. Bennett, American Scientist 67 (1979) 450

1979BO22 V.I. Bogatin, O.V. Lozhkin and Y.P. Yakovlev, Nucl. Phys. A326 (1979) 508

1979BU12 B. Buck, A.C. Merchant and N. Rowley, Nucl. Phys. A327 (1979) 29

1979BY1B Byrd, Bull. Amer. Phys. Soc. 24 (1979) 814

1979BYZZ R.C. Byrd, C.F. Floyd, P.P. Guss, R.K. Murphy and R.L. Walter, Bull. Amer. Phys. Soc. 24 (1979) 828, BD4

1979CA1A Cameron et al., Conf. Proc. TRIUMF, Vancouver (1979) Paper 4A15

1979CH22 M.L. Chatterjee, H.C. Cheung and B. Cujec, Nucl. Phys. A323 (1979) 461

1979CL06 M.R. Clover, T.M. Cormier, B.R. Fulton and B.J. Herman, Phys. Lett. 43 (1979) 256

1979CLZS T.B. Clegg, S.A. Wender, W.R. Wylie, C. Floyd, P. Guss, R.C. Byrd, R.K. Murphy and R.L. Walter Bull. Amer. Phys. Soc. 24 (1979) 846, FD3

1979DE01 P. Desgrolard and P.A.M. Guichon, Phys. Rev. C19 (1979) 120

1979DE15 P. Desgrolard and P.A.M. Guichon, Z. Phys. A290 (179) 373

1979DE1P de Vries, BNL-51115 (1979) 513

1979DE1V Dergachev and Ostryakov, Izv. Akad. Nauk SSSR Ser. Fiz. 43 (1979) 2620

1979DO14 Doering, Tadceucci, Galonsky and Patterson, Phys. Rev. C20 (1979) 1627

1979DO17 G.E. Dogotar, R.A. Eramzhyan, M. Gmitro, H.R. Kissener and E. Tinkova, J. Phys. (London) G5 (1979) L221

1979DO1E Donnelly and Peccei, Phys. Rept. 50 (1979) 1

1979DO1P Donnelly, Dubach and Haxton, Conf. Proc. TRIUMF, Vancouver (1979) Paper 4D15

1979DY01 P. Dyer, T.C. Awes, C.K. Gelbke, B.B. Back, A. Mignerey, K.L. Wolf, H. Breuer, V.E. Viola, Jr. and W.G. Meyer, Phys. Rev. Lett. 42 (1979) 560

1979EN01 N. Ensslin, L.W. Fagg, R.A. Lindgren, W.L. Bendel and E.C. Jones, Jr., Phys. Rev. C19 (1979) 569

1979EN1D Engelmann and Loeuillet, IEEE Trans. on Nucl. Sci. 26 (1979) 1539

1979FE02 J.M. Feagin, E. Merzbacher and W.J. Thompson, Phys. Lett. B81 (1979) 107

1979FE1E Feagin, Merzbacher and Thompson, IEEE Trans, on Nucl. Sci. 26 (1979) 1223

1979FU04 C.B. Fulmer, R.M. Wieland, D.C. Hensley, S. Raman, G.R. Satchler, A.H. Snell, P.H. Stelson and R.G. Stokstad, Phys. Rev. C20 (1979) 670

1979GA04 J.A. Gaidos, L.J. Gutay, A.S. Hirsch, R. Mitchell, T.V. Ragland, R.P. Scharenberg, F. Turkot, R.B. Willmann and C.L. Wilson, Phys. Rev. Lett. 42 (1979) 82

1979GA1D Gal, AIP Conf. Proc. 54 (1979) 680

1979GE1A Gelbke, BNL-51115 (1979) 1

1979GO09 J. Gomez del Campo, R.A. Dayras, J.A. Biggerstaff, D. Shapira, A.H. Snell, P.H. Stelson and R.G. Stokstad, Phys. Rev. Lett. 43 (1979) 26

1979GO11 J. Gomez del Campo, R.G. Stokstad, J.A. Biggerstaff, R.A. Dayras, A.H. Snell and P.H. Stelson, Phys. Rev. C19 (1979) 2170

1979GO1L Gove et al., IEEE Trans. on Nucl. Sci. 26 (1979) 1414

1979GO1M Goncalves et al., Conf. Proc. TRIUMF, Vancouver (1979) Paper 5B3

1979GO1R Gomez del Campo, Bull. Amer. Phys. Soc. 24 (1979) 814

1979GR1E Greenwood, Proc. 3rd Symp. on Neutron Capture Gamma Rays, 1978 (1979) 441

1979GR1J Greeenwood and Chrien, Proc. 3rd Symp. on Neutron Capture Gamma Rays, 1978 (1979) 618

1979GU1D Guzik, Bull. Amer. Phys. Soc. 24 (1979) 692

1979HA1Q Haustein, BNL-51115 (1979) 561

1979HAYZ L.H. Harwood and G.M. Crawley, Bull. Amer. Phys. Soc. 24 (1979) 817, AC2

1979HE02 P.-H. Heenen and D. Baye, Phys. Lett. B81 (1979) 295

1979HE1D Hering et al., BNL-51115 (1979) 759

1979HE1F K.T. Hecht and W. Zahn, Nucl. Phys. A313 (1979) 77

1979HO1F Hoistad et al., Conf. Proc. TRIUMF, Vancouver (1979) Paper 4B5

1979HO1H Hosono et al., Ysukuba Symp. on Polariz. Phenom., Nov. 1979; Ed., K. Yagi (1979) 117

1979HOZW P. Hoffmann-Pinther and R.O. Lane, Bull. Amer. Phys. Soc. 24 (1979) 590, BK3

1979HU1B M.S. Hussein, Phys. Rev. C19 (1979) 807

1979JO1C Jones, AIP Conf. Proc. 54 (1979) 116

1979KA13 B. Kampfer and I. Rotter, J. Phys. (London) G5 (1979) 747

1979KA1T Kaler, Astrophys. J. 228 (1979) 163

1979KA27 S. Kahana, B.T. Kim and M. Mermaz, Phys. Rev. C20 (1979) 2124

1979KI10 M. Kirchbach and H.-U. Jager, Yad. Fiz. 29 (1979) 1191; Sov. J. Nucl. Phys. 29 (1979) 614

1979KI11 H.R. Kissener and R.A. Eramzhyan, Nucl. Phys. A326 (1979) 289

1979KI1G Kim and Primakoff, Mesons in Nucl.; Eds., Rho and Wilkenson (1979) 69

1979KI1K Kissener and Eramzhyan, Conf. Proc. TRIUMF, Vancouver (1979) Paper 5A3

1979KL07 U. Klein, G. Buche, W. Kluge, H. Matthay, G. Mechtersheimer and A. Moline, Nucl. Phys. A329 (1979) 339

1979KN1F Knopfle, Proc. Mainz, 1979, Springer Lect. Notes 108 (1979) 311

1979KO1M Kosice and Leningrad Collaboration, Yad. Fiz. 29 (1979) 117

1979KO1V Kozlowski, Conf. Proc. TRIUMF, Vancouver (1979) Paper 5B6

1979KO20 D.G. Kovar, D.F. Geesaman, T.H. Braid, Y. Eisen, W. Henning, T.R. Ophel, M. Paul, K.E. Rehm, S.J. Sanders, P. Sperr et al., Phys. Rev. C20 (1979) 1305

1979KO26 L. Koester, K. Knopf and W. Waschkowski, Z. Phys. A292 (1979) 95

1979KOZM R.L. Kozub, J. Lin, J.F. Mateja, C.J. Lister and E.K. Warburton, Bull. Amer. Phys. Soc. 24 (1979) 817, AC1

1979KOZZ S.K. Korotky, K.A. Erb, R.L. Phillips, S.J. Willett and D.A. Bromley, Bull. Amer. Phys. Soc. 24 (1979) 13, AF4

1979LA1H Lazareff, Audouze, Starrfield and Truran, Astrophys. J. 228 (1979) 875

1979LI1C Litherland, Bull. Amer. Phys. Soc. 24 (1979) 599

1979LI1H Liu, Jinag and Li, Phys. Energ. Fortis Phys. Nucl. (China) 3 (1979) 247

1979MA1T Makowska-Rzeszutko, Nukleonika 24 (1979) 495

1979MA20 T.A.J. Maris, M.R. Teodoro and C.A.Z. Vasconcellos, Nucl. Phys. A322 (1979) 461

1979MA2H Madey et al., Conf. Proc. TRIUMF, Vancouver (1979) Paper 1E22

1979MA2K V. Managoli and A.C. Phillips, Nucl. Phys. A323 (1979) 285

1979MA38 R.E. Marrs, R.E. Pollock and W.W. Jacobs, Phys. Rev. C20 (1979) 2308

1979MA39 R.E. Marrs and R.E. Pollock, Phys. Rev. C20 (1979) 2446

1979ME1E Mezzdrani, Pompei, Puddu and Quarati, Int. Conf. Nucl. Phys. with Electromag. Interact., Mainz (1979) 1.27

1979MEZX A. Menchaca-Rocha, M.E. Ortiz, A. Dacal, M. Buenerd, D.L. Hendrie, J. Mahoney, C. Olmer and D.K. Scott, Bull. Amer. Phys. Soc. 24 (1979) 572, AL11

1979MO14 T. Motobayashi, I. Kohno, T. Ooi and S. Nakajima, Nucl. Phys. A331 (1979) 193

1979MO1E Moss et al., Conf. Proc. TRIUMF, Vancouver (1979) Paper 4A11

1979MO1J U. Mosel, Phys. Rev. C19 (1979) 2167

1979MU1E R.A. Muller, Phys. Today 32 (1979) 23

1979NA03 K. Nagatani and J.C. Peng, Phys. Rev. C19 (1979) 747

1979NA1G Nagatani, BNL-51115 (1979) 833

1979NO1F Norris and Cottrell, Astrophys. J. 229 (1979) L65

1979NOZZ J.A. Nolen, Jr., P.H. Barker and M.S. Curtin, Bull. Amer. Phys. Soc. 24 (1979) 63, JF14

1979OL1B Olsen and Richer, Astrophys. J. 227 (1979) 534

1979OR01 M.E. Ortiz, A. Dacal, A. Menchaca-Rocha, M. Buenerd, D.L. Hendrie, J. Mahoney, C. Olmer and D.K. Scott, Phys. Lett. B84 (1979) 63

1979PE1C Perroud, 1978 RPI Symp. Photopion Nucl. Phys. (1979) 69

1979PE1E Penzias, Rev. Mod. Phys. 51 (1979) 425

1979PI01 A.A. Pilt, M.A.M. Shahabuddin and J.A. Kuehner, Phys. Rev. C19 (1979) 20

1979PR07 G. Proudfoot and W.D.M. Rae, Nucl. Phys. A329 (1979) 271

1979PR1D H. Primakoff, Nucl. Phys. A317 (1979) 279

1979RA18 N.K. Rao, S.C. Gupta, T.Y. Singh and Y. Prakash, J. Phys. Soc. Jpn. 46 (1979) 1683

1979RA1C Ramaty, Kozlovsky and Lingenfelter, Astrophys. J. Suppl. 40 (1979) 487

1979SA1M Sackman, CAP-551 (1979)

1979SA26 F. Saint-Laurent, M. Conjeaud, S. Harar, J.M. Loiseaux, J. Menet and J.B. Viano, Nucl. Phys. A327 (1979) 517

1979SA27 G.R. Satchler, Nucl. Phys. A329 (1979) 233

1979SC08 T.C. Schweizer, R.R. Doering, S.T. Thornton, L.C. Dennis, K.R. Cordell and R.L. Parks, Phys. Rev. C19 (1979) 1408

1979SE04 F. Seiler and H.W. Roser, Nucl. Phys. A315 (1979) 45

1979SI07 M. Sieminski, M. Sosnowski and P. Zupranski, Can. J. Phys. 57 (1979) 292

1979SO01 L.M. Solin, Y.A. Nemilov, V.N. Kuzmin and K.I. Zherebtsova, Yad. Fiz. 29 (1979) 289; Sov. J. Nucl. Phys. 29 (1979) 143

1979SO1B Sowerby, Nucl. Instrum. Meth. 166 (1979) 571

1979SOZY F. Soga, R.D. Bent, P.H. Pile, R.E. Pollak, M.C. Green and T.P. Sjoreen, Bull. Amer. Phys. Soc. 24 (1979) 614, DN7

1979SP1C Sparrow, Bull. Amer. Phys. Soc. 24 (1979) 618

1979ST1D Stanley, Glover and Petrovich, Bull. Amer. Phys. Soc. 24 (1979) 816

1979ST1P Stephenson, Mast and Muller, Nucl. Instrum. Meth. 158 (1979) 571

1979SW1B Sweigart and Mengel, Astrophys. J. 229 (1979) 624

1979SZ07 L. Szybisz, Z. Phys. A292 (1979) 49

1979TA1N Tans, de Jong and Mook, Nature 280 (1979) 826

1979TAZW T.N. Taddeucci, R.R. Doering, L.C. Dennis, A. Galonsky and S.M. Austin, Bull. Amer. Phys. Soc. 24 (1979) 594, BM8

1979TR1G Trautvetter, Elix, Rolfs and Brnad, Nucl. Instrum. Meth. 161 (1979) 173

1979UL1A Ullrich, AIP Conf. Proc. 54 (1979) 154

1979VA1D Vartsky, Ellis and Cohn, Proc. 3rd Symp. on Neutron Capture Gamma Rays, 1978 (1979) 785

1979WE1F Webber, kish and Yushak, Bull. Amer. Phys. Soc. 24 (1979) 692

1979WI1A Winhold, 1978 RPI Symp. Photopion Nucl. Phys. (1979) 19

1979WI1C Winter and Andra, Z. Phys. A291 (1979) 5

1979WI1L Williams et al., Bull. Amer. Phys. Soc. 24 (1979) 1012

1979WIZW S.W. Wissink, J.R. Calarco and S.S. Hanna, Bull. Amer. Phys. Soc. 24 (1979) 646, GK6

1980AJ01 F. Ajzenberg-Selove and C.L. Busch, Nucl. Phys. A336 (1980) 1

1980AN1E Antoni et al., Izv. Akad. Nauk SSSR Ser. Fiz. 44 (1980) 1031

1980BA1M Barker et al., Proc. Int. Conf. in At. Masses and Fund. Constants; Eds., Nolen and Beneson (1980) 233

1980CA1C Canal, Isern and Sanahuja, Astrophys. J. 235 (1980) 504

1980CO05 J.R. Comfort, S.M. Austin, P.T. Debevec, G.L. Moake, R.W. Finlay and W.G. Love, Phys. Rev. C21 (1980) 2147

1980DE10 V. DeCarlo, N. Freed, W. Rhodes, B. Bulow, G.G. Jonsson, K. Lindgren and R. Pettersson, Phys. Rev. C21 (1980) 1460

1980DO1C Domogatsky and Nadyozhin, Astrophys. Space Sci. 70 (1980) 33, 77

1980ER01 R.A. Eramzhyan, M. Gmitro and H.R. Kissener, Nucl. Phys. A338 (1980) 436

1980FA07 E. Fabrici, S. Micheletti, M. Pignanelli, F.G. Resmini, R. De Leo, G. D'Erasmo and A. Pantaleo, Phys. Rev. C21 (11980) 844

1980FI05 A. Figureau and N.C. Mukhopadhyay, Nucl. Phys. A338 (1980) 514

1980FO05 S.H. Fox and S.M. Austin, Phys. Rev. C21 (1980) 1133

1980FR03 R.M. Freeman, F. Haas and G. Korschinek, Phys. Lett. B90 (1980) 229

1980FR1G P.H. Frampton and S.L. Glashow, Phys. Rev. Lett. 44 (1980) 1481

1980GO1B Gove et al., Nucl. Instrum. Meth. Phys. Res. 168 (1980) 425

1980HA1E Hamill and Peterson, Bull. Amer. Phys. Soc. 25 (1980) 593

1980JE1A Jensen et al., Bull. Amer. Phys. Soc. 25 (1980) 603

1980JU02 J.W. Jury, C.K. Ross and N.K. Sherman, Nucl. Phys. A337 (1980) 503

1980KA03 T. Kammuri, H. Shimaoka, P.D. Kunz, S. Kato, K. Okada, M. Kondo, K. Hosono, T. Saito, N. Matsuoka, S. Nagamachi et al., Phys. Lett. B90 (1980) 197

1980KR01 W. Kretschmer, G. Probstle and W. Stach, Nucl. Phys. A333 (1980) 13

1980LE11 S.M. Lee, T. Matsuse and A. Arima, Phys. Rev. Lett. 45 (1980) 165

1980LO02 M. Lozano and G. Madurga, Phys. Lett. B90 (1980) 50

1980LO07 B. Lorazo and B. Goulard, Can. J. Phys. 58 (1980) 388

1980MA10 G. Mairle, K.T. Knopfle, H. Riedesel, G.J. Wagner, V. Bechtold and L. Friedrich, Nucl. Phys. A339 (1980) 61

1980MA1E Manglos et al., Bull. Amer. Phys. Soc. 25 (1980) 603

1980MC1C W.J. McDonald, Nucl. Phys. A335 (1980) 463

1980ME12 G. Mezzorani and A. Pompei, Lett. Nuovo Cim. 27 (1980) 394

1980ME1B Mewaldt, Spalding, Stone and Vogt, Bull. Amer. Phys. Soc. 25 (1980) 546

1980MI01 T. Mikumo, M. Sasagase, M. Sato, T. Ooi, Y. Higashi, Y. Nagashima and M. Yamanouchi, Phys. Rev. C21 (1980) 620

1980MO01 G.L. Moake and P.T. Debevec, Phys. Rev. C21 (1980) 25

1980MO10 G.L. Moake, L.J. Gutay, R.P. Scharenberg, P.T. Debevec and P.A. Quin, Phys. Rev. C21 (1980) 2211

1980MU1B N.C. Mukhopadhyay, Nucl. Phys. A335 (1980) 111

1980NA14 F. Naulin, C. Detraz, M. Bernas, D. Guillemaud, E. Kashy, M. Langevin, F. Pougheon, P. Roussel and M. Roy-Stephan, J. Phys. Lett. 41 (1980) L79

1980NO1A Nolen, Proc. Int. Conf. in At. Masses and Fund. Constants; Eds., Nolen and Beneson (1980) 505

1980OR1C Ortiz et al., Bull. Amer. Phys. Soc. 25 (1980) 483

1980PE1F Penzias, Science 208 (1980) 663

1980RA06 C. Rangacharyulu and C. St-Pierre, Can. J. Phys. 58 (1980) 150

1980RO1D Roberts and Sutton, Health Sci. 38 (1980) 839

1980SI07 M.K. Singham and F. Tabakin, Phys. Rev. C21 (1980) 1039

1980SP1B Spulak, Astrophys. J. 235 (1980) 565

1980ST1C M. Stuiver and P.D. Quay, Science 207 (1980) 11

1980TA1B Tabor, Dennis, Neuschaefer and Theisen, Bull. Amer. Phys. Soc. 25 (1980) 524

1980TO05 M. Toulemonde, K.H. Souw, J.C. Adloff and N. Schulz, Phys. Rev. C22 (1980) 553

1980TU01 J.D. Turner, N.R. Roberson, S.A. Wender, H.R. Weller and D.R. Tilley, Phys. Rev. C21 (1980) 525

1980VA03 R. Vandenbosch, Nucl. Phys. A339 (1980) 167

1980WH1A C.A., Jr. Whitten, Nucl. Phys. A335 (1980) 419

1980WI09 J.P. Wieleczko, S. Harar, M. Conjeaud and F. Saint-Laurent, Phys. Lett. B93 (1980) 35

1980WI1H Wilson, Kavanagh and Mann, LAP-167 (1980)

1980ZE05 N.S. Zelenskaya, V.M. Lebedev and A.G. Serebryakov, Izv. Akad. Nauk SSSR Ser. Fiz. 44 (1980) 189; Bull. Acad. Sci. USSR Phys. Ser. 44 (1980) 158

1981KO08 R.L. Kozub, J. Lin, J.F. Mateja, C.J. Lister, D.J. Millener and E.K. Warburton, Phys. Rev. C23 (1981) 1571

1982AJ01 F. Ajzenberg-Selove, Nucl. Phys. A375 (1982) 1

1983AJ01 F. Ajzenberg-Selove, Nucl. Phys. A392 (1983) 1; Erratum Nucl. Phys. A413 (1984) 168

FI76F Unknown Source