

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 A449* (1986), 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. [Reference](#) key numbers have been changed to the NNDC/TUNL format.

(References closed June 1, 1985)

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 have been scanned in and are available on this website or via the link below.

A. Nuclides: [\$^{14}\text{He}\$](#) , [\$^{14}\text{Li}\$](#) , [\$^{14}\text{Be}\$](#) , [\$^{14}\text{B}\$](#) , [\$^{14}\text{C}\$](#) , [\$^{14}\text{N}\$](#) , [\$^{14}\text{O}\$](#) , [\$^{14}\text{F}\$](#) , [\$^{14}\text{Ne}\$](#) , [\$^{14}\text{Na}\$](#) , [\$^{14}\text{Mg}\$](#)

B. Tables of Recommended Level Energies:

[Table 14.1](#): Energy levels of ^{14}B

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

[Table 14.12](#): Energy levels of ^{14}N

[Table 14.25](#): Energy levels of ^{14}O

C. [References](#)

D. Figures: [\$^{14}\text{B}\$](#) , [\$^{14}\text{C}\$](#) , [\$^{14}\text{N}\$](#) , [\$^{14}\text{O}\$](#) , [Isobar diagram](#)

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

¹⁴He

(Not illustrated)

¹⁴He has not been observed. See also (1983ANZQ; theor.).

¹⁴Li

(Not illustrated)

¹⁴Li has not been observed. The calculated mass excess is 72.29 MeV: see (1981AJ01). ¹⁴Li is then particle unstable with respect to decay into ¹³Li + n and ¹²Li + 2n by 3.88 and 3.22 MeV, respectively.

¹⁴Be

(Figs. 5 and 9)

¹⁴Be has been observed in the 4.8 GeV proton bombardment of uranium [see (1976AJ04)], in the bombardment of ²³²Th by 145 MeV ¹⁵N ions (1982OG02; forward differential cross section is 4×10^{-5} mb/sr) and in the ¹⁴C(π^- , π^+)¹⁴Be reaction (1984GI09; $E_{\pi^-} = 164$ MeV, $\theta = 5^\circ$). It has not been observed in the ⁴⁸Ca(¹⁴C, ¹⁴Be)⁴⁸Ti reaction ($E(^{14}\text{C}) = 87.4$ MeV, $\theta = 4^\circ - 8^\circ$) (1981NA1H). A group in the (π^- , π^+) reaction is observed at $Q = -37.08 \pm 0.13$ MeV [(Value quoted by (1984GI09) + $2m_e c^2$.)] with a cross section of 0.73 ± 0.19 $\mu\text{b/sr}$ (1984GI09). If this is the ground-state group, the atomic mass excess is 40.10 ± 0.13 MeV. ¹⁴Be is then bound by 2.97 and 1.12 MeV, respectively, with respect to decay into ¹³Be + n and ¹²Be + 2n. See also (1984EP1A) and (1981KI04, 1981SE06, 1983ANZQ, 1985WI1B; theor.).

¹⁴B

(Figs. 5 and 9)

GENERAL: (See also (1981AJ01).)

Nuclear models: (1981SE06, 1984VA06).

Complex reactions involving ¹⁴B: (1983WI1A, 1984HI1A).

Pion capture and reactions: (1983TR1J).

Hypernuclei: (1981WA1J, 1982KA1D, 1983FE07).

Other topics: (1984PO11).

Ground state of ¹⁴B: (1983ANZQ).

Mass of ¹⁴B: We adopt the Wapstra atomic mass excess for ¹⁴B: 23664 ± 21 keV. See also (1981NA1H).

Table 14.1: Energy levels of ^{14}B

E_x (MeV \pm keV)	$J^\pi; T$	$\tau_{1/2}$ (msec) or Γ (MeV)	Decay	Reactions
g.s.	$2^-; 2$	$\tau_{1/2} = 16.1 \pm 1.2$	β^-	1, 3, 4
0.74 ± 40	$(1^-); 2$			3
1.38 ± 30	$(3^-); 2$			3
1.86 ± 70	$2^-; 2$	$\Gamma = 1.0 \pm 0.5$		2, 3
2.08 ± 50	$(4^-); 2$			3
(2.32 ± 40)				3
2.97 ± 40				3
a				

^a See reaction 2.

$$1. \ ^{14}\text{B}(\beta^-)^{14}\text{C} \quad Q_m = 20.64$$

^{14}B has a half-life of 16.1 ± 1.2 msec. The β^- decay is primarily to $^{14}\text{C}^*(6.09, 6.73)$: see Table 14.2. The nature of the decay fixes the J^π of ^{14}B to be 2^- .

$$2. \ ^{14}\text{C}(\pi^-, \gamma)^{14}\text{B} \quad Q_m = 118.92$$

A single strong transition is observed in this pion capture cross section to a state in ^{14}B at $E_x = 2.15 \pm 0.17$ MeV, $\Gamma = 1.0 \pm 0.5$ MeV, with $J^\pi = 2^-$. The relative branching ratio of the ground state [2^-] to this second 2^- state is < 0.1 . The data are also suggestive of the population of 2^- and 1^- states in the $E_x = 5 - 7$ MeV region (1983BA36).

$$3. \ ^{14}\text{C}(^7\text{Li}, ^7\text{Be})^{14}\text{B} \quad Q_m = -21.51$$

^{14}B states with $0 < E_x < 3$ MeV have been populated in this reaction at $E(^7\text{Li}) = 52$ MeV: see Table 14.1. Similarities in the relative intensities of $^{14}\text{B}^*(0, 0.74, 1.38, 1.82, 2.08)$ and of $^{12}\text{B}^*(1.67, 2.62, 3.39, 4.30, 4.52)$ [populated in $^{12}\text{C}(^7\text{Li}, ^7\text{Be})^{12}\text{B}$], and the similarity in the ΔE_x of these ^{12}B states with the E_x of the ^{14}B states suggest that they have the same J^π (1973BA34). See also (1982AL1G, 1984GL1G).

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

Decay to $^{14}\text{C}^*$ (MeV)	J^π	Branch (%)	$\log ft$
0	0^+	(5 ± 3) ^c	
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 ^d	> 4.9

^a (1974AL11).

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

^c This branch has not been observed. It is assumed to be $(5 \pm 3)\%$ in the calculation of the branching ratios to $^{14}\text{C}^*(6.09, 6.73)$.

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

4. $^{14}\text{C}(^{14}\text{C}, ^{14}\text{N})^{14}\text{B}$

$$Q_m = -20.49$$

At $E(^{14}\text{C}) = 87.4$ MeV the ground state of ^{14}B is observed: the atomic mass excess is 23.67 ± 0.03 MeV. The differential cross section ($\theta = 4^\circ - 8^\circ$) is $7 \mu\text{b/sr}$. The previously reported excited state at 0.74 MeV is not observed (1981NA1H).

¹⁴C
(Figs. 6 and 9)

GENERAL: (See also (1981AJ01).)

Nuclear models: (1982SA1U, 1983SH38, 1983VA31, 1984AS07, 1984SA37, 1984VA06).

Special states: (1983GO1R, 1983GO1B, 1983VA31, 1984AS07, 1984GO1M, 1984SA37, 1984VA06, 1985WE02).

Electromagnetic transitions and giant resonances: (1980RI06, 1982RI04, 1984AS07, 1984KU07, 1985WE02).

Astrophysical questions: (1981GU1D, 1983RE1B).

Applied work: (1979PE1B, 1979TA1B, 1980EL1B, 1980EL1C, 1980SH1Q, 1981FA1E, 1981LI1K, 1981SC1D, 1982ZA1C, 1983BR1Q, 1983DO1H, 1983DO1K, 1983FA1B, 1983FA1H, 1983GI1E, 1983JU1B, 1983KR1B, 1983KU1C, 1983LI1A, 1983NE1A, 1983RE1B, 1983SC1B, 1983SU1C, 1983TU1C, 1984AN1P, 1984AN1Q, 1984BE1H, 1984BI1E, 1984BO1T, 1984CU1A, 1984DO1B, 1984EL1B, 1984EL1C, 1984FA1G, 1984GI1K, 1984GI1L, 1984GI1M, 1984HE1G, 1984HE1B, 1984KA1R, 1984KL1E, 1984LI1R, 1984MO1T, 1984NA1R, 1984NE1C, 1984NE1E, 1984PO1L, 1984PO1C, 1984RU1C, 1984SP1B, 1984SU1B, 1984SU1J, 1984TA1P, 1984VA1D, 1984VO1J).

Complex reactions involving ¹⁴C: (1981ME13, 1981OL1C, 1981VO06, 1982LY1A, 1983CH23, 1983EN04, 1983FR17, 1983FR1A, 1983MA06, 1983OL1A, 1983SA06, 1983WI1A, 1984AL34, 1984BA1H, 1984GA38, 1984GR08, 1984HI1A, 1984HO23, 1984KU1K, 1985PR01, 1985PR1G, 1985SA02, 1985SH01, 1985SH07).

Muon and neutrino capture and reactions (See also reaction 32): (1981GI08, 1981PH1C, 1982SC11, 1983GM1A, 1984KO1U).

Pion and kaon capture and reactions (See also reactions 15, 25, 33 and 34.): (1980GO1M, 1981HA1L, 1981SE1B, 1981SI09, 1981WH01, 1982DE1K, 1982IN1A, 1982KA16, 1982MU09, 1982RE1M, 1982THZZ, 1983AS01, 1983GM1A, 1983KRZZ, 1983LI1G, 1983MA63, 1983PE14, 1983SE16, 1983TR1J, 1984AS05, 1984CO1V, 1984GR27, 1984MI15, 1984SE14, 1985ALZX, 1985DY1C, 1985GI1J, 1985LE05).

Hypernuclei: (1981WA1J, 1982KA1D, 1982RA1L, 1983CH1T, 1983FE07, 1983MA63, 1984AS1D, 1984CH1G, 1984SH1J, 1985AH1A).

Other topics: (1982NG01, 1983GO1R, 1984PO11, 1985BO1D).

Ground state of ¹⁴C: (1980WH03, 1981AV02, 1982NG01, 1983ANZQ, 1983VA31, 1984FR13, 1984WE04, 1985WE02).

$$\langle r^2 \rangle^{1/2} = 2.4962 (19) \text{ fm (1982SC11)}.$$

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

E_x in ^{14}C (MeV \pm keV)	$J^\pi; T$	τ or $\Gamma_{\text{c.m.}}$	Decay	Reactions
g.s.	$0^+; 1$	$\tau_{1/2} = 5730 \pm 40 \text{ y}$	β^-	1, 3, 4, 5, 7, 8, 9, 10, 11, 12, 13, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43
6.0938 ± 0.2	1^-	$\tau_m < 10 \text{ fsec}$	γ	3, 4, 8, 9, 13, 15, 16, 17, 22, 24, 25, 26, 28, 38, 41
6.5894 ± 0.2	0^+	$4.3 \pm 0.6 \text{ psec}$	γ	3, 4, 9, 13, 16, 26
6.7282 ± 1.3	3^-	$96 \pm 11 \text{ psec}$ $ g = 0.272 \pm 0.007$	γ	3, 4, 8, 9, 10, 11, 12, 15, 16, 17, 19, 22, 24, 25, 26, 28, 30, 38, 41
6.9026 ± 0.2	0^-	$36 \pm 4 \text{ fsec}$	γ	3, 4, 8, 9, 10, 13, 15, 16, 17, 24, 25, 26, 34
7.0120 ± 4.2	2^+	$13 \pm 2 \text{ fsec}$	γ	3, 4, 8, 9, 15, 16, 17, 24, 25, 26, 28, 32, 34, 38, 39
7.3414 ± 3.1	2^-	$160 \pm 60 \text{ fsec}$	γ	3, 4, 8, 9, 15, 16, 17, 19, 24, 26, 28, 38
8.3179 ± 0.8	2^+	$\Gamma = 3.4 \pm 0.6 \text{ keV}$	$\gamma, \text{ n}$	3, 4, 8, 9, 10, 13, 14, 15, 16, 24, 25, 26, 28, 34, 35, 38, 39
9.746 ± 7	0^+			9
9.801 ± 6	3^-	45 ± 12	$\gamma, \text{ n}$	3, 9, 14, 16, 24, 28, 38
10.425 ± 5	2^+		 n	9, 14, 16, 28, 38
10.449 ± 7	≥ 1		 n	3, 8, 9, 14, 38
10.498 ± 4	(3^-)	26 ± 8	 n	3, 8, 9, 14, 16
10.736 ± 5	4^+	20 ± 7		3, 8, 9, 10, 11, 12, 16, 28
11.306 ± 15	1^+	46 ± 12	$\gamma, \text{ n}$	3, 14, 23, 24, 28, 38
11.395 ± 8	1^-	22 ± 7	 n	3, 8, 9, 14, 16

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

E_x in ^{14}C (MeV \pm keV)	$J^\pi; T$	τ or $\Gamma_{\text{c.m.}}$	Decay	Reactions
11.666 \pm 10	4^-	20 ± 7	γ	3, 8, 9, 10, 16, 24, 25, 28, 38
11.730 \pm 9	(5^-)			3, 8, 9
11.9 \pm 300		950 ± 300		16
12.583 \pm 10	3^-	95 ± 15	n	3, 8, 9, 14, 16, 24, 28, 38
12.863 \pm 8		30 ± 10	n	3, 8, 9, 14, 16
12.963 \pm 9	(3^-)	30 ± 10	n	3, 8, 9, 14, 16, 28
13.58	1^-	(≈ 1300)	(n)	14, 28
14.667 \pm 20	$2^+, 3, 4, 5, 6^+$	57 ± 15		3, 8
14.868 \pm 20	$(6^+, 5^-)$			3, 8, 10, 38
15.20 \pm 23	4^-			3, 8, 24, 25
(15.37 \pm 30)				3
15.44 \pm 40				3, 35
(16.02 \pm 50)				3
16.43 \pm 16				3, 8
(16.57 \pm 40)				3
16.715 \pm 30	(1^+)	≈ 200	γ, n	3, 13
17.30 \pm 30	4^-		γ	3, 8, 24, 25
(17.5)	(1^+)	≈ 200	γ, n	13
17.95 \pm 40				3
18.10 \pm 40				3
20.4		wide		35
22.1			γ	24
24.3	$4^-; (T = 2)$	< 300	γ	24, 25
24.5		wide		25

^a See also Tables 14.4 and 14.5, and Table 14.3 in (1981AJ01).

1. $^{14}\text{C}(\beta^-)^{14}\text{N}$

$$Q_m = 0.1565$$

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

$^{14}\text{C}^*$ (MeV)	τ_m	Reaction	Refs.
6.09	< 10 fsec	$^9\text{Be}(^{13}\text{C}, ^8\text{Be})$	(1975SE04)
6.59	3.7 ± 0.9 psec	$^7\text{Li}(^9\text{Be}, \text{np})$	(1981KO08)
	4.6 ± 0.7 psec	$^2\text{H}(^{13}\text{C}, \text{p})$	(1980TO05)
6.73	4.3 ± 0.6 psec		mean
	97 ± 15 psec	$^{12}\text{C}(\text{t}, \text{p})$	(1968AL12)
	96 ± 15 psec	$^7\text{Li}(^9\text{Be}, \text{np})$	(1981KO08)
6.90	96 ± 11 psec		mean
	36 ± 4 fsec	$^9\text{Be}(^{13}\text{C}, ^8\text{Be})$	(1975SE04)
7.01	13 ± 2 fsec	$^{14}\text{C}(\text{e}, \text{e})$	(1972CR1A)
7.34	160 ± 60 fsec	$^{11}\text{B}(\alpha, \text{p})$	(1976GR02)

^a See also Table 14.10 in (1976AJ04).

The adopted value of the half-life is 5730 ± 40 y: see (1976AJ04). See also (1981KH1E). Using Q_m , $\log ft = 9.04$ (1971GO40). For discussions of the lifetime of ^{14}C see (1959AJ76, 1970AJ04, 1976AJ04). See also (1981MA1P, 1983GO2C) and (1981PR1G, 1984HUZY; theor.).

2. (a) $^7\text{Li}(^7\text{Li}, \text{n})^{13}\text{C}$	$Q_m = 18.617$	$E_b = 26.794$
(b) $^7\text{Li}(^7\text{Li}, \text{p})^{13}\text{B}$	$Q_m = 5.963$	
(c) $^7\text{Li}(^7\text{Li}, \text{d})^{12}\text{B}$	$Q_m = 3.309$	
(d) $^7\text{Li}(^7\text{Li}, \text{t})^{11}\text{B}$	$Q_m = 6.196$	
(e) $^7\text{Li}(^7\text{Li}, \alpha)^{10}\text{Be}$	$Q_m = 14.782$	
(f) $^7\text{Li}(^7\text{Li}, ^7\text{Li})^7\text{Li}$		
(g) $^7\text{Li}(^7\text{Li}, ^8\text{Be})^6\text{He}$	$Q_m = 7.280$	

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. There is a report of 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 they are due to a forward-direction cluster transfer process: see (1976AJ04) for references. The elastic scattering has been studied for $E(^7\text{Li}) = 2.0$ to 5.5 MeV by (1983NO08). See also (1983KAZF).

3. $^9\text{Be}(^6\text{Li}, \text{p})^{14}\text{C}$	$Q_m = 15.1244$
--	-----------------

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

E_i (MeV)	J_i^π	E_f (MeV)	Branch (%)
6.09	1^-	0	100
6.59	0^+	0	1.1 ± 0.1 ^b
		6.09	98.9 ± 0.1 ^c
6.73	3^-	0	96.4 ± 1.2
		6.09	3.6 ± 1.2
6.90	0^-	6.09	100 ^d
7.01	2^+	0	98.6 ± 0.7
		6.09	1.4 ± 0.7
7.34	2^-	0	16.7 ± 3.5
		6.09	49.0 ± 3.1 ^{e,f}
		6.73	34.3 ± 3.5 ^e

^a For references see Table 14.5 in (1981AJ01).

^b Internal pairs. $\Gamma_\pi/\Gamma = (1.1 \pm 0.1) \times 10^{-2}$, $\langle M \rangle_\pi = 0.36 \pm 0.06 \text{ fm}^2$.

^c $E_\gamma = 495.35 \pm 0.10 \text{ keV}$ (1981KO08).

^d $E_\gamma = 808.7 \pm 1.0 \text{ keV}$.

^e $\delta(M2/E1) = -0.04 \pm 0.09$ and $+0.07 \pm 0.30$, respectively.

^f $E_\gamma = 1248 \pm 3 \text{ keV}$.

Observed proton groups are displayed in Table 14.6. See also ^{15}N .

4. $^9\text{Be}(^7\text{Li}, d)^{14}\text{C}$ $Q_m = 10.099$

Angular distributions have been measured at $E(^7\text{Li}) = 5.6$ to 6.2 MeV for the deuterons to $^{14}\text{C}^*(0, 6.09, 6.59 + 6.73, 6.90 + 7.01, 7.34, 8.32)$. Gamma rays with $E_\gamma = 6094.5 \pm 3.2$, 6728.1 ± 1.4 and $7011.7 \pm 5.2 \text{ keV}$ have been reported. For τ_m and E_γ measurements see Table 14.4 and 14.5 (1981KO08) [see this reference for an extensive study of electromagnetic transitions in ^{14}C and ^{14}N].

5. $^9\text{Be}(^9\text{Be}, \alpha)^{14}\text{C}$ $Q_m = 17.2506$

See (1981AJ01).

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

E_x (MeV \pm keV)	$\Gamma_{\text{c.m.}}$ (keV)	$2J_f + 1$ ^b	$J\pi$ ^c
6.089 \pm 10		2.5 [3]	
6.588 \pm 10		1.0 [1]	
6.726 \pm 10		7.6 [7]	
6.899 \pm 10		1.1 [1]	
7.016 \pm 10		4.5 [5]	
7.341 \pm 10		5.2 [5]	
8.318 \pm 10	22 \pm 6	5.1	2 ⁺
9.796 \pm 10	45 \pm 12	7.7	3
10.441 \pm 15		10.8	2 ⁺ , 3
10.512 \pm 15	26 \pm 8	9.1	4
10.743 \pm 15	20 \pm 7	15.4	
11.306 \pm 15	46 \pm 12	2.4	1 ⁻
11.397 \pm 15	22 \pm 7	6.2	2 ⁺ , 3
11.667 \pm 15	20 \pm 7	12.4	5 ⁻
11.74 \pm 20			
12.57 \pm 25	80 \pm 20	15.1	
12.867 \pm 20	30 \pm 10	10.4	4, 5
12.970 \pm 20	30 \pm 10	7.8	3, 4
14.667 \pm 20	57 \pm 15		2 ⁺ , 3, 4, 5, 6 ⁺
14.867 \pm 25			
15.19 \pm 30			
(15.37 \pm 30)			
15.44 \pm 40			
(16.02 \pm 50)			
16.411 \pm 20			
(16.57 \pm 40)			
16.715 \pm 30			
(17.28 \pm 40)			
17.95 \pm 40			
18.10 \pm 40			

^a (1973AJ01): $E(^6\text{Li}) = 20$ MeV. See Table 14.6 in (1981AJ01) for additional information on cross sections and reduced widths.

^b 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 brackets, gives $2J_f + 1$ derived from the J_f assignments shown in Table 14.3.

^c Suggested from the $2J_f + 1$ rule and comparison of predicted neutron width with observed $\Gamma_{c.m.}$ assuming $0.01 < \theta_n^2 < 1.0$.

6. (a) $^{11}\text{B}(t, n)^{13}\text{C}$	$Q_m = 12.4215$	$E_b = 20.5980$
(b) $^{11}\text{B}(t, \alpha)^{10}\text{Be}$	$Q_m = 8.5860$	

For possible resonant structure in (a) see (1976AJ04). For reaction (b) see (1981AJ01) and see also (1983CE01).

7. $^{11}\text{B}(\alpha, p)^{14}\text{C}$	$Q_m = 0.7840$
--	----------------

Angular distributions of p_0 have been measured at $E_\alpha = 1.43$ to 25.1 MeV: see (1976AJ04, 1981AJ01) and at 31.2 MeV (1984KO1Q). See also ^{15}N .

8. (a) $^{11}\text{B}(^6\text{Li}, ^3\text{He})^{14}\text{C}$	$Q_m = 4.8024$
(b) $^{11}\text{B}(^7\text{Li}, \alpha)^{14}\text{C}$	$Q_m = 18.130$

Below $E_x = 10.4$ MeV, $^{14}\text{C}^*(6.09, 6.73, 6.90 + 7.01, 7.34, 8.32, 9.78)$ are observed in both reactions at $E(\text{Li}) = 34$ MeV (1984CL08): the states observed at higher excitation energies are displayed in Table 14.7. The intensities of the ^3He and α groups in the two reactions are significantly different. Comparison of the angular distributions in reaction (a) and in the analog reaction $^{11}\text{B}(^6\text{Li}, t)^{14}\text{N}$, as well as other data, leads to the assignment of analog pairs: see reaction 10 in ^{14}N . It is suggested that $^{14}\text{C}^*(11.73)$ and not $^{14}\text{C}^*(11.67)$ is populated in the inelastic pion scattering (1984CL08). For earlier work on reaction (b) see (1976AJ04).

9. $^{12}\text{C}(t, p)^{14}\text{C}$	$Q_m = 4.6410$
---------------------------------------	----------------

Table 14.7: States in ^{14}C from $^{11}\text{B}(^6\text{Li}, ^3\text{He})$ and $^{11}\text{B}(^7\text{Li}, \alpha)$ ^a

E_x (MeV \pm keV) ^b	$d\sigma/d\Omega_{\text{c.m.}}$ ($\mu\text{b/sr}$) ^c		E_x (MeV \pm keV) ^b	$d\sigma/d\Omega_{\text{c.m.}}$ ($\mu\text{b/sr}$) ^c	
	A	B		A	B
10.47 \pm 15 ^d	127	130	14.67 \pm 30	127	489
10.74 \pm 15	365	57	14.87 \pm 30	430	
11.40 \pm 20	38	112	15.21 \pm 30	188	291
11.66 \pm 15	75	90	16.45 \pm 25	633	1285
11.73 \pm 15	120	80	17.32 \pm 40	76	293
12.58 \pm 30	106	123			
12.86 \pm 30	276	275			
12.96 \pm 30					

A: $^{11}\text{B}(^6\text{Li}, ^3\text{He})$.

B: $^{11}\text{B}(^7\text{Li}, \alpha)$.

^a (1984CL08): $E(\text{Li}) = 34$ MeV. See for angular distributions and for discussion of analog states in ^{14}N . See also reaction 10 in ^{14}N .

^b States below $E_x = 10.4$ MeV are not displayed here.

^c At $\theta_{\text{lab}} = 10^\circ$. Uncertainties in the differential cross sections are approximately $\pm 20\%$.

^d Unresolved.

Observed proton groups are displayed in Table 14.8. Angular distributions have been measured at $E_t = 5.5$ to 23 MeV. The (t, p) strength to the positive parity states of ^{14}C are well accounted for by a model of (sd)² two-neutron states coupled to an inert ^{12}C core: see (1981AJ01). The amplitude of sd-shell excitation in $^{14}\text{C}_{\text{g.s.}}$ is 0.35 ± 0.02 (1982FO01). The nuclear gyromagnetic ratio for $^{14}\text{C}^*(6.73)$ 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). For τ_m see Table 14.4. See also ^{15}N .

$$10. \ ^{12}\text{C}(\alpha, 2p)^{14}\text{C} \quad Q_m = -15.1731$$

At $E_\alpha = 65$ MeV angular distributions have been measured to $^{14}\text{C}^*(0, 6.73 \pm 0.02(\text{u}), 8.40 \pm 0.14, 10.69 \pm 0.05, 11.69 \pm 0.06(\text{u}), 14.84 \pm 0.4)$ [groups known to be unresolved are labelled (u)]. The two most strongly populated states (or groups of states) are $^{14}\text{C}^*(6.73, 10.69)$. $J^\pi = 1^-$ and ($6^+, 5^-$) are favored for $^{14}\text{C}^*(11.69, 14.84)$. For the latter 4^+ is considered to be very unlikely (1980VA17). See also (1981AJ01) for the earlier work.

Table 14.8: ^{14}C states from $^{12}\text{C}(t, p)^{14}\text{C}$ ^a

E_x ^b (MeV \pm keV)	E_x ^c (MeV \pm keV)	L ^{b,c}	J^π
-0.006 ± 10	0	0	0^+
6.087 ± 10	6.099 ± 10	1	1^-
6.577 ± 10	6.589 ± 10	0	0^+
6.725 ± 10	6.731 ± 10	3	3^-
6.895 ± 10	6.899 ± 10	weak	
$\equiv 7.012$	7.017 ± 10	2	2^+
7.336 ± 10	7.342 ± 10	weak	
8.307 ± 12	8.315 ± 10	2	2^+
9.746 ± 7 ^d		0	0^+
09.809 ± 10 ^d	9.80 ± 20 ^e	(1)	(1^-)
10.425 ± 6 ^d	10.419 ± 20	2	2^+
10.448 ± 10			
10.498 ± 4 ^d	10.492 ± 20	(3)	(3^-) ^f
10.736 ± 5 ^d	10.730 ± 20	4	4^+
11.398 ± 10	11.377 ± 20	1	1^-
11.665 ± 13	11.647 ± 30	(1)	(1^-)
11.727 ± 10	^e	(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 Tables 14.5 in (1976AJ04) and 14.7 in (1981AJ01), and (1982FO01).

^b $E_t = 18$ MeV (1978MO07, 1978MO08).

^c $E_t = 23$ MeV (1978AJ02).

^d The widths for $^{14}\text{C}^*(9.75, 9.81, 10.43, 10.50, 10.74)$ are, respectively 18, 40, 14, 18 and 15 keV (1978MO07, 1978MO08).

^e Very weak at all angles.

^f See also the note added in proof on p. 476 of (1978MO08).

$$11. \text{}^{12}\text{C}(\text{}^{10}\text{B}, \text{}^8\text{B})\text{}^{14}\text{C} \quad Q_m = -13.889$$

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

$$12. \text{}^{12}\text{C}(\text{}^{16}\text{O}, \text{}^{14}\text{O})\text{}^{14}\text{C} \quad Q_m = -15.7635$$

At $E(^{16}\text{O}) = 128$ MeV angular distributions have been measured to $^{14}\text{C}^*(0, 6.73, 10.74)$ [$J^\pi = 0^+, 3^-, 4^+$] ([1979PR07](#)). See also ([1981AJ01](#)).

$$13. \text{}^{13}\text{C}(\text{n}, \gamma)\text{}^{14}\text{C} \quad Q_m = 8.1765$$

$$Q_0 = 8176.483 \pm 0.015 \text{ keV [see ([1983CO09](#))].}$$

The thermal capture cross section is 1.37 ± 0.04 mb ([1982MU14](#)). The decay is primarily to $^{14}\text{C}^*(0, 6.59)$ [(84.0 ± 2.3)%, (8.5 ± 0.5)%] with weaker branches to $^{14}\text{C}^*(6.09, 6.90)$ [(2.5 ± 0.5)%, (4.9 ± 1)%]. Gamma rays with $E_\gamma = 8173.92, 6092.4 \pm 0.2, 2082.6 \pm 0.3, 1586.8 \pm 0.2, 1273.9 \pm 0.2, 808.9 \pm 0.2$ and 495.4 ± 0.3 keV have been observed: $E_x = 6093.8 \pm 0.2, 6589.4 \pm 0.2$ and 6902.6 ± 0.2 keV are reported for $^{14}\text{C}^*(6.09, 6.59, 6.90)$. A (d, p) spectroscopic factor of 0.060 ± 0.004 was deduced for $^{14}\text{C}^*(6.59)$ ([1982MU14](#)). The neutron capture yield for $E_n = 95$ to 235 keV shows a resonance at $E_n = 152 \pm 1$ keV, $\Gamma_{\text{lab}} = 5 \pm 1$ keV, $\Gamma_\gamma = 4.0 \pm 1.6$ eV: see Table 14.8 in ([1981AJ01](#)). Angular distributions of cross sections and A_γ and the $90^\circ \gamma_0$ cross sections have been measured in the range $E_n = 5.6$ to 17 MeV. M1 resonances are indicated at $E_n \approx 9.2$ and 10.1 MeV ($\Gamma \approx 200$ keV) [$E_x = 16.7$ and 17.5 MeV]. $\sigma(E2)$ is less than 2% of the total capture cross section for $E_n = 5.6$ to 17 MeV ([1985WR01](#)). See also ([1984SE16](#)).

$$14. \text{}^{13}\text{C}(\text{n}, \text{n})\text{}^{13}\text{C} \quad E_b = 8.1765$$

The coherent scattering length (thermal, bound) is 6.19 ± 0.09 fm, $\sigma_{\text{scatt}} = 4.16 \pm 0.13$ b ([1979KO26](#)). [However F.C. Barker, private communication, has recalculated this value and finds $\sigma_{\text{scatt}} = 4.84$ b.] The difference in the bound-state scattering lengths, $b^+ - b^- = -1.2 \pm 0.2$ fm ([1979GL12](#)). The free coherent scattering length $a_+ = 5.47 \pm 0.09$ fm ([1982MU14](#)). See also ([1981MUZQ](#)). The total cross section has been measured for $E_n = 0.10$ to 23 MeV: see ([1981AJ01](#)). Elastic differential cross sections have been measured for $E_n = 1.25$ to 6.5 MeV ([1981LA05](#)), 4.55 to 8.25 MeV ([1982REZY](#), [1982REZX](#); also n_{1-3}) and 10 to 18 MeV ([1982DA05](#), [1983DA22](#)). See also ^{13}C , ([1983GO1H](#)) and ([1985WE02](#); theor.).

The results of an R -matrix analysis based on σ_T and $\sigma(\theta)$ (elastic) measurements ([1981LA05](#)) are summarized in Table [14.9](#).

Table 14.9: R -matrix analysis of $^{13}\text{C}(n, n)$ ^a

E_n (keV)	E_x (MeV)	$\Gamma_{n,\text{lab}}$ ^b (keV)	J^π
152.9 ± 1.4	8.3184	3.7 ± 0.7	
1736	9.79	15	3^-
1754	9.80	41	1^-
2426	10.43	10	$3^{(-)}$
2445	10.45	7	$(1^+, 2)$
2504	10.50	$\ll 5$	≥ 1
3350	11.3	≈ 180	1^+
3466	11.39	$\lesssim 7$	≥ 2 ^d
3510	11.4		1^-
3710	11.6		2^-
4350	12.2		1^-
4770	12.6	130	3^- ^e
5050 ^{b,c}	12.86		
5162 ^{b,c}	12.97		
5900	13.7	≈ 1300	$(1, 2)^-$

^a (1981LA05): based on an analysis of σ_T and $\sigma(\theta)$ elastic measurements, except for the 153 keV resonances. See also Table 14.8 in (1981AJ01).

^b Quoted by (1981LA05) from work by (1979AU07), except for first value.

^c Not included in R -matrix fit.

^d See, however, Table 14.8.

^e (1982REZY).

$$15. \text{}^{13}\text{C}(\text{p}, \pi^+)\text{}^{14}\text{C} \quad Q_m = -132.1732$$

At $E_p = 185$ MeV (1973DA37) and 200 MeV (1980HO20) the angular distributions of π^+ and π^- to the ground states of ^{14}C and ^{14}O are very different. The population of $^{14}\text{C}^*(6.09, 6.73 + 6.90 + 7.01, 7.34, 8.32)$ is also reported; that to the first excited state is very strong (1980SO05). See also (1981AJ01), the “GENERAL” section here, (1982GRZY, 1983THZZ, 1984KOZU) and (1979ME2A, 1981AU1C).

$$16. \text{}^{13}\text{C}(\text{d}, \text{p})\text{}^{14}\text{C} \quad Q_m = 5.9519$$

Observed proton groups are displayed in Table 14.10. Angular distributions have been measured at a number of energies up to $E_d = 14.8$ MeV [see (1981AJ01)] and at $E_d = 17.7$ MeV (1984PE24; DWBA, CCBA; see Table 14.10) and at $E_d = 56$ MeV (1984HA26; p_0 ; A_y).

Gamma rays are exhibited in Table 14.5: studies of these, of the angular distributions analyzed by DWBA, and of $p\gamma$ correlations lead to the following J^π assignments [see reaction 14 in (1970AJ04) for a full discussion of the evidence and a listing of the relevant references]. $^{14}\text{C}(6.09)$ is 1^- (decay is E1); $^{14}\text{C}^*(6.59)$ is 0^+ (internal pairs only); $^{14}\text{C}^*(6.73)$ is 3^- (γ_0 is E3; $l_n = 2$); $^{14}\text{C}^*(6.90)$ 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); $^{14}\text{C}^*(7.34)$ is 2^- (strength of cascade decay and angular correlation results). See also ^{15}N .

$$17. \text{}^{13}\text{C}(\text{}^7\text{Li}, \text{}^6\text{Li})\text{}^{14}\text{C} \quad Q_m = 0.926$$

At $E(^7\text{Li}) = 34$ MeV the angular distribution to $^{14}\text{C}_{\text{g.s.}}$ has been measured: see (1976AJ04). $^{14}\text{C}^*(6.09, 6.73, 6.90, 7.01, 7.34, 10.47)$ are also populated at that energy (1984CL08).

$$18. \text{}^{13}\text{C}(\text{}^9\text{Be}, \text{}^8\text{Be})\text{}^{14}\text{C} \quad Q_m = 6.511$$

At $E(^9\text{Be}) = 28.8$ MeV the angular distribution to $^{14}\text{C}_{\text{g.s.}}$ has been measured (1980BO21). See also (1984DA17).

$$19. \text{}^{13}\text{C}(\text{}^{11}\text{B}, \text{}^{10}\text{B})\text{}^{14}\text{C} \quad Q_m = -3.2777$$

At $E(^{11}\text{B}) = 114$ MeV $^{14}\text{C}_{\text{g.s.}}$ is weakly excited but $^{14}\text{C}^*(6.73, 7.34)$ [$J^\pi = 3^-$ and 2^-] are strongly populated: see (1976AJ04).

Table 14.10: Proton groups from $^{13}\text{C}(\text{d}, \text{p})^{14}\text{C}$ ^a

E_x ^b (MeV)	J^π ^c	j trans. ^d	S ^d
0	0^+		
6.09	1^-	$\frac{1}{2}^+$	0.75
6.59	0^+	$(\frac{1}{2}^-)$	(0.14)
6.73	3^-	$\frac{5}{2}^+$	0.65
6.90	0^-	$\frac{1}{2}^+$	1.02
7.01	2^+	$\frac{3}{2}^-$	0.065
7.34	2^-	$\frac{5}{2}^+$	0.72
8.32	2^+	$\frac{3}{2}^-$	0.065
9.80	3^-	$\frac{5}{2}^+$	0.07
10.43	2^+		
10.50	(3^-)		
10.74	4^+	$(\frac{7}{2}^-)$	(0.06)
11.5	$(1^-, 2^-)$	$\frac{3}{2}^+$	≈ 1
11.67	4^-		
11.9 ^e			
12.58 ^f			
12.86			
12.96	(1^-)		

^a See also Table 14.9 in (1981AJ01).

^b Nominal values: see Table 14.3.

^c See Table 14.3 and text.

^d (1984PE24).

^e ± 300 keV, $\Gamma_{\text{lab}} = 1.10 \pm 0.30$ MeV.

^f $\Gamma_{\text{lab}} = 0.13 \pm 0.02$ MeV.

20. $^{13}\text{C}(^{13}\text{C}, ^{12}\text{C})^{14}\text{C}$ $Q_m = 3.2301$

Elastic angular distributions have been studied at $E(^{13}\text{C}) = 16$ to 50 MeV (1983KO15). For yield measurements see (1983KO15, 1984BA31). See also (1981BR1P) and (1983KO16; theor.).

21. (a) $^{13}\text{C}(^{17}\text{O}, ^{16}\text{O})^{14}\text{C}$ $Q_m = 4.0328$
 (b) $^{13}\text{C}(^{18}\text{O}, ^{17}\text{O})^{14}\text{C}$ $Q_m = 0.132$

Angular distributions have been measured at $E(^{17}\text{O}) = 29.8$ and 32.3 MeV and $E(^{18}\text{O}) = 31.0$ MeV: see (1981AJ01). See also (1984AB1A; theor.).

22. $^{14}\text{B}(\beta^-)^{14}\text{C}$ $Q_m = 20.64$

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

23. $^{14}\text{C}(\gamma, n)^{13}\text{C}$ $Q_m = -8.1765$

A narrow resonance is observed in the (γ, n_0) reaction at $E_x = 11.3$ MeV with an integrated cross section of 1.65 ± 0.12 MeV · mb of which 0.62 ± 0.06 MeV · mb is due to the GDR tail. Nearly 100% of the photoneutron reaction proceeds to $^{13}\text{C}_{\text{g.s.}}$ below $E_x \approx 13$ MeV. Above this energy (and below 28 MeV) about one-half of the $T_{<}$ GDR is in the g.s. channel. There are strong indications of E1-M1 interference at 11.3 MeV [for which $J^\pi = 1^+$ is suggested]. There is no evidence for E2 excitation for $15 < E_x < 20$ MeV (1985KU01).

24. $^{14}\text{C}(e, e)^{14}\text{C}$

The charge radius of ^{14}C , $r_{\text{rms}} = 2.56 \pm 0.05$ fm (1973KL12). At $E_e = 37-60$ MeV ($\theta = 180^\circ$) inelastic groups are reported to $^{14}\text{C}^*(7.01, 7.34, 8.32, 9.80, 10.5, 11.31 \pm 0.02, 12.96, 14.67)$ with the 11.3 MeV state [1^+ , $\Gamma = 207 \pm 13$ keV, $\Gamma_{\gamma_0} = 6.8 \pm 1.4$ eV] dominant (1977CR02). At $E_e = 196.3$ MeV ($\theta = 180^\circ$) (1984PL02) find the dominant strength to be to 4^- states at 11.7, 17.3 and 24.3 MeV [± 0.1 MeV]. The first two of these are $T = 1$ states reported in the (π, π) reaction below, the third is suggested to have $T = 2$. The M4 form factors account for 41% and 37% of the $T = 1$ and $T = 2$ single-particle (e, e') cross section, respectively. The observed transitions to the $T = 1$ states exhaust 33 – 45% of the total isovector transition strength and 1 – 15% of the isoscalar transition strength. Magnetic electron scattering is most sensitive to isovector transitions. $^{14}\text{C}^*(6.09, 6.7, 7.0, 8.32, 9.8, 10.5, 22.1)$ are also populated (1984PL02). See also (1983TR1J, 1984LI25) and (1983GM1A, 1984GO1J; theor.).

25. $^{14}\text{C}(\pi^\pm, \pi^\pm)^{14}\text{C}$

Elastic angular distributions have been measured at $E_{\pi^\pm} = 50$ MeV (1983MIZY, 1984MI1M) and 65 and 80 MeV (1983BL11). At $E_{\pi^\pm} = 164$ MeV π^+ and π^- spectra have been studied: angular distributions have been obtained to states at $E_x = 6.7 \pm 0.1, 11.7 \pm 0.1, 15.2 \pm 0.1, 17.3 \pm 0.1$ MeV with $J^\pi = 3^-, 4^-, 4^-, 4^-$ (1985HO07). In addition a broad structure ($\Gamma \approx 1.7$ MeV) is observed near 24.5 MeV. It may include a narrower peak at 24.4 MeV. $^{14}\text{C}^*(7.01, 8.32)$ are also populated (1985HO07). $^{14}\text{C}^*(6.1, 10.4, 12.6, 15.1)$ are also observed (1981HO14). See also reaction 8.

26. (a) $^{14}\text{C}(n, n)^{14}\text{C}$

(b) $^{14}\text{C}(p, p)^{14}\text{C}$

(c) $^{14}\text{C}(d, d)^{14}\text{C}$

Elastic angular distributions have been studied for $E_p = 19$ to 27 MeV (1984BAZZ). See also ^{15}N . Angular distributions have also been studied at $E_d = 19$ to 27 MeV to $^{14}\text{C}^*(6.09, 6.59, 6.73, 6.90, 7.01, 7.34, 8.32)$ (1985BAZZ). See also (1981AJ01) and (1985DI1B; theor.).

27. $^{14}\text{C}(^3\text{He}, ^3\text{He})^{14}\text{C}$

Elastic angular distributions have been measured at $E(^3\text{He}) = 4.5$ to 18 MeV: see (1976AJ04).

28. $^{14}\text{C}(\alpha, \alpha)^{14}\text{C}$

Elastic angular distributions have been studied at $E_\alpha = 22, 24$ and 28 MeV [see (1976AJ04)] and at $E_\alpha = 35.5$ MeV (1984PE24). At the latter energy many inelastic groups have also been studied: see Table 14.11 and reaction 16 (1984PE24). See also (1984RA17), ^{18}O in (1987AJ02) and (1983WI12, 1984LA01; theor.).

29. $^{14}\text{C}(^6\text{Li}, \alpha d)^{14}\text{C}$

$$Q_m = -1.4751$$

See (1983AR11, 1983CU03) and ^{18}O in (1987AJ02).

Table 14.11: States of ^{14}C from $^{14}\text{C}(\alpha, \alpha')$ ^a

E_x (MeV) ^b	L ^c	J^π	β^2 ^d
6.09	1	1^-	0.050
6.73	3	3^-	0.158
7.01 ^e	2	2^+	0.086
7.34		2^-	
8.32 ^e	2	2^+	0.049
9.80	3	3^-	0.068
10.44 ± 0.06 ^e	2	2^+	0.038
10.74	4	4^+	0.018
11.32 ± 0.06	2	2^+	0.014
11.62 ± 0.08		4^-	
12.58	3	3^-	0.041
12.96	(3)	(3^-)	0.033
13.58	1	1^-	0.068
14.82	3	3^-	0.079
15.66	3	3^-	0.096

^a (1984PE24): $E_\alpha = 35$ MeV.

^b Excitation energies without uncertainties are from Table 14.3, except for the last three values.

^c Microscopic DWBA analysis.

^d Collective deformations.

^e Isoscalar transition rates $B(02)$ are 168, 96 and 74 fm^4 for $^{14}\text{C}^*(7.01, 8.32, 10.44)$.

30. (a) $^{14}\text{C}(^{12}\text{C}, ^{12}\text{C})^{14}\text{C}$
 (b) $^{14}\text{C}(^{13}\text{C}, ^{13}\text{C})^{14}\text{C}$
 (c) $^{14}\text{C}(^{14}\text{C}, ^{14}\text{C})^{14}\text{C}$

The elastic scattering for reaction (a) has been studied at $E(\text{C}) = 12, 15, 18$ and 20 MeV, and at 15 MeV for reaction (b) [see (1976AJ04)] and at $E(^{14}\text{C}) = 31$ to 56 MeV for reaction (a) (1985KO04) and for reaction (c) at $E(^{14}\text{C}) = 31.4, 35.4, 38.9, 47.9$ and 55.9 MeV (1981DR01) and 31 to 56 MeV (1980KO23, 1985KO04). For yield and fusion studies see (1981HE08, 1985KO04, 1985RI1C) for reaction (a) and (1980KO23, 1981DR01, 1981FR23, 1985KO04) for reaction (c). (1981FR23, 1985KO04) have studied the yields of γ -rays from $^{14}\text{C}^*(6.73)$ [$J^\pi = 3^-$] for $E(^{14}\text{C}) = 25$ to 70 MeV. See also (1981BR1P, 1981HA1V, 1982CI1C, 1982FR1U, 1983BI1A) and (1981AB1A, 1981HA18, 1981TA20, 1982AB1F, 1983BA38, 1983FR23; theor.).

31. (a) $^{14}\text{C}(^{16}\text{O}, ^{16}\text{O})^{14}\text{C}$
 (b) $^{14}\text{C}(^{17}\text{O}, ^{17}\text{O})^{14}\text{C}$

The elastic scattering angular distributions have been measured at $E(^{16}\text{O}) = 20, 25$ and 30 MeV: see (1981AJ01). For excitation functions see (1981KO07, 1982HE07, 1983VO1B). See also (1981HA1V, 1982FR1U) and (1981HA18, 1983DU13, 1983FR23, 1984AB1F; theor.).

32. $^{14}\text{N}(\mu^-, \nu)^{14}\text{C}$ $Q_m = 105.5030$

Observation of the γ -transition has led to the determination of the capture rate to $^{14}\text{C}^*(7.01)$ [$J^\pi = 2^+$]: the experimental value is four times smaller than that predicted by theory (1981GI08). See also the “GENERAL” section here.

33. $^{14}\text{N}(\gamma, \pi^+)^{14}\text{C}$ $Q_m = -139.7238$

The π^+ production has been studied at $E_\gamma = 173$ MeV to $^{14}\text{C}_{\text{g.s.}}$: the Cohen-Kurath wave functions overestimate the data as much as a factor of 4 (1985RO05). See also (1984COZW) and the “GENERAL” section here.

34. $^{14}\text{N}(\pi^-, \gamma)^{14}\text{C}$ $Q_m = 139.4108$

Branching ratios have been measured for the capture of stopped pions to $^{14}\text{C}^*(0, 7.0 \pm 0.1, 8.3, 11.3, 20.0 \pm 1.0)$. The total radiative capture branching is $(2.1 \pm 0.2)\%$ [see (1981AJ01)]. See also the “GENERAL” section here.

$$35. \ ^{14}\text{N}(n, p)^{14}\text{C} \quad Q_m = 0.6259$$

The p_0 angular distribution has been measured at $E_n = 14$ MeV: see (1981AJ01). At $E_n = 60$ MeV the strongest transitions are to $^{14}\text{C}^*(7.0 + 8.3, 11.3, 15.4)$ and to the giant resonance peak, centered at ≈ 20.4 MeV, and angular distributions have been studied to these groups (1982NE04). See also (1984TU1D; search for supermassive Cahn-Glashow particles), (1981BR1L), (1983FI1L, 1983KH1F; applied) and (1983GM1A; theor.).

$$36. \ ^{15}\text{N}(\gamma, p)^{14}\text{C} \quad Q_m = -10.2074$$

See (1981AJ01).

$$37. \ ^{15}\text{N}(n, d)^{14}\text{C} \quad Q_m = -7.9829$$

Ground-state angular distributions have been measured for $E_n = 14.1-14.8$ MeV: see (1976AJ04, 1981AJ01).

$$38. \ ^{15}\text{N}(d, ^3\text{He})^{14}\text{C} \quad Q_m = -4.7139$$

^{14}C states populated in this reaction are displayed in Table 14.9 of (1976AJ04), together with l and C^2S values.

$$39. \ ^{16}\text{O}(^6\text{Li}, ^8\text{B})^{14}\text{C} \quad Q_m = -16.592$$

At $E(^6\text{Li}) = 93$ MeV $^{14}\text{C}^*(0, 7.01, 8.32, 10.45)$ are populated, the first two of these strongly: see (1981AJ01).

$$40. \ ^{16}\text{O}(^{18}\text{O}, ^{20}\text{Ne})^{14}\text{C} \quad Q_m = -1.493$$

Angular distributions are reported at $E(^{18}\text{O}) = 28, 32$ and 36.1 MeV: see (1981AJ01).

$$41. \ ^{18}\text{O}(\gamma, \alpha)^{14}\text{C} \quad Q_{\text{m}} = -6.2270$$

The ground-state reaction has been studied at $E_{\text{bs}} = 24$ and 32 MeV (1982BA03): see ^{18}O in (1983AJ01). See also (1981AJ01).

$$42. \ ^{18}\text{O}(\text{d}, \ ^6\text{Li})^{14}\text{C} \quad Q_{\text{m}} = -4.7519$$

See (1984NE1A).

$$43. \ ^{19}\text{F}(\text{d}, \ ^7\text{Be})^{14}\text{C} \quad Q_{\text{m}} = -7.1402$$

The ground-state angular distribution has been measured at $E_{\text{d}} = 13.6$ MeV by (1980GA27). See also (1984NE1A).

^{14}N
(Figs. 7 and 9)

GENERAL: (See also (1981AJ01).)

Nuclear models: (1983KA1K, 1983SH38, 1983VA31, 1984AS07, 1984VA06, 1984ZW1A).

Special states: (1980GO1Q, 1980KA28, 1980RI06, 1983AD1B, 1983AD1D, 1983GO1R, 1983VA31, 1984AD1E, 1984AS07, 1984GO1M, 1984VA06, 1984ZW1A, 1985HA1J).

Electromagnetic transitions and giant resonances: (1980RI06, 1980SP1E, 1981KN06, 1982RI04, 1983GO1B, 1984AS07, 1984BI10, 1984KU07, 1984MA2J).

Astrophysical questions: (1980CO1R, 1980SC1L, 1981AD1F, 1981BE2K, 1981DE2C, 1981GA1C, 1981GA1H, 1981GU1D, 1981IB1A, 1981LA1L, 1981WA1N, 1981WA1Q, 1982IB1B, 1983AL1M, 1983BO1F, 1983SI1B, 1984CO1H, 1984TR1C, 1985DR1A, 1985GU1A).

Complex reactions involving ^{14}N : (1980CE1B, 1980GR10, 1980RI06, 1981BH02, 1981CI03, 1981EG02, 1981ME13, 1981TA16, 1982BO1M, 1982LE1N, 1982LY1A, 1982TA02, 1983BH09, 1983CH23, 1983DE26, 1983FR1A, 1983JA05, 1983OL1A, 1983PAZT, 1983PL1A, 1983SA06, 1983SO08, 1983WI1A, 1984BA1H, 1984BE22, 1984FI17, 1984GR08, 1984HI1A, 1984HO23, 1984KA1J, 1984NA12, 1984SI15, 1984TS03, 1985AG1A, 1985BH02, 1985GU1A, 1985JA1B, 1985LI1B, 1985MC03, 1985MO08, 1985ST1J).

Applied work: (1980MC1H, 1980SE1E, 1982BE1R, 1983AM1A, 1983DU1D, 1983FI1L, 1983FI1C, 1983KU1C, 1984CA1D, 1984HA1Q, 1984MA2H, 1985WA1R).

Muon and neutrino capture and reactions: (1980SC18, 1981GI08, 1981MU1E, 1982NA01, 1983GM1A, 1983VA1E, 1984KE1D, 1984KO1U).

Pion capture and reactions (See also reactions 36 and 43.): (1980BE24, 1980BE56, 1980ST25, 1981BE63, 1981BE2P, 1981DU1H, 1981FE2A, 1981FR1F, 1981GI1E, 1981GI15, 1981RO14, 1981SI1D, 1981TA08, 1981WH1D, 1982BI08, 1982KA16, 1982LI15, 1982MA22, 1982MU09, 1982RA28, 1982RI1A, 1982WH1A, 1983AZ1B, 1983GE12, 1983GM1A, 1983RI1C, 1983RO07, 1983SP06, 1983TO17, 1983TR1J, 1984CO1V, 1984MI1L, 1985ALZX, 1985DY1C, 1985RO05).

Kaon capture and reactions: (1981BA1H, 1981MA27, 1982BA1R, 1982ER1E, 1982KA1U, 1983AN05, 1983FE07, 1983GA17, 1983MA63).

Antiproton reactions: (1983SU04, 1983SU07, 1984SU07).

Hypernuclei: (1980IW1A, 1981MA27, 1981WA1J, 1982BA1R, 1982ER1E, 1982KA1U, 1982KA1D, 1982ZO1B, 1983AU1A, 1983FE07, 1983MA63, 1983SH38, 1983SH1E, 1984AS1D, 1984BA1N, 1984DA03, 1984ER1A).

Other topics: (1980GO1Q, 1981BL1K, 1982BA2G, 1982DE1N, 1982NG01, 1982VE02, 1983AD1B, 1983GO1R, 1983MA35, 1984BU1Q).

Table 14.12: Energy levels of $^{14}\text{N}^a$

E_x in $^{14}\text{N}^b$ (MeV \pm keV)	$J^\pi; T$	τ_m or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
g.s.	$1^+; 0$	stable	–	1, 6, 7, 8, 9, 18, 19, 20, 21, 24, 30, 31, 32, 33, 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, 62, 63, 64, 65, 66, 67
2.312798 ± 0.011	$0^+; 1$	$\tau_m = 92 \pm 10$ fsec	γ	1, 9, 18, 19, 21, 24, 30, 31, 32, 33, 36, 37, 38, 39, 44, 45, 46, 47, 48, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66
3.94810 ± 0.20	$1^+; 0$	8.0 ± 1.0 fsec	γ	1, 6, 7, 9, 18, 19, 20, 21, 24, 30, 31, 32, 33, 37, 38, 39, 43, 44, 45, 46, 47, 48, 57, 58, 59, 60, 62, 63, 64, 65, 66
4.9151 ± 1.4	$0^-; 0$	7.6 ± 1.4 fsec	γ	1, 6, 7, 18, 19, 20, 21, 24, 30, 31, 32, 38, 43, 44, 45, 46, 47, 48, 59, 60, 65
5.10589 ± 0.10	$2^-; 0$	6.27 ± 0.07 psec $ g = 0.66 \pm 0.04$	γ	1, 6, 7, 18, 19, 20, 21, 24, 30, 31, 32, 33, 38, 39, 43, 44, 45, 46, 47, 48, 58, 59, 60, 62, 64, 65
5.69144 ± 0.13	$1^-; 0$	16 ± 8 fsec	γ	6, 7, 18, 19, 20, 21, 24, 30, 31, 33, 38, 43, 44, 45, 46, 47, 48, 59, 60, 65

Table 14.12: Energy levels of ^{14}N ^a (continued)

E_x in ^{14}N ^b (MeV \pm keV)	$J^\pi; T$	τ_m or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
5.83425 ± 0.14	$3^-; 0$	11.98 ± 0.23 psec	γ	1, 6, 7, 11, 18, 19, 20, 21, 23, 30, 31, 33, 38, 39, 43, 44, 45, 46, 47, 48, 58, 59, 60, 62, 65
6.2035 ± 0.6	$1^+; 0$	160 ± 20 fsec	γ	1, 6, 7, 18, 19, 20, 21, 24, 30, 31, 38, 39, 45, 46, 47, 48, 59, 60, 65
6.44617 ± 0.10	$3^+; 0$	620 ± 60 fsec	γ	1, 6, 7, 18, 19, 20, 21, 24, 30, 31, 38, 44, 45, 46, 48, 59, 60, 65
7.02912 ± 0.12	$2^+; 0$	5.4 ± 0.5 fsec	γ	6, 7, 18, 19, 20, 21, 24, 30, 31, 33, 38, 39, 43, 44, 45, 46, 47, 48, 58, 59, 60, 64, 65
7.9669 ± 0.5	$2^-; 0$	$\Gamma = (2.5 \pm 0.7) \times 10^{-3}$	γ, p	6, 7, 18, 19, 20, 21, 24, 30, 31, 45, 48, 59, 64, 65
8.062 ± 1.0	$1^-; 1$	30 ± 1	γ, p	18, 19, 24, 25, 30, 31, 41, 45, 59, 60
8.4899 ± 1.2	$4^-; 0$	$\tau_m = 19 \pm 3$ fsec	γ, p	6, 7, 18, 19, 20, 21, 24, 30, 31, 39, 43, 45, 48, 65
8.6197 ± 1.4	$0^+; 1$	$\Gamma = 3.8 \pm 0.3$	γ, p	18, 19, 24, 25, 30, 31, 45, 59, 60, 65
8.776 ± 7	$0^-; 1$	410 ± 20	γ, p	24, 25, 31
8.9118 ± 2.0	$3^-; 1$	16 ± 2	γ, p	19, 24, 25, 30, 31, 33, 42, 45, 59, 60
8.9638 ± 1.2	$5^+; 0$	$\tau_m = 105 \pm 17$ fsec	γ, p	7, 11, 19, 20, 21, 22, 23, 24, 52, 59
8.9804 ± 2.4	$2^+; (0)$	$\Gamma = 8 \pm 2$	γ, p	6, 7, 19, 24, 25, 30, 31, 59

Table 14.12: Energy levels of ^{14}N ^a (continued)

E_x in ^{14}N ^b (MeV \pm keV)	$J^\pi; T$	τ_m or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
9.1289 ± 0.5 ^c	$3^+; 0$	$\tau_m = 13 \pm 5$ fsec	γ, p	6, 7, 19, 20, 24, 30, 31, 48
9.17250 ± 0.28	$2^+; 1$	$\Gamma = 0.135 \pm 0.008$	γ, p	19, 24, 30, 31, 41, 42, 45, 59, 60, 64
9.3893 ± 1.4	$2^-; 0$	13 ± 3	p	6, 7, 19, 20, 21, 25, 30, 31, 45, 48, 59, 60, 65
9.509 ± 3	$2^-; 1$	41 ± 2	γ, p	19, 24, 25, 30, 31, 45, 59, 60, 65
9.703 ± 4	$1^+; 0$	15 ± 3	p	6, 19, 20, 21, 25, 30, 31, 45, 60, 65
10.079 ± 10	(3^+)	< 10		6, 7, 10, 19, 21, 31
10.101 ± 15	$2^+, 1^+; 0$	12 ± 3	γ, p	19, 20, 21, 24, 25, 31, 45, 65
10.226 ± 8	$1^{(-)}; 0$	80 ± 15	γ, p	19, 21, 24, 25, 31, 65
10.432 ± 7	$2^+; 1$	33 ± 3	γ, p	10, 19, 24, 25, 38, 42, 59, 65
10.534 ± 20	(1^-)	140	p	19, 25, 31
10.812 ± 15	$5^+; 0$	$(0.39 \pm 0.16) \times 10^{-3}$	γ	6, 7, 10, 19, 20, 21, 31, 59, 65
11.00 ± 30		165 ± 30	γ, p	24, 48
11.050 ± 5	3^+	1.2 ± 0.4	γ, p	6, 7, 10, 19, 21, 24, 31, 59, 64
11.07	$1^+; 0$	100	n, p, d	7, 13, 20, 25, 26, 65
11.21 ± 30	$T = 1$	220 ± 30	γ, p, d	13, 24, 31, 65
11.24 ± 15	$3^-; 0$	11	γ, n, p	10, 19, 23, 25, 26, 31, 42, 45, 46, 47, 48
11.27 ± 15	$2^-; 0$	180	n, p, d	6, 13, 14, 20, 21, 25, 31

Table 14.12: Energy levels of ^{14}N ^a (continued)

E_x in ^{14}N ^b (MeV \pm keV)	$J^\pi; T$	τ_m or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
11.357 \pm 15	1 ⁺ ; 0	30	n, p, d	13, 14, 19, 20, 25, 26, 65
11.5135 \pm 1.5	2 ⁺ , 3 ⁺	7.0 \pm 0.5	p, d	6, 7, 10, 13, 14, 19, 20, 21, 31, 65
11.676 \pm 18	1 ⁻ , 2 ⁻	150 \pm 20	n, p, d	13, 14, 26, 31
11.741 \pm 6	1 ⁻ , 2 ⁻	40 \pm 9	(γ), p, d	13, 24
11.761 \pm 6	3 ⁻ , 4 ⁻	78 \pm 6	(γ), p, d	13, 24
11.807 \pm 7	2 ⁻ , (1 ⁺)	119 \pm 9	n, p, d	6, 13, 14
11.874 \pm 6	2 ⁻ , (1 ⁻)	101 \pm 9	n, p, d	13, 26
12.20 \pm 19	1 ⁻ , 2 ⁻	300 \pm 30	n, p, d	13, 14, 20, 26, 59
12.408 \pm 3	(4 ⁻)	34 \pm 3	n, p, d, α	3, 4, 6, 7, 10, 13, 14, 19, 20, 21
12.418 \pm 3	3 ⁻ , 4 ⁻	41 \pm 4	p, d	6, 7, 10, 13, 19, 21
12.495 \pm 9		39 \pm 5	γ , n, p, d, α	3, 13, 19, 24, 38, 42, 59, 64
12.594 \pm 3	3 ⁺	48 \pm 2	(n), p, d, α	3, 13, 14, 19, 20, 59
12.690 \pm 5	3 ⁻	18 \pm 5	n, p, d, α	2, 3, 4, 5, 6, 10, 13, 14, 19, 20, 21, 26, 48
(12.708 \pm 9)		(43 \pm 15)	p, d	13
12.789 \pm 5	4 ⁺	16 \pm 3	n, p, d, α	2, 3, 4, 5, 7, 10, 13, 14, 19, 59
12.813 \pm 4	4 ⁻	5 \pm 2	γ , p, d, α	3, 4, 6, 7, 13, 19, 42, 43, 45, 46, 47, 48, 59
12.826 \pm 6		11 \pm 3	n, p, d	7, 13, 14
12.857 \pm 6		78 \pm 10	n, p, d	13, 21, 26
12.883 \pm 8		134 \pm 11	p, d	13, 19
12.922 \pm 5	4 ⁺	22 \pm 4	p, d, α	3, 4, 10, 13, 14, 19, 22

Table 14.12: Energy levels of ^{14}N ^a (continued)

E_x in ^{14}N ^b (MeV \pm keV)	$J^\pi; T$	τ_m or $\Gamma_{\text{c.m.}}$ (keV)	Decay	Reactions
13.007 \pm 17		120 \pm 30	γ, p	6, 7, 24
13.167 \pm 5	1 ⁺	15 \pm 5	γ, n, p, d, α	2, 3, 4, 5, 13, 14, 19, 42, 59
13.192 \pm 9	3 ⁺	65 \pm 10	α	5, 6, 10, 59
13.243 \pm 10	2 ⁻	92 \pm 5	γ, n, p, α	2, 3, 26, 42, 48, 59
13.30 \pm 40	(2 ⁻); 1	1000 \pm 150	γ, p	24
13.656 \pm 5	(2 ⁺ , 3 ⁺)	\approx 90	n, p, d, α	2, 3, 5, 13, 14
13.714 \pm 5	2 ⁻ , 3 ⁺	105 \pm 25	γ, n, p, d, α	2, 3, 4, 6, 10, 42, 59
13.74 \pm 10	1 ⁺ ; 1	180 \pm 20	(γ), n, p, d, α	2, 3, 5, 13, 14, 24, 26, 38, 59
13.77 \pm 10	(1 ⁺)	120	p, α	3
14.04 \pm 30		100	n, p, d, α	2, 3, 13, 14, 26
14.16 \pm 30		230	n, p, d, α	2, 3, 13, 14
14.25 \pm 50	3 ⁺	420 \pm 100	p, α	3, 5
14.30 \pm 20		150	p, α	3
14.56 \pm 20		100	n, p, α	2, 3, 6, 10
14.59 \pm 30		50	n, p, α	2, 3, 6, 10
14.66 \pm 10	5 ⁻ ; 0	100 \pm 20	α	5, 43
14.73 \pm 25	(2 ⁻ ; 1)	125	γ, n, p, α	2, 3, 42
14.86 \pm 30		140	n, p, d, α	2, 3, 6, 10, 13, 14, 16, 19, 21, 26
14.92 \pm 30		43 \pm 8	n, p, α	2, 3, 10, 19, 26
15.02 \pm 20	3 ⁻ , 4 ⁻ ; 1	\approx 60	γ, n, p, α	2, 6, 26, 42, 43
15.24 \pm 20		100	p, d, α	3, 6, 7, 10, 13, 14
15.43 \pm 20		100	n, p, d, α	2, 3, 13, 16, 21, 48
15.70 \pm 50		350	γ, n, p, d, α	6, 13, 14, 16, 19, 21, 26, 42
16.21 \pm 20		125	n, p, α	2, 3, 21, 26, 42

Table 14.12: Energy levels of ^{14}N ^a (continued)

E_x in ^{14}N ^b (MeV \pm keV)	$J^\pi; T$	τ_m or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
16.40 \pm 20		150	p, d, α	3, 16
16.65 \pm 25 ^d	4 ⁺ ; 0 + 1	240 \pm 25	d, α	16
16.91 \pm 20	5 ⁻ ; 1	170 \pm 25	γ	42
16.91 \pm 30	4 ⁺ ; 0 + 1	290 \pm 30	p, d, α	3, 10, 16
16.92 \pm 20 ^e	2 ⁺ ; 0 + 1	830 \pm 170	d, α	16
17.03 \pm 50	3 ⁻ ; 0 + 1	245 \pm 50	d, α	16
17.17 \pm 30	1 ⁻ ; 0 + 1	300 \pm 30	γ , p, d, α	3, 10, 16, 20, 21, 42
17.31 \pm 30	4 ⁺ ; 0 + 1	275 \pm 30	d, α	16, 19
17.40 \pm 25	4 ⁺ ; 0 + 1	245 \pm 25	d, α	16, 19
17.46	5 ⁻ ; 0			43
17.85 \pm 50 ^e	4 ⁺ ; 0 + 1	475 \pm 50	d, α	16
17.85 \pm 50 ^e	3 ⁻ ; 0 + 1	440 \pm 50	d, α	16
17.93 \pm 70 ^e	2 ⁺ ; 0 + 1	340 \pm 70	d, α	16
18.02 \pm 60	3 ⁻ ; 0 + 1	570 \pm 60	d, α	16
18.14 \pm 50	4 ⁺ ; 0 + 1	480 \pm 50	d, α	16, 43
18.35 \pm 60	1 ⁻ ; 0 + 1	560 \pm 60	d, α	16, 43
18.43 \pm 65	4 ⁺ ; 0 + 1	315 \pm 65	d, α	16, 43
18.50 \pm 10	5 ⁻ ; 0 + 1	62 \pm 10	d, α	16, 42
18.53 \pm 80	2 ⁺ ; 0 + 1	410 \pm 80	d, α	16
18.53 \pm 60	3 ⁻ ; 0 + 1	310 \pm 60	d, α	16
18.64 \pm 70	3 ⁻ ; 0 + 1	675 \pm 70	d, α	16, 43
18.78 \pm 35	1 ⁻ ; 0 + 1	315 \pm 35	d, α	16
18.88 \pm 50	4 ⁺ ; 0 + 1	475 \pm 50	d, α	16
18.93 \pm 50	2 ⁺ , 3 ⁻ ; 0 + 1	450 \pm 50	d, α	16
19.10 \pm 90	3 ⁻ ; 0 + 1	870 \pm 90	d, α	16
19.90 \pm 60	2 ⁺ ; 0 + 1	575 \pm 60	d, α	16
19.99 \pm 50	1 ⁻ ; 0 + 1	510 \pm 50	d, α	16
(20.11 \pm 20)	3 ⁻ , 4 ⁻ ; 0 + 1	120 \pm 20	γ	42, 43
20.63 \pm 110	4 ⁺ ; 0 + 1	1100 \pm 110	d, α	16

Table 14.12: Energy levels of ^{14}N ^a (continued)

E_x in ^{14}N ^b (MeV \pm keV)	$J^\pi; T$	τ_m or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
20.65 \pm 60	5 ⁻ ; 0 + 1	610 \pm 60	d, α	16
21.24 \pm 50	4 ⁺ ; 0 + 1	415 \pm 50	d, α	16
21.51 \pm 25	3 ⁻ ; 0 + 1	235 \pm 25	d, α	16
21.53 \pm 75	5 ⁻ ; 0 + 1	360 \pm 75	d, α	16
21.68 \pm 40	4 ⁺ ; 0 + 1	360 \pm 40	d, α	16
21.8	4 ⁺ ; 0 + 1	650	γ , ^3He	8
22.26 \pm 15	4 ⁺ ; 0 + 1	65 \pm 15	d, α	16
22.31 \pm 60	5 ⁻ ; 0 + 1	570 \pm 60	d, α	16
22.5	2 ⁻ ; $T = 1$		γ , p	24, 40
23.0	2 ⁻ ; $T = 1$	\approx 3000	γ , n, p	24, 40
23.40 \pm 70	5 ⁻ ; 0 + 1	640 \pm 70	d, α	16
24.0		\approx 1000	n, ^3He , α	8

^a See also Tables 14.13 and 14.14.

^b I am indebted to E.K. Warburton for sending me a reanalysis of the E_x of many of the states in ^{14}N with $E_x < 9.4$ MeV: see e.g. footnote ^b in Table 14.18.

^c The present evidence (E.K. Warburton, to be published) only supports the presence of one state at $E_x \approx 9.13$ MeV, with $J^\pi = 3^+$. The only remaining evidence for a doublet is the $^{12}\text{C}(^3\text{He}, p)^{14}\text{N}(p)^{13}\text{C}_{g.s.}$ work by (1974NO01).

^d With the exception of $^{14}\text{N}^*(16.9, 17.5, 21.8, 22.5, 23.0, 24.0)$, this state and all the higher states were derived from an S -matrix analysis of the $^{12}\text{C}(d, \alpha_1)$ reaction by (1981JO02).

^e See, however, Tables 14.22 and 14.23. I am indebted to F.C. Barker for his comments.

Ground state of ^{14}N : (1981AV02, 1982BA2G, 1982LO13, 1982NG01, 1983ANZQ, 1983VA31, 1984AN1B, 1984BR25, 1984WE04, 1985HA18).

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

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

$$\langle r^2 \rangle^{1/2} = 2.560 (11) \text{ fm (1980SC18). See also (1984BR25).}$$

$$\text{Natural abundance: } (99.634 \pm 0.009)\% \text{ (1984DE53).}$$

Table 14.13: Radiative decays in $^{14}\text{N}^a$

E_i (MeV)	$J_i^\pi; T$	E_f (MeV)	$J_f^\pi; T$	Branch (%)	Γ_γ (eV)
2.31	$0^+; 1$	0	$1^+; 0$	100	$(7.2 \pm 0.8) \times 10^{-3}$
3.95	$1^+; 0$	0	$1^+; 0$	3.9 ± 0.2	(M1) $(3.6 \pm 0.7) \times 10^{-4}$ (E2) $(2.8 \pm 0.2) \times 10^{-3}$
		2.31	$0^+; 1$	96.1 ± 0.2	0.079 ± 0.010
4.92	$0^-; 0$	0	$1^+; 0$	97 ± 3	$(8.4 \pm 1.6) \times 10^{-2}$
		2.31	$0^+; 1$	< 1	
		3.95	$1^+; 0$	^b	
5.11	$2^-; 0$	0	$1^+; 0$	79.9 ± 1.0	(E1) $(8.00 \pm 0.18) \times 10^{-5}$ ^c (M2) $(2.05 \pm 0.51) \times 10^{-6}$ ^{c,d} (E3) $(1.80 \pm 0.51) \times 10^{-6}$ ^{c,d}
		2.31	$0^+; 1$	19.4 ± 1.2	$(2.04 \pm 0.13) \times 10^{-5}$ ^c
		3.95	$1^+; 0$	(0.7 ± 0.4)	$(7.4 \pm 4.2) \times 10^{-7}$ ^c
5.69	$1^-; 0$	0	$1^+; 0$	36.1 ± 1.2 ^e	$(0.9 \pm 0.5) \times 10^{-2}$
		2.31	$0^+; 1$	63.9 ± 1.2 ^e	$(1.7 \pm 0.8) \times 10^{-2}$
5.83	$3^-; 0$	0	$1^+; 0$	21.3 ± 1.3 ^f	(M2) $(4.8 \pm 1.4) \times 10^{-6}$ ^c (E3) $(6.9 \pm 1.5) \times 10^{-6}$ ^c
		5.11	$2^-; 0$	78.7 ± 1.3 ^f	(M1) $(4.32 \pm 0.11) \times 10^{-5}$ ^c (E2) $(7_{-5}^{+8}) \times 10^{-8}$ ^c
6.20	$1^+; 0$	0	$1^+; 0$	23.1 ± 1.9 ^e	$(0.9 \pm 0.1) \times 10^{-3}$
		2.31	$0^+; 1$	76.9 ± 2.0 ^e	$(3.2 \pm 0.4) \times 10^{-3}$
6.45	$3^+; 0$	0	$1^+; 0$	70.1 ± 1.5 ^e	$(7.4 \pm 0.7) \times 10^{-4}$ ^g
		3.95	$1^+; 0$	19.7 ± 1.0 ^e	$(2.1 \pm 0.3) \times 10^{-4}$
		5.11	$2^-; 0$	6.5 ± 0.6 ^e	$(0.7 \pm 0.1) \times 10^{-4}$
		5.83	$3^-; 0$	3.7 ± 0.6 ^e	$(0.4 \pm 0.1) \times 10^{-4}$
7.03	$2^+; 0$	0	$1^+; 0$	98.6 ± 0.3	(M1) $(7.8 \pm 1.1) \times 10^{-2}$ ^h (E2) $(4.3 \pm 1.0) \times 10^{-2}$
		2.31	$0^+; 1$	0.5 ± 0.1	(E2) $(6.2 \pm 1.4) \times 10^{-4}$
		3.95	$1^+; 0$	0.9 ± 0.25	$< (11 \pm 3) \times 10^{-4}$
7.97 ⁱ	$2^-; 0$	0	$1^+; 0$	55 ± 3	0.010
		3.95	$1^+; 0$	45 ± 3	0.008
8.06 ^f	$1^-; 1$	0	$1^+; 0$	80.3 ± 0.6	9.9 ± 2.5

Table 14.13: Radiative decays in $^{14}\text{N}^a$ (continued)

E_i (MeV)	$J_i^\pi; T$	E_f (MeV)	$J_f^\pi; T$	Branch (%)	Γ_γ (eV)
8.49 ^f	4 ⁻ ; 0	2.31	0 ⁺ ; 1	1.40 ± 0.14	0.17 ± 0.05
		3.95	1 ⁺ ; 0	12.7 ± 0.4	1.56 ± 0.40
		4.92	0 ⁻ ; 0	1.86 ± 0.14	0.23 ± 0.06
		5.11	2 ⁻ ; 0	0.25 ± 0.14	0.03 ± 0.02
		5.69	1 ⁻ ; 0	3.5 ± 0.4	0.43 ± 0.12
		5.11	2 ⁻ ; 0	83 ± 3	(6.1 ± 1.5) × 10 ⁻³ j
8.62	0 ⁺ ; 1	5.83	3 ⁻ ; 0	17 ± 3	(1.3 ± 0.4) × 10 ⁻³ j
		0	1 ⁺ ; 0	23	1.20
8.79 ^f	0 ⁻ ; 1	3.95	1 ⁺ ; 0	24	1.26
		5.69	1 ⁻ ; 0	13	0.69
		6.20	1 ⁺ ; 0	40	
		0	1 ⁺ ; 0	90 ± 10	46 ± 12
8.91 ^f	3 ⁻ ; 1	0	1 ⁺ ; 0	1.6 ± 0.5	(6.6 ± 2.2) × 10 ⁻³
		5.11	2 ⁻ ; 0	5.4 ± 2.5	(2.3 ± 1.2) × 10 ⁻²
		5.83	3 ⁻ ; 0	89 ± 3	0.37 ± 0.10
		6.45	3 ⁺ ; 0	3 ± 1	0.012 ± 0.006
		7.03	2 ⁺ ; 0	1.4 ± 0.8	0.006 ± 0.004
8.96	5 ⁺ ; 0	0	1 ⁺ ; 0	< 1	
		6.45	3 ⁺ ; 0	100	(1.2 ± 0.2) × 10 ⁻³ k
9.13	3 ⁺ ; 0	0	1 ⁺ ; 0	82 ± 3	(8.5 ± 1.0) × 10 ⁻³ l
		5.83	3 ⁻ ; 0	9 ± 3	(0.9 ± 0.3) × 10 ⁻³ l
		6.45	3 ⁺ ; 0	9 ± 3	(0.9 ± 0.3) × 10 ⁻³ l
9.17 ^m	2 ⁺ ; 1	0	1 ⁺ ; 0	85.9 ± 1.0 ^e	6.2 ± 0.3
		2.31	0 ⁺ ; 1	0.86 ± 0.08 ^e	(6.2 ± 0.7) × 10 ⁻²
		5.69	1 ⁻ ; 0	0.50 ± 0.10 ^e	(3.6 ± 0.8) × 10 ⁻²
		5.83	3 ⁻ ; 0	0.62 ± 0.08 ^e	(4.5 ± 0.7) × 10 ⁻²
		6.45	3 ⁺ ; 0	8.9 ± 0.8 ^e	0.64 ± 0.07
		7.03	2 ⁺ ; 0	3.2 ± 0.3 ^e	0.23 ± 0.03
9.51 ^f	2 ⁻ ; 1	0	1 ⁺ ; 0	< 0.16	< 0.008
		3.95	1 ⁺ ; 0	6 ± 1	0.30 ± 0.09
		5.11	2 ⁻ ; 0	78 ± 3	3.84 ± 0.97

Table 14.13: Radiative decays in ^{14}N ^a (continued)

E_i (MeV)	$J_i^\pi; T$	E_f (MeV)	$J_f^\pi; T$	Branch (%)	Γ_γ (eV)
		5.83	$3^-; 0$	16 ± 2	0.79 ± 0.22
10.23	$1^{(-)}; 0$	2.31	$0^+; 1$	≈ 100	4 ± 1.3
10.43 ⁿ	$2^+; 1$	0	$1^+; 0$	81.4	10.21 ± 0.65
		5.11	$2^-; 0$	2.2	0.28 ± 0.04
		5.69	$1^-; 0$	1.9	0.24 ± 0.04
		6.45	$3^+; 0$	7.4	0.93 ± 0.12
		7.03	$2^+; 0$	7.0	0.88 ± 0.12
10.81	$5^+; 0$	6.45	$3^+; 0$	100	$(1.6 \pm 0.7) \times 10^{-2}$ ^o
11.05	3^+	0	$1^+; 0$		0.12 ± 0.02
		3.95	$1^+; 0$		0.09 ± 0.02

^a See Table 14.11 in (1981AJ01) for the earlier references and for additional comments. See also Table 14.14 here and (1981KO08) for additional discussions.

^b Two values have been reported: $(1.3 \pm 1.0)\%$ and $\leq 0.5\%$.

^c (1982BH06).

^d $\delta(\text{M2/E1}) = -0.16 \pm 0.02$, $\delta(\text{E3/E1}) = -0.15 \pm 0.025$: see (1981KO08).

^e Recalculated to sum to 100%: see Table 14.11 in (1981AJ01).

^f (1981KO08).

^g $\delta(\text{M3/E2}) = -0.004 \pm 0.010$.

^h $\delta(\text{E2/M1}) = 0.74 \pm 0.09$; and E.K. Warburton, private communication.

ⁱ $\Gamma_\gamma/\Gamma = (0.7 \pm 0.2)\%$; $(2J+1)\Gamma_p = 12.6 \pm 3.6$ eV; $\Gamma = 2.5 \pm 0.7$ eV.

^j $\Gamma = (3.5 \pm 0.5) \times 10^{-2}$ eV from Table 14.14; $\Gamma_p/\Gamma = 3.7 \pm 1.1$ [see (1981AJ01)] leads to $\Gamma_\gamma = 7.4 \pm 2.5$ meV.

^k $\Gamma = 6.3 \pm 1.0$ meV from Table 14.14; $\Gamma_p/\Gamma_\gamma = 4.1 \pm 0.5$.

^l $\Gamma_p = 43_{+31}^{-15}$ meV; $\delta(\text{M3/E2}) = -0.03 \pm 0.02$.

^m $\Gamma_\gamma = 7.2 \pm 0.4$ eV (1981BI17) [from $^{14}\text{N}(\gamma, \gamma)$].

ⁿ See (1983PR1B; preliminary work). Branching ratios from Γ_γ . See also (1981AJ01).

^o $\Gamma_\gamma/\Gamma = (4.1 \pm 0.8)\%$; $\Gamma = 0.39 \pm 0.16$ eV.

1. $^9\text{Be}(^7\text{Li}, 2n)^{14}\text{N}$

$$Q_m = 7.248$$

The energy of the $5.83 \rightarrow 5.11$ γ -transition is $E_\gamma = 728.34 \pm 0.10$ keV. When corrected for the nuclear recoil and added to $E_x = 5105.87 \pm 0.18$ keV, $E_x = 5834.23 \pm 0.21$ keV for $^{14}\text{N}^*(5.83)$ (1981KO08). For branching ratios and τ_m see Tables 14.13 and 14.14 (1981KO08).

Table 14.14: Lifetimes of some ^{14}N states ^a

E_x (MeV)	τ_m (fsec)	Reaction	Refs.
2.31	75 ± 19	$^{13}\text{C}(p, \gamma)$	(1972RE10)
	105 ± 15	$^{13}\text{C}(p, \gamma)$	(1977BI07)
	79 ± 7	$^{13}\text{C}(p, \gamma)$	(1980AN1E)
	<u>106 ± 10</u>	$^{14}\text{N}(\gamma, \gamma)$	<u>(1975RA22)</u>
	92 ± 10^A		
3.95	8.4 ± 0.4	$^{13}\text{C}(p, \gamma)$	(1977BI07)
	5.7 ± 0.7	$^{13}\text{C}(p, \gamma)$	(1980AN1E)
	<u>8.7 ± 0.9</u>	$^{14}\text{N}(e, e)$	<u>see reaction 45 in (1981AJ01)</u>
	8.0 ± 1.0^A		
4.92	7.6 ± 1.4^A		b
5.11	(6.2 ± 0.4) psec ^c	$^{12}\text{C}(^3\text{He}, p)$	(1978MO27)
	(6.27 ± 0.07) psec ^A	$^{11}\text{B}(\alpha, n)$	(1982BH06)
5.69	16 ± 8^A	$^{13}\text{C}(p, \gamma)$	(1977BI07)
5.83	(13.7 ± 1.1) psec	$^{12}\text{C}(^3\text{He}, p)$	(1978MO27)
	(12.9 ± 1.9) psec	$^9\text{Be}(^7\text{Li}, 2n)$	(1981KO08)
	<u>(11.88 ± 0.24) psec</u>	$^{11}\text{B}(\alpha, n)$	<u>(1982BH06)</u>
	(11.98 ± 0.23) psec		mean
6.20	185 ± 15	$^{13}\text{C}(p, \gamma)$	(1977BI07)
	<u>132 ± 8</u>	$^{13}\text{C}(p, \gamma)$	<u>(1980AN1E)</u>
	160 ± 20^A		e
6.45	620 ± 60^A		e
7.03	5.4 ± 0.5	$^{14}\text{N}(\gamma, \gamma)$	(1966SW01)
8.49 ^d	19 ± 3	$^{13}\text{C}(p, \gamma)$	(1978KE03) ^e
8.96	105 ± 17	$^{13}\text{C}(p, \gamma)$	(1978KE03) ^e
9.13	13 ± 5	$^{13}\text{C}(p, \gamma)$	(1978KE03)

A = adopted.

^a See also Tables 14.13 in (1976AJ04), 14.12 in (1981AJ01) and 14.22 here.

^b Based on unpublished measurements: see (1976AJ04).

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

^d See also (1981KO08).

^e I am indebted to P.M. Endt for his suggestions.

See (1981KO08) also for a general discussion of electromagnetic transitions in ^{14}C and ^{14}N , and comparison with theory.

$$2. \ ^{10}\text{B}(\alpha, \text{n})^{13}\text{N} \qquad Q_{\text{m}} = 1.0589 \qquad E_{\text{b}} = 111.6123$$

Observed resonances are displayed in Table 14.15. See also (1979BA48).

$$3. \ ^{10}\text{B}(\alpha, \text{p})^{13}\text{C} \qquad Q_{\text{m}} = 4.0616 \qquad E_{\text{b}} = 11.6123$$

Excitation functions have been measured to $E_{\alpha} = 26$ MeV. Observed resonances are displayed in Table 14.15. (1975WI04) has expanded the angular distributions of the $\text{p}_0 \rightarrow \text{p}_3$ groups into Legendre polynomials and fitted the coefficients at resonances corresponding to $^{14}\text{N}^*(13.16, 13.24, 13.67, 13.76)$ obtaining $J^{\pi} = 1^+, 2^-, 2$ or 3^+ , and 1, respectively, for these states. However an R -matrix analysis by (1983CS03) suggests $J^{\pi} = 2^-, 3^+, 1^+$ for $^{14}\text{N}^*(13.69, 13.74, 13.77)$. (1975WI04) finds that a surprising proportion of states have a higher cross section for neutron than for proton emission: the fluctuations of $\sigma_{\text{n}}/\sigma_{\text{p}}$ at low E_{α} suggest sizable isospin impurities in the ^{14}N states.

$$4. \ ^{10}\text{B}(\alpha, \text{d})^{12}\text{C} \qquad Q_{\text{m}} = 1.3399 \qquad E_{\text{b}} = 11.6123$$

Excitation curves have been measured at E_{α} up to 27 MeV [see (1970AJ04, 1976AJ04, 1981AJ01)]. The low energy resonances are exhibited in Table 14.15. At the higher energies the yield curves are fairly smooth although broad resonances in the d_1 and d_0 yields corresponding to $^{14}\text{N}^*(23, 25)$, respectively, have been reported as has a sharp rise in the 15.1 MeV γ yield ≈ 1 MeV above the $^{12}\text{C}^*(15.1) + \text{p} + \text{n}$ threshold, a channel which is not isospin forbidden: see (1981AJ01).

$$5. \ ^{10}\text{B}(\alpha, \alpha)^{10}\text{B} \qquad E_{\text{b}} = 11.6123$$

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 50.6 MeV: see (1981AJ01). Observed resonances are displayed in Table 14.15. In addition to two strong resonances in the α_0 yields at $E_{\alpha} = 2.21$ and 4.26 MeV ($^{14}\text{N}^*(13.19, 14.66)$), two other states ($^{14}\text{N}^*(13.72, 14.25)$) are required to fit the data: an R -matrix calculation leads to $J^{\pi} = 3^+, 1^+$ [see, however, (1975WI04)], 3^+ and 2^- for $^{14}\text{N}^*(13.19, 13.72, 14.25, 14.66)$: see (1981AJ01).

$$6. \ ^{10}\text{B}(^6\text{Li}, \text{d})^{14}\text{N} \qquad Q_{\text{m}} = 10.1371$$

Table 14.15: Resonances in $^{10}\text{B} + \alpha$ ^a

E_α (MeV \pm keV)	$\Gamma_{\text{c.m.}}$ (keV)	Outgoing particle (x) ^b	$^{14}\text{N}^*$ (MeV)	J^π
0.95		p_0	12.29	
1.13 ± 5	30 ± 5	$p_0 \rightarrow p_3, d$	12.42	4^-
1.20 ± 5	≈ 20	$p_0, (p_2), p_3$	12.47	
1.23 ± 5	35 ± 5	p_0, p_3	12.49	
1.40 ± 5	46 ± 4	$p_1, p_2, (p_3)$	12.61	3^+
1.507 ± 5	18 ± 5	$n_0, p_0, p_1, p_2, p_3, d, \alpha$ ^c	12.690	3^-
1.645 ± 5	16 ± 3	$n_0, p_0, p_1, p_2, p_3, d, \alpha$ ^d	12.789	4^+
1.68 ± 5	5 ± 2	p_1, p_2, p_3, d	12.814	4^-
1.83 ± 5	22 ± 4	$p_0 \rightarrow p_3, d$	12.921	4^+
2.174 ± 5	15 ± 5	$n_0, p_0 \rightarrow p_3, d, \alpha_1$	13.166	1^+
2.21 ± 10	65 ± 10	α_0	13.192	3^+
2.281 ± 10	92 ± 5	$n_0, p_0 \rightarrow p_3$	13.243	2^-
2.86 ± 5	≈ 90	n_0, p_1, p_2, α_1	13.656	
2.94 ± 5 ^e	105 ± 25	$n_0, p_0 \rightarrow p_3, d$	13.714	$2^-, 3^+$
2.98 ± 10 ^e	180 ± 20	$n_0, p_0, p_1, (p_2), \alpha_0$	13.74	$3^+, 1^{(+)}$
3.02 ± 10 ^e	120	p_1, p_3	13.77	(1^+)
3.40 ± 30	100	n_0, p_1	14.04	
3.56 ± 30	230	$n_0, (p_0), p_3$	14.16	
3.69 ± 50	420 ± 100	p, α_0	14.25	3^+
3.76 ± 20	150	p_1	14.30	
3.98 ± 20	100	n_0, p_0, p_2	14.56	
4.16 ± 30	50	n_0, p_0, p_3	14.59	
4.26 ± 10	100 ± 20	α_0	14.66	2^-
4.36 ± 30	125	$n_0, p_0, p_1, (p_2)$	14.73	
4.54 ± 30	140	n_0, p_2, p_3	14.86	
4.633 ± 30	43 ± 8	n_0, n_{2+3}, p_0	14.92	
4.77 ± 20	≈ 60	n_0, n_1	15.02	
5.08 ± 20	100	p_3	15.24	
5.35 ± 20	100	n_1, p_2, p_3	15.43	
6.44 ± 20	125	n_0, p_0, p_2	16.21	
6.70 ± 20	150	p_2	16.40	
7.42 ± 20		p_0	16.91	
7.78 ± 20	50	p_3	17.17	

^a See references in Table 14.13 in (1981AJ01) as well as in (1970AJ04, 1976AJ04). See also Table 1 in (1975WI04).

^b n_0, n_1, n_{2+3} correspond to $^{13}\text{N}^*(0, 2.37, 3.51 + 3.55)$; p_0, p_1, p_2, p_3 correspond to $^{13}\text{C}^*(0, 3.09, 3.68, 3.85)$ and the corresponding γ -rays; α_1 corresponds to the transition to $^{10}\text{B}^*(0.7)$. For θ_x^2 see Table 14.8 in (1970AJ04).

^c $\Gamma_x = 4.3, 0.62, 0.17, 0.70, 5.6, 0.93, 1.7$ keV for $n_0, p_0, p_1, p_2, p_3, d, \alpha$.

^d $\Gamma_x \leq 0.6, 0.18, 0.085, 0.44, 9.6, 2.0, 1.0$ keV for $n_0, p_0, p_1, p_2, p_3, d, \alpha$.

^e See (1983CS03).

States with $E_x > 10$ MeV studied in this reaction at $E(^6\text{Li}) = 34$ MeV are displayed in Table 14.16 (1984CL08). In addition most of the lower-lying $T = 0$ states have been populated: see (1970AJ04).

$$7. \ ^{10}\text{B}(^7\text{Li}, t)^{14}\text{N} \quad Q_m = 9.144$$

At $E(^7\text{Li}) = 24$ MeV angular distributions of the tritons to $^{14}\text{N}^*(3.95, 5.83, 6.45, 8.96, 9.13, 10.06, 10.81, 12.79 + 12.83, 13.03, 15.26)$ have been studied. $^{14}\text{N}^*(4.91, 5.11, 5.69, 6.20, 7.03, 7.97, 8.49, 8.98, 9.39, 11.05, 11.51, 12.42)$ are also populated: see (1981AJ01).

8. (a) $^{11}\text{B}(^3\text{He}, \gamma)^{14}\text{N}$	$Q_m = 20.7359$	
(b) $^{11}\text{B}(^3\text{He}, n)^{13}\text{N}$	$Q_m = 10.1824$	$E_b = 20.7359$
(c) $^{11}\text{B}(^3\text{He}, p)^{13}\text{C}$	$Q_m = 13.1853$	
(d) $^{11}\text{B}(^3\text{He}, d)^{12}\text{C}$	$Q_m = 10.4635$	
(e) $^{11}\text{B}(^3\text{He}, t)^{11}\text{C}$	$Q_m = -2.001$	
(f) $^{11}\text{B}(^3\text{He}, ^3\text{He})^{11}\text{B}$		
(g) $^{11}\text{B}(^3\text{He}, \alpha)^{10}\text{B}$	$Q_m = 9.1236$	
(h) $^{11}\text{B}(^3\text{He}, ^6\text{Li})^8\text{Be}$	$Q_m = 4.5720$	

The capture γ -rays [reaction (a)] have been studied at $E(^3\text{He}) = 0.9$ to 2.6 MeV ($\theta = 0^\circ, 90^\circ$). When the barrier penetration factor has been removed a single resonance is observed at $E(^3\text{He}) \approx 1.4$ MeV [$^{14}\text{N}^*(21.8)$], $\Gamma_{\text{c.m.}} = 0.65$ MeV.

The excitation function for reaction (b) has been measured for $E(^3\text{He}) = 1.5$ to 18 MeV [see (1981AJ01)]. A broad peak at $E(^3\text{He}) = 4.15$ MeV may indicate the existence of $^{14}\text{N}^*(24)$, $\Gamma \approx 1$ MeV.

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. This is also true for the ground-state deuterons of reaction (d) in the same energy interval. Yield curves for reaction (e) have been measured for $E(^3\text{He}) = 6$ to 30 MeV: see (1976AJ04). A_y measurements for t_0 and t_1 are reported at $E(^3\text{He}) = 33$ MeV by (1981BA1G). See also ^{13}C and ^{13}N , and $^{11}\text{B}, ^{11}\text{C}, ^{12}\text{C}$ in (1985AJ01).

Table 14.16: States in ^{14}N from $^{10}\text{B}(^6\text{Li}, \text{d})$, $^{11}\text{B}(^6\text{Li}, \text{t})$, $^{12}\text{C}(^6\text{Li}, \alpha)$ ^a

^b E_x (MeV \pm keV)	$d\sigma/d\Omega_{\text{c.m.}}$ ($\mu\text{b}/\text{sr}$) ^c		
	A	B	C
10.07 \pm 15	266	262	290
10.43 \pm 15		88	
10.81 \pm 15	234	164	
11.05 \pm 15	82	64	770
11.24 \pm 15		118	
11.27 \pm 15	74		1510
11.51 \pm 20	102	65	1170
11.79 \pm 20	55		
12.42 \pm 15	68	305	2702
12.66 \pm 30	82	286	1175
12.79 \pm 15		434	
12.81 \pm 15	149		
12.85 \pm 30			4960
12.92 \pm 20		324	
13.00 \pm 30	138		
13.19 \pm 20	80	234	
13.71 \pm 20	34	202	
14.57 \pm 20	183	217	
14.81 \pm 25		332	
14.85 \pm 30	189		2325
14.95 \pm 30		515	
15.00 \pm 30	157		
15.24 \pm 20	141	540	
15.40 \pm 50			1653
15.70 \pm 50	51		3530
16.20 \pm 50			1830
16.80 \pm 40		246	
16.91 \pm 30		297	
17.17 \pm 30		712	4860

A: $^{10}\text{B}(^6\text{Li}, \text{d})$; $E(^6\text{Li}) = 34$ MeV.

B: $^{11}\text{B}(^6\text{Li}, \text{t})$; $E(^6\text{Li}) = 34$ MeV.

C: $^{12}\text{C}(^6\text{Li}, \alpha)$; $E(^6\text{Li}) = 32$ MeV.

^a (1984CL08): see for angular distributions and for discussion of analog states in ^{14}C .

^b States below $E_x = 10$ MeV are not displayed here.

^c At $\theta_{\text{lab}} = 10^\circ$. Uncertainties in the differential cross sections are approximately $\pm 20\%$.

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. See also ^{10}B in (1984AJ01).

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. At $E(^3\text{He}) = 25.20$ to 26.25 MeV the excitation functions for the transitions to $^8\text{Be}^*(0, 16.63, 16.91, 17.64)$ are smooth, indicating a predominantly direct reaction mechanism: see (1976AJ04).

$$9. \ ^{11}\text{B}(\alpha, \text{n})^{14}\text{N} \quad Q_{\text{m}} = 0.1581$$

For angular distributions to $E_\alpha = 13.9$ MeV see (1981AJ01). For radiative transitions and τ_{m} see (1982BH06) in Tables 14.13 and 14.14. See also ^{15}N .

$$10. \ ^{11}\text{B}(^6\text{Li}, \text{t})^{14}\text{N} \quad Q_{\text{m}} = 4.9403$$

States with $E_{\text{x}} > 10$ MeV studied in this reaction at $E(^6\text{Li}) = 34$ MeV are displayed in Table 14.16 (1984CL08).

$$11. \ ^{11}\text{B}(^{11}\text{B}, ^8\text{Li})^{14}\text{N} \quad Q_{\text{m}} = -6.473$$

At $E(^{11}\text{B}) = 114$ MeV the relatively strongly populated states are $^{14}\text{N}^*(5.83, 8.96, 12.8)$ [$J^\pi = 3^-, 5^+, 4^+$]: see (1976AJ04).

$$12. \ ^{12}\text{C}(\text{d}, \gamma)^{14}\text{N} \quad Q_{\text{m}} = 10.27239$$

At 1.5 MeV the capture cross section is $< 1 \mu\text{b}$: see (1970AJ04).

$$13. \ (a) \ ^{12}\text{C}(\text{d}, \text{n})^{13}\text{N} \quad Q_{\text{m}} = -0.2811 \quad E_{\text{b}} = 10.27239$$

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

Resonances in the yields of neutrons and protons are displayed in Table 14.17. Earlier 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 0° yield of neutrons has also been

reported by (1981LI23: n_0 , 5.5 to 13.5 MeV; n_1 , 6 to 14 MeV): broad structures are observed at $E_d \approx 7.2$ and 11.5 MeV [n_0] and 8 and (10.8) MeV [n_1] as well as a sharper structure at $E_d \approx 9.5$ MeV [n_0]. The 25° excitation functions for n_0 , n_1 and n_{2+3} are reported for $E_d = 10.6$ to 13 MeV (1984SC04). See also (1981SH22). Excitation functions for proton groups ($p_0 \rightarrow p_3$) are also reported for $E_d = 0.5$ to 2.5 MeV (1980HA1X, 1983JI04).

The VAP and the 0° transverse vector polarization transfer coefficient $K_y^{y'}(0^\circ)$ have been measured for $E_d = 5.7$ 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). $K_y^{y'}(0^\circ)$ has also been measured in the range $E_d = 5 \rightarrow 12$ MeV by (1981LI23; n_0 , n_1). Polarization measurements are also reported at $E_d = 10$ MeV (1981DR1D; n_0) and 12.3 MeV (1981BR1E; n_0 , n_1 , n_{2+3}), and for reaction (b) at $E_d = 10$ MeV (1981DR1D; p_0), 11.35 MeV (1982BU03; p_0) and 56 MeV (1984HA26; $p_0 \rightarrow p_3$). For earlier polarization studies see Tables 14.12 (1970AJ04), 14.17 (1976AJ04) and (1981AJ01).

Table 14.17: Resonances in $^{12}\text{C} + \text{d}$ ^a

E_d (MeV \pm keV)	$\Gamma_{\text{c.m.}}$ (keV)	Particles out	$^{14}\text{N}^*$ (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	$1^-, 2^-$
1.715 ± 6	40 ± 9	p_2	11.741	$1^-, 2^-$
1.738 ± 6 ^b	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	$2^-, (1^+)$
1.870 ± 6	101 ± 9	p_0 , p_1 , p_2	11.874	$2^-, (1^-)$
2.250 ± 19	300 ± 30	n, $p_0 \rightarrow p_3$, d_0	12.20	$1^-, 2^-$
2.494 ± 3 ^c	37 ± 4	n, $p_0 \rightarrow p_3$, d_0	12.408	$3^+, (3^-, 4^-)$
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	
2.712 ± 3	48 ± 2	(n), $p_0 \rightarrow p_3$, d_0	12.594	3^+
(2.817 ± 7)	27 ± 6	n, p_1 , p_2 , p_3 , d_0	(12.684)	
2.844 ± 9	43 ± 15	p_2 , p_3	12.708	

Table 14.17: Resonances in $^{12}\text{C} + \text{d}$ ^a (continued)

E_d (MeV \pm keV)	$\Gamma_{\text{c.m.}}$ (keV)	Particles out	$^{14}\text{N}^*$ (MeV)	$J^\pi; T$
2.940 \pm 10	30 \pm 10	p ₂ , p ₃ , d	12.790	
2.967 \pm 5	37 \pm 6	p ₁	12.813	
2.982 \pm 6	11 \pm 3	n, p ₃ , d	12.826	
3.018 \pm 6	78 \pm 10	n, p ₀ , p ₁	12.857	
3.049 \pm 8	134 \pm 11	p ₁	12.883	
3.100 \pm 10	20 \pm 14	p ₁ , p ₂ , p ₃ , d	12.927	(3 ⁻ , 4 ⁻)
3.39 \pm 12	47 \pm 15	n, p ₂ , p ₃ , d	13.17	(0 ⁻ , 1 ⁻)
3.97 \pm 30	< 200	p ₀ , p ₂ , p ₃ , (d)	13.67	(2 ⁺ , 3 ⁺)
4.02 ⁺²⁰ ₋₁₀	\approx 235	n, (p), d	13.71	(1 ⁺)
4.40		p ₀ \rightarrow p ₃ , d	14.04	
4.55		n, p ₂ , d	14.17	
4.80		p ₀ , p ₂ , d	14.38	
5.17		d	14.70	
5.34	\approx 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	
7.448 ^d	240	α_2	16.65 ^d	4 ⁺
7.760 ^e	828	α_2	16.92	2 ⁺
7.784	293	α_2	16.94	4 ⁺
7.887	246	α_2	17.03	3 ⁻
8.034	307	α_2	17.15	1 ⁻
8.217	275	α_2	17.31	4 ⁺
8.327	244	α_2	17.40	4 ⁺
8.851	473	α_2	17.85	4 ⁺
8.852	437	α_2	17.85	3 ⁻
8.942 ^e	336	α_2	17.93	2 ⁺
9.051	567	α_2	18.02	3 ⁻
9.186	481	α_2	18.14	4 ⁺

Table 14.17: Resonances in $^{12}\text{C} + \text{d}$ ^a (continued)

E_d (MeV \pm keV)	$\Gamma_{\text{c.m.}}$ (keV)	Particles out	$^{14}\text{N}^*$ (MeV)	$J^\pi; T$
9.433	558	α_2	18.35	1^-
9.530 ^e	313	α_2	18.43	4^+
9.610	62	α_2	18.50	5^-
9.637 ^e	410	α_2	18.53	2^+
9.647 ^e	312	α_2	18.53	3^-
9.768	673	α_2	18.64	3^-
9.939	314	α_2	18.78	1^-
10.057	475	α_2	18.88	4^+
10.112	452	α_2	18.93	$2^+, 3^-$
10.306	872	α_2	19.10	3^-
11.237	575	α_2	19.90	2^+
11.348	506	α_2	19.99	1^-
12.094	1071	α_2, α_3	20.63	4^+
12.122	612	α_2	20.65	5^-
12.809	414	α_2	21.24	4^+
13.124	233	α_2	21.51	3^-
13.148 ^e	362	α_2	21.53	5^-
13.323	357	α_2	21.68	4^+
14.002 ^e	65	α_2	22.26	4^+
14.054	568	α_2	22.31	5^-
15.334	640	α_2	23.40	5^-

^a For references see Table 14.15 in (1976AJ04).

^b See also (1983JI04).

^c 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.

^d S -matrix analysis of α_2 by (1981JO02) leads to the resonance parameters for the states shown below, all of which are isospin-mixed. See also Table 14.14 in (1981AJ01) and Table 1 in (1981JO02). Uncertainties in $\Gamma_{\text{c.m.}}$ and E_x are about 10% of $\Gamma_{\text{c.m.}}$.

^e Uncertainties in $\Gamma_{\text{c.m.}}$ and E_x are about 20% of $\Gamma_{\text{c.m.}}$.

For continuum cross sections [reaction (b)] see (1980MA32; $E_d = 56$ MeV). For neutron production cross sections see (1984SH04). For total cross sections see (1980DE28, 1981PE01, 1983IM1A). For pion emission see (1981AL1K, 1984AL1L). For fragmentation studies see

(1980BO31, 1983AB01). See also (1980HA1N, 1983LIZW) and (1981NO1B, 1984NA06, 1985MAIL; theor.).

14. $^{12}\text{C}(\text{d}, \text{d})^{12}\text{C}$

$$E_b = 10.27239$$

Reported resonances are displayed in Table 14.17. Yield measurements of d_0 up to $E_d = 26.5$ MeV are listed in Table 14.16 of (1976AJ04). A recent measurement at $E_d = 0.5$ to 2.5 MeV is reported by (1980HA1X). See also (1981AJ01). For polarization measurements to $E_d = 52$ MeV see Table 14.17 in (1976AJ04), (1981AJ01) and (1984HA26: $E_{\bar{d}} = 56$ MeV; d_0). For polarization transfer in the deuteron breakup at $E_{\bar{d}} = 56$ MeV see (1985SA16). See also (1981DA1B, 1983JI04) and (1980HA56, 1980ST1K, 1982TA19, 1983BA1V; theor.).

15. (a) $^{12}\text{C}(\text{d}, \text{t})^{11}\text{C}$

$$Q_m = -12.4642$$

$$E_b = 10.27239$$

(b) $^{12}\text{C}(\text{d}, ^3\text{He})^{11}\text{B}$

$$Q_m = -10.4635$$

At $E_{\bar{d}} = 29$ MeV, polarizations of the groups to $^{11}\text{B}_{\text{g.s.}}$ and $^{11}\text{C}_{\text{g.s.}}$ have been studied by (1978CO13). VAP measurements to $^{11}\text{B}_{\text{g.s.}}$ are reported at $E_{\bar{d}} = 52$ MeV by (1981MA14).

16. $^{12}\text{C}(\text{d}, \alpha)^{10}\text{B}$

$$Q_m = -1.3399$$

$$E_b = 10.27239$$

Reported resonances are displayed in Table 14.17. Listing of the measurements of the yields of α -groups to $E_d = 29.5$ 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 (1971RI15, 1972SM07) 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). An S -matrix analysis leads to the resonance parameters shown in Table 14.17 (1981JO02). See also (1972SM07, 1974JO01).

Polarization measurements have been reported at $E_{\bar{d}} = 11$ to 29 MeV [see (1981AJ01)] and at 52 MeV (1982MA25; $\alpha_0, \alpha_1, \alpha_{3 \rightarrow 5}$).

17. $^{12}\text{C}(\text{d}, ^6\text{Li})^8\text{Be}$

$$Q_m = -5.8915$$

$$E_b = 10.27239$$

For polarization measurements see (1981AJ01) and (1983TA1Q, 1983YA1D; $E_{\vec{d}} = 51.7$ MeV).

$$18. \ ^{12}\text{C}(t, n)^{14}\text{N} \quad Q_m = 4.01511$$

Angular distributions have been measured to states below 8.7 MeV at $E_t = 1.12$ to 1.68 MeV and at 8 MeV: see (1976AJ04).

$$19. \ ^{12}\text{C}(^3\text{He}, p)^{14}\text{N} \quad Q_m = 4.7789$$

Observed proton groups are displayed in Table 14.18. Angular distributions have been measured for $E(^3\text{He})$ to 25.3 MeV [see (1970AJ04, 1976AJ04)] and at $E(^3\vec{\text{He}}) = 33$ MeV (1983RO22, 1983LE17; p_0, p_1, p_2). See also ^{15}O . For τ_m and $|g|$ measurements see Table 14.14. For inclusive proton measurements see (1984AA01; $E(^3\text{He}) = 52$ MeV). See also (1983CA07) and (1983GO2D; applied).

$$20. \ ^{12}\text{C}(\alpha, d)^{14}\text{N} \quad Q_m = -13.57434$$

Angular distributions of deuterons corresponding to $T = 0$ states in ^{14}N have been measured at $E_\alpha = 42$ and 55 MeV: see Table 14.19 in (1976AJ04), and (1981AJ01). At $E_\alpha = 34.5$ MeV a ZRDWBA analysis has been made of the angular distributions to $^{14}\text{N}^*(4.92, 5.11, 5.69, 5.83, 7.97, 8.49, 8.96, 9.13, 9.39, 10.81)$. Spectroscopic information on the 2^- states $^{14}\text{N}^*(5.11, 7.97, 9.13, 9.39)$ [but see Table 14.12] is also reported (1984YA03). At the higher energies 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).

$$21. \ ^{12}\text{C}(^6\text{Li}, \alpha)^{14}\text{N} \quad Q_m = 8.7972$$

At $E(^6\text{Li}) = 20$ MeV [see Table 14.9 in (1976AJ04)] and 32 MeV (1984CL08: see Table 14.16 here) many of the α -groups corresponding to $T = 0$ states with $E_x < 17.2$ MeV are observed. The spectrum is dominated by the α -group corresponding to the 5^+ state at 9.0 MeV: see (1970AJ04). Angular distributions have been measured for $E(^6\text{Li}) = 2$ to 33 MeV [see (1981AJ01)] and at $E(^6\text{Li}) = 3.2$ to 8.0 MeV (1981SC13; $\alpha_0 \rightarrow \alpha_2$). See also ^{18}F in (1983AJ01) and (1981MA26, 1983OS03; theor.).

Table 14.18: States of ^{14}N from $^{12}\text{C}(^3\text{He}, \text{p})^{14}\text{N}$ ^a

E_x (MeV \pm keV)	L	$J^\pi; T$	E_x (MeV \pm keV)	L	$J^\pi; T$
0	2		10.063 ± 15 ^e		$3^+, \geq 4$
2.319 ± 15	0		10.101 ± 15		$1^+, 2^+$
3.9502 ± 1.5 ^b	0		10.23		1
4.9153 ± 1.4 ^b	1		10.441 ± 15	^g	$(2^+; 1)$ ^h
$\equiv 5.10587 \pm 0.18$	1		10.53		1, 2
5.6888 ± 1.4 ^b	1		10.812 ± 15		$5^+; 0$
5.8324 ± 1.4 ^b	3		11.053 ± 15		
6.2025 ± 1.4 ^b	0		11.249 ± 15		
6.4449 ± 1.4 ^b	2		11.357 ± 15		
7.0279 ± 1.4 ^b	2		11.517 ± 15		
7.9649 ± 1.4 ^b	3		^f		
8.072 ± 15	1		12.29 ± 15		
8.4864 ± 1.5 ^{b,c}	3	$4^-; 0$	12.425 ± 15		
8.6174 ± 4 ^b	0	$(0^+; 1)$ ^h	12.506 ± 15		
8.9099 ± 1.9 ^{b,d}		$(3^-; 1)$ ^h	12.608 ± 15		
8.9598 ± 1.4 ^b			12.69 ± 15		
8.9773 ± 4 ^b		$(2^+; 0)$ ^h	12.80 ± 15		
9.1241 ± 1.5 ^b			12.90 ± 25 ^f		
9.1674 ± 1.4 ^b	^g	$(2^+; 1)$ ^h	13.15 ± 40		
9.3854 ± 1.6 ^{b,d}		$2^-; 0$ ⁱ	14.91 ± 60		
9.51		$(2^-; 1)$ ^h	15.8 ± 200		
9.703 ± 15		$(1^+; 0)$ ^h	17.4 ± 200		

^a See Tables 14.14 in (1970AJ04), 14.18 in (1976AJ04) and 14.15 in (1981AJ01) for references.

^b A re-evaluation by E.K. Warburton (private communication) [based on an overall comparison with γ -ray values) of the E_x obtained by (1971DU03) leads to $E_x = 3949.1 \pm 1.5, 4915.1 \pm 1.4, 5689.4 \pm 1.4, 5833.1 \pm 1.4, 6203.6 \pm 1.4, 6446.2 \pm 1.4, 7029.8 \pm 1.4, 7967.8 \pm 1.4, 8489.8 \pm 1.5, 8620.9 \pm 4.0, 8913.7 \pm 1.9, 8963.7 \pm 1.4, 8981.2 \pm 4.0, 9128.1 \pm 1.5, 9171.5 \pm 1.4$ and 9389.7 ± 1.6 keV.

^c $\Gamma_p/\Gamma = 0.73 \pm 0.10$.

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

^e $\Gamma < 10$ keV (J.W. Noe, private communication).

^f See Table 14.15 in (1981AJ01).

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

^h Known from other data; consistent with the results in this reaction.

ⁱ Or $J^\pi = 3^-$.

$$22. \text{}^{12}\text{C}(\text{}^{11}\text{B}, \text{}^9\text{Be})\text{}^{14}\text{N} \quad Q_m = -5.5431$$

At $E(\text{}^{11}\text{B}) = 114$ MeV the spectrum is dominated by groups to the 5^+ state at $E_x = 8.96$ MeV and to one or more of states at 12.9 MeV, presumably the 4^+ one: see (1981AJ01).

$$23. \text{}^{12}\text{C}(\text{}^{12}\text{C}, \text{}^{10}\text{B})\text{}^{14}\text{N} \quad Q_m = -14.9142$$

This reaction has been studied at $E(\text{}^{12}\text{C}) = 114$ MeV: the spectrum is dominated by $^{14}\text{N}^*(8.96)[J^\pi = 5^+]$ but there is substantial population also of $^{14}\text{N}^*(5.83)[3^-]$ and of a state at $E_x = 11.2$ MeV. Angular distributions are reported at $E(\text{}^{12}\text{C}) = 58$ to 64.5 MeV, at 93.8 MeV [see (1981AJ01)] and at $E(\text{}^{12}\text{C}) = 49.0$ to 75.5 MeV (1980CO10; involving also $^{10}\text{B}^*(0, 0.7)$; see also for excitation functions).

$$24. \text{(a) } \text{}^{13}\text{C}(\text{p}, \gamma)\text{}^{14}\text{N} \quad Q_m = 7.55062$$

$$\text{(b) } \text{}^{13}\text{C}(\text{p}, \text{p}'\gamma)\text{}^{13}\text{C} \quad E_b = 7.55062$$

Observed resonances are displayed in Table 14.19. Radiative decay and τ_m measurements are exhibited in Tables 14.13 and 14.14.

The low-energy capture cross section yields an extrapolated S -factor at $E_p = 25$ keV (c.m.), $S_0 = 6.0 \pm 0.8$ keV \cdot b. The capture cross section rises from $(7.7 \pm 1.8) \times 10^{-10}$ b at $E_p = 100$ keV to $(9.8 \pm 1.2) \times 10^{-9}$ b at $E_p = 140$ keV: see (1970AJ04).

Following is a summary of the reasons for the assignments of J^π ; T to some of the lower resonances displayed in Table 14.19: for a fuller discussion and complete references see (1970AJ04, 1976AJ04, 1981AJ01). $^{14}\text{N}^*(7.97)$: angular distribution of the γ -rays is consistent with $J^\pi = 2^-$. $^{14}\text{N}^*(8.06)$: width of resonance, isotropy of γ -rays show $l_p = 0$: $J^\pi = 1^-$ from $^{13}\text{C}(\text{p}, \text{p})$; E1 transition to g.s. is uninhibited e.g. $T = 1$ [but 1.4% $8.06 \rightarrow 2.31$ transition [$E_x = 2312.6 \pm 0.3$ keV] shows $T = 0$ admixture: $\alpha_2 = 0.046$]. The strong transition $8.06 \rightarrow 5.69$ [3.5%] permits either E1 or M1, $\Delta T = 1$. Since $5.69 \rightarrow 2.31$ is seen $^{14}\text{N}^*(5.69)$ cannot have $J^\pi = 0^+$, and 2^+ is excluded by the strength of the $8.62 \rightarrow 5.69$ transition. It is then $J^\pi = 1^-$; $T = 0$ [the isospin mixing $\alpha_2 = 0.09$]; $E_x = 5690.5 \pm 1.5$ keV. $^{14}\text{N}^*(8.49, 8.96, 9.13)$ correspond to anomalies in the cross section. The nature of their γ -decays [see Table 14.13] and the angular distribution leads to J^π ; $T = 4^-$; $0, 5^+$; $0, 3^+$; 0 , respectively.

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

$^{14}\text{N}^*(6.45)$ [see however Table 14.12] and $J = 2$ for $^{14}\text{N}^*(7.03)$. For a recent study of $^{14}\text{N}^*(9.17)$ see (1981BI17): $E_x = 9172.5 \pm 0.3$ keV from E_γ , $\Gamma_{\gamma_0}/\Gamma_\gamma = (79 \pm 4)\%$, Γ [from (p, p)] = 135 ± 8 eV [135 ± 11 eV in (γ, γ)]. Other E_x determined by (1981BI17) are 2312.90 ± 0.03 , 3948.2 ± 0.2 , 5105.9 ± 0.3 , 5691.55 ± 0.13 and 6446.3 ± 0.2 keV. See also Table 14.13.

Table 14.19: Levels of ^{14}N from $^{13}\text{C}(p, \gamma)^{14}\text{N}$ and $^{13}\text{C}(p, p)^{13}\text{C}$ ^a

E_p (MeV \pm keV)	$\Gamma_{\text{c.m.}}$ (keV)	l_p	$\omega\Gamma_\gamma$ (eV)	$J^\pi; T$	$^{14}\text{N}^*$ (MeV)
0.4485 \pm 0.5	< 0.37	2	0.022	2 ⁻	7.9669
0.551 \pm 1	30 \pm 1	0	9.2	1 ⁻ ; 1	8.062
1.012 \pm 2	\leq 0.2	4	\approx 0.01	(4 ⁻); 0	8.490
1.152 \pm 1.4 ^b	3.8 \pm 0.3	1	1.3	0 ⁺ ; 1	8.620
1.320 \pm 7 ^b	410 \pm 20	0	12.8	0 ⁻ ; 1	8.776
1.462 \pm 3	16 \pm 2	2	0.72	3 ⁻ ; 1	8.907
1.523 \pm 2	< 1		\approx 0.003	5 ⁺ ; 0	8.964
1.540 \pm 3	8 \pm 2	1, (3)	0.13	2 ⁺	8.980
1.7005 \pm 1	< 1			3 ⁺ ; 0	9.1287
1.7476 \pm 0.9 ^c	135 \pm 8 eV		^c	2 ⁺ ; 1	9.1724
1.980 \pm 3	13 \pm 3	2		3 ⁻ , 2 ⁻	9.388
2.110 \pm 3	41 \pm 2	2	6.2	2 ⁻ ; 1	9.509
2.319 \pm 4	15 \pm 3	1		1 ⁺	9.703
2.743 ^d	12 \pm 3	1	j	1 ⁺ , (2 ⁺)	10.096
2.885 \pm 10 ^d	80 \pm 15	0, 2		1 ⁽⁻⁾ ; 0	10.228
3.105 \pm 7 ^{d,e}	33 \pm 3	1	17	2 ⁺ ; 1	10.432
3.20 ^d	140	0, 2		1 ⁻	10.52
3.72 \pm 30 ^f	165 \pm 30				11.00
3.771 \pm 5	1.2 \pm 0.4		k	3 ⁺	11.050
3.79	100			1 ⁺	11.07
3.94 \pm 30	220 \pm 30				11.21
3.98 ^d	11	2		3 ⁻	11.24
4.04 ^d	175	2		2 ⁻	11.30
4.14 ^d	28	1		1 ⁺	11.39
4.525 \pm 15 ^g	115 \pm 10		l	1 ⁺	11.750
5.325 \pm 10	48 \pm 7		m		12.492
5.88 \pm 20 ^f	120 \pm 30				13.01

Table 14.19: Levels of ^{14}N from $^{13}\text{C}(p, \gamma)^{14}\text{N}$ and $^{13}\text{C}((p, p)^{13}\text{C})^a$ (continued)

E_p (MeV \pm keV)	$\Gamma_{\text{c.m.}}$ (keV)	l_p	$\omega\Gamma_\gamma$ (eV)	$J^\pi; T$	$^{14}\text{N}^*$ (MeV)
$6.20 \pm 100^{\text{h}}$	1000 ± 150		ⁿ	$(2^-); 1$	13.30
$6.62 \pm 20^{\text{f}}$					13.69
ⁱ					
16.1				$2^-; 1$	22.5
16.7				$2^-; 1$	23.0

^a See references in Tables 14.16 in (1970AJ04), 14.20 in (1976AJ04) and 14.16 in (1981AJ01).

^b (1985FEZY). See also (1984AD04).

^c See (1981BI17): $E_x = 9172.5 \pm 0.3$ keV from γ -ray measurements. See also Table 14.13, $\Gamma_{\gamma_0}/\Gamma_\gamma = (79 \pm 4)\%$; Γ_{γ_0} (from reaction 41) = 7.2 ± 0.4 eV; $\Gamma_{\text{c.m.}}$ from $^{13}\text{C}(p, p)$.

^d Reduced width for proton emission is of the order of 1% of the Wigner limit.

^e $\Gamma_{\gamma_0} = 11.2 \pm 1.4$ eV (1983PR1B; prelim.).

^f Weak resonance.

^g In the $\gamma_{3.09}$ channel the peak occurs 55 keV higher: interference effects may be present.

^h Part of the giant dipole resonance.

ⁱ Some broad structures appear in the $\gamma_0, \gamma_{3.68}$ and $\gamma_{3.85}$ yields. See also reaction 25.

^j $(2J + 1)\Gamma_\gamma = 0.5 \pm 0.2$ eV.

^k $\Gamma_\gamma = 1.2 \pm 0.4$ keV; $\Gamma_p = 0.5\%$ of single-particle unit. J^π based on angular distribution of γ_0 . For nature of γ -decay see Table 14.13.

^l $(2J + 1)\Gamma_\gamma = (18.5 \pm 4.2)\Gamma/\Gamma_p$ eV; if $J = 1, \Gamma_\gamma \geq 6$ eV.

^m $(2J + 1)\Gamma_{\gamma_0} = 2.3\Gamma/\Gamma_p$ eV; if $\Gamma = 38$ eV is assumed.

ⁿ $(2J + 1)\Gamma_{\gamma_0} \geq 200$ eV: thus the transition is dipole and $T = 1$. The resonance is asymmetric and it is suggested that two states are involved, 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 $^{14}\text{N}^*(10.23)$: $T = 0$ from $M^2(\text{M1})$ [see, however, Table 14.12]. The γ_0 angular distribution is consistent with $J = 2$ for $^{14}\text{N}^*(10.43)$: the similar decay characteristics of this state and of $^{14}\text{N}^*(9.17)$ 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. A number of resonances in the γ_0 yield and in the yield of the ground-state γ -rays from $^{13}\text{C}^*(3.09, 3.68, 3.85)$ have been observed: these are shown in Table 14.19 in the range $E_p = 3.7$ to 6.6 MeV. 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. Measurements of the γ_0 and $\gamma_1, 90^\circ$ yields $E_x = 23$ to 33 MeV find that the $T = 2$ resonances reported earlier 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. 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. A 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. The γ_0 results are in good agreement with those in the inverse reaction [$^{14}\text{N}(\gamma, p)^{13}\text{C}$]. 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. At $E_p = 25$ MeV strong transitions are observed to two groups of states centered near $E_x = 5.8$ and 8.9 MeV.

See also (1980WE1D, 1981WE1A, 1984SE16), (1981BA2F, 1982BA80, 1984BO1Q, 1984TR1C; astrophys.) and (1980SO1D, 1981AB1E, 1983GO1B; theor.).

25. $^{13}\text{C}(p, p)^{13}\text{C}$

$$E_b = 7.55062$$

The elastic scattering has been studied for $E_p = 0.14$ MeV to 1 GeV: see (1981AJ01) and ^{13}C here. For observed resonances see Table 14.19. A study of the $0^+ - 0^-$ doublet at $E_x \approx 8.7$ MeV is presented by (1984AD04). 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 (1978WE13). A_y measurements are reported at $E_{\bar{p}} = 200$ MeV (1981ME02) and 547 MeV (1984SE12; $p_0 \rightarrow p_4$ and to $^{13}\text{C}^*(7.55, 8.86, 9.5)$). See also (1976AJ04) and (1981CO1D; theor.).

26. $^{13}\text{C}(p, n)^{13}\text{N}$

$$Q_m = -3.0028$$

$$E_b = 7.55062$$

The yield of neutrons has been measured from threshold to $E_p = 13.7$ MeV: see (1970AJ04). Observed resonances are displayed in Table 14.20. The n_0 excitation function is also reported for $E_p = 10.1$ to 16.8 MeV (1981BY01; n_0). 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 the excited states of ^{13}N with neutron emission making this a convenient fast neutron calibration source. A_y measurements are reported for $E_{\bar{p}} = 6.88$ to 17.0 MeV (1981MU1C, 1981MU1D; n_0 ; prelim.) and 160 MeV (1981GO1D; $^{13}\text{N}^*(0, 3.5)$). For the earlier work see (1981AJ01). See also ^{13}N and (1981BY1C, 1984HE20).

27. $^{13}\text{C}(p, d)^{12}\text{C}$

$$Q_m = -2.7218$$

$$E_b = 7.55062$$

Excitation functions have been reported recently for $E_p = 16$ to 21 MeV (1982MA1H) and 200 to 500 MeV (1980KA01; d_0, d_1). A_y measurements have been made at $E_{\bar{p}} = 13.6$ to 14.4 MeV (1982BU03; d_0), 65 MeV (1980HO18; for d to $^{12}\text{C}^*(0, 12.71, 15.1, 16.1)$), (1982KA01; for d to $^{12}\text{C}^*(16.11)$), 200 and 400 MeV (1981LI06; d_0, d_1) and 530 MeV (1984OH06; d_0). See also ^{12}C in (1985AJ01), (1981IR1A) and (1982YA1A).

Table 14.20: Resonances in $^{13}\text{C}(\text{p}, \text{n})^{13}\text{N}$ (1961DA09) ^a

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

^a See also Table 14.9 in (1959AJ76).

^b (1959GI47).

$$28. \text{ (a) } ^{13}\text{C}(\text{p}, \text{t})^{11}\text{C} \quad Q_m = -15.186 \quad E_b = 7.55062$$

$$\text{ (b) } ^{13}\text{C}(\text{p}, ^3\text{He})^{11}\text{B} \quad Q_m = -13.1853$$

At $E_p = 49.6$ MeV polarization measurements have been carried out for the tritons and ^3He ions to the mirror groups $^{11}\text{B}^*(0, 2.12, 4.45, 5.02, 6.74, 12.91)$ and $^{11}\text{C}^*(0, 2.00, 4.32, 4.80, 6.48, 12.50)$ (1974MA12). A_y measurements are reported at $E_{\bar{p}} = 65$ MeV for the triton and ^3He groups to $^{11}\text{B}^*(0, 2.12)$ and $^{11}\text{C}^*(0, 2.00)$ (1982KA01).

$$29. ^{13}\text{C}(\text{p}, \alpha)^{10}\text{B} \quad Q_m = -4.0616 \quad E_b = 7.55062$$

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 $^{10}\text{B}^*(5.11)$) to 18 MeV. Total cross sections have also been obtained for the production of ^6Li , ^9Be and ^{10}B : the latter shows a great deal of structure. The analyzing power for the α_0 group has been measured at $E_{\bar{p}} = 65$ MeV: see (1981AJ01).

$$30. ^{13}\text{C}(\text{d}, \text{n})^{14}\text{N} \quad Q_m = 5.3260$$

Table 14.21: ^{14}N levels from $^{13}\text{C}(\text{d}, \text{n})$ and $^{13}\text{C}(\text{}^3\text{He}, \text{d})$ ^a

$^{14}\text{N}^*$ ^b (MeV \pm keV)	$J^\pi; T$ ^b	l_p ^c	l_j ^d	$(2J_f + 1)C^2S$ ^d
0	$1^+; 0$	1	$p_{1/2}$	2.27
2.31	$0^+; 1$	1	$p_{1/2}$	0.92
3.95	$1^+; 0$	1	$p_{3/2}$	1.10
4.92	$0^-; 0$	0	$s_{1/2}$	0.29
5.11	$2^-; 0$	2	$d_{5/2}$	1.79
5.69	$1^-; 0$	0	$s_{1/2}$	0.91
			$d_{3/2}$	0.29
5.83	$3^-; 0$	2	$d_{5/2}$	2.19
6.20	$1^+; 0$	1	$p_{1/2}$	0.032
6.45	$3^+; 0$	1	$f_{7/2}$	(0.1)
7.03	$2^+; 0$	1	$p_{3/2}$	0.31
7.97	$2^-; 0$		$d_{5/2}$	0.051
8.06	$1^-; 1$	0	$s_{1/2}$	0.10
			$d_{3/2}$	< 0.006
8.49	$4^-; 0$	4 ^{h,i}		
8.62	$0^+; 1$	1 ^j	$p_{1/2}$	0.021
8.79	$0^-; 1$		$s_{1/2}$	< 0.009
8.91	$3^-; 1$	2 ^k	$d_{5/2}$	3.32
8.98	$2^+; (0)$	(1, 2, 3)	$p_{3/2}$	< 0.2
9.12	$(2^-; 0)$ ^g	2	$d_{5/2}$	0.14
9.17	$2^+; 1$	(1, 3)	$p_{3/2}$	< 0.08
9.39	$2^-; 0$	2	$d_{5/2}$	0.62
9.51	$2^-; 1$	2	$d_{5/2}$	1.31
9.70	$1^+; 0$	1	$p_{1/2}$	0.039
10.085 \pm 12	$(1 - 3)^-$ ^e		$d_{5/2}$	0.054
10.222 \pm 12	$(0 - 2)^+$ ^e		$p_{1/2}$	0.16
10.534 \pm 20	$(0 - 2)^+$ ^{e,f}		$p_{1/2}$	0.34
10.81	$5^+; 0$ ^f			
11.05	(3^+) ^{e,f}			
11.26 \pm 50	$(0 - 2)^+$ ^{e,f}		$p_{1/2}$	0.22
11.49 \pm 40	$(0 - 2)^+$ ^{e,f}		$p_{3/2}$	0.040

Table 14.21: ^{14}N levels from $^{13}\text{C}(\text{d}, \text{n})$ and $^{13}\text{C}(^3\text{He}, \text{d})$ ^a (continued)

$^{14}\text{N}^*$ ^b (MeV \pm keV)	$J^\pi; T$ ^b	l_p ^c	l_j ^d	$(2J_f + 1)C^2S$ ^d
11.66 ± 40	$(0 - 2)^+$ ^{e,f}		$p_{1/2}$	0.092

^a See also Table 14.18 in (1981AJ01) and 14.23 in (1976AJ04).

^b From Table 14.12.

^c $^{13}\text{C}(\text{d}, \text{n})^{14}\text{N}$: $E_d = 4.5$ to 6.5 MeV.

^d $^{13}\text{C}(^3\text{He}, \text{d})^{14}\text{N}$: $E(^3\text{He}) = 43.6$ MeV (1981PE07); DWBA.

^e From (1981PE07).

^f $\Gamma \approx 200, 50, 50, 80, 80$ and 100 keV for $^{14}\text{N}^*(10.53, 10.81, 11.06, 11.26, 11.51, 11.66)$.

^g See, however, Table 14.12.

^h Observed in (d, n) and (^3He , d).

ⁱ $\Gamma_p < 9.9 \times 10^{-2}$ eV.

^j $\Gamma_p < 18$ keV.

^k $\Gamma_p = 12.1$ keV.

Observed neutron groups are displayed in Table 14.21. Angular distributions have been reported at many energies up to $E_d = 12$ MeV: see (1970AJ04). Comparisons of relative spectroscopic factors obtained in this reaction and in reaction 31 are shown in Table 14.23 of (1976AJ04): it appears that S_{rel} for $^{14}\text{N}^*(2.31)$ [$T = 1$] is smaller in this reaction than in the (^3He , d) reaction although simple DWBA calculations would suggest that the factors would be the same in both proton pickup reactions. The $\tau \cdot \mathbf{T}$ term appear to be energy dependednt: see Table 14.23 (1976AJ04). See also ^{15}N .

$$31. \ ^{13}\text{C}(^3\text{He}, \text{d})^{14}\text{N} \quad Q_m = 2.5071$$

Angular distributions have been studied at $E(^3\text{He}) = 13$ to 17 MeV [see (1976AJ04)] and at 43.6 MeV (1981PE07): see Table 14.21 for the states observed in this reaction. See also (1981AJ01).

$$32. \ ^{13}\text{C}(\alpha, \text{t})^{14}\text{N} \quad Q_m = -12.2634$$

Angular distributions have been measured at $E_\alpha = 27$ MeV for the α groups to $^{14}\text{N}^*(0, 2.31, 3.95, 4.92, 5.11)$. See also (1981AJ01).

$$33. \ ^{13}\text{C}(^7\text{Li}, ^6\text{He})^{14}\text{N} \quad Q_m = -2.424$$

Table 14.22: ^{14}N states from $^{14}\text{N}(\gamma, \gamma')$ and $^{14}\text{N}(e, e')$ ^a

E_x (MeV \pm keV)	Mult.	$J^\pi; T$	Γ_{γ_0} (eV)	Γ (keV)
8.06	E1	$1^-; 1$	10.5 ± 6	
8.91	M2	$3^-; 1$	$(6.6 \pm 2.2) \times 10^{-3}$	
9.17	M1	$2^+; 1$	7.2 ± 0.4 ^b	
			6.3 ± 0.3 ^c	
10.43 ^d	M1	$2^+; 1$	9.6 ± 1.9 ^e	
11.24 ^f	C3	(3^-)		
12.54 ± 100 ^e	(M1, C2)	$J = 0 \rightarrow 3$	$\frac{14.7 \pm 3.2}{2J + 1}$	
12.81 ^f	C3	4^-		
13.27 ± 100 ^e	(M1, M2, C2)	$J = 0 \rightarrow 3$		
13.76 ± 100 ^e	(M1, C1)	$J = 0 \rightarrow 2$	$(4 \pm 1) \times 10^{-3}$ ^g	
14.72 ± 30 ^f	M2	$(2^-; 1)$		≈ 100
15.01 ± 30 ^f	M4	$3^-, 4^-; \approx 1$		≈ 100
16.11 ± 100 ^e	(M2)	$J = 0 \rightarrow 3$		
16.91 ± 20 ^f	M4	$5^-; \approx 1$		170 ± 20
18.48 ± 40 ^f	M4	$5^-; \approx 1$		
20.11 ± 20 ^f	M4	$3^-, 4^-; \approx 1$		120 ± 20

^a See Table 14.19 in (1981AJ01) for references and additional information. See also Tables 14.13 and 14.14 here.

^b (1981BI17).

^c A. Richter and G. Kuehner, private communication.

^d $\Gamma = 44$ keV, $\Gamma_{\gamma_0} = 8.8$ eV (A. Richter and G. Kuehner, private communication).

^e (1979EN01).

^f (1984BE13).

^g And $\Gamma = 105 \pm 20$ keV (A. Richter and G. Kuehner, private communication).

At $E(^7\text{Li}) = 34 \text{ MeV}$ $^{14}\text{N}^*(0, 2.31, 3.95, 5.11, 5.69, 5.83, 7.03, 8.91)$ are populated: the ground state is dominant (1984CL08). See also (1981AJ01) and reaction 17 in ^{14}C .

$$34. \text{}^{13}\text{C}(^{13}\text{C}, \text{}^{12}\text{C})^{14}\text{C} \quad Q_m = 3.3866$$

For fusion cross sections [and population of a 6.73 MeV γ -ray] see (1982CH05).

$$35. \text{}^{14}\text{C}(\beta^-)^{14}\text{N} \quad Q_m = 0.15647$$

See ^{14}C .

$$36. \text{}^{14}\text{C}(\pi^+, \pi^0)^{14}\text{N} \quad Q_m = 4.761$$

Forward-angle differential cross sections for the isobaric-analog state have been measured at $E_{\pi^+} = 100, 165, 230$ and 295 MeV (1983IR04). See also (1984KNZY, 1985KNZZ; $E_{\pi^+} = 35 - 100 \text{ MeV}$) and (1985KA04).

$$37. \text{}^{14}\text{C}(p, n)^{14}\text{N} \quad Q_m = -0.6259$$

Angular distributions, generally for the n_0, n_1 and n_2 groups, have been measured in the range $E_p = 2.45$ to 35 MeV [see (1981AJ01)] and at $25.7, 35$ and 45 MeV (1984TA02). (1984TA07) have measured the transverse spin-transfer coefficients [$D_{\text{NN}}(0^\circ)$] at 160 MeV for the groups to $^{14}\text{N}^*(0, 2.31 [D_{\text{NN}} = 1], 3.95, 13.72)$. The main GT strength lies in the three 1^+ states and their D_{NN} values, which are consistent with $\frac{1}{3}$, are those expected for pure $L = 0$ transitions (1984TA07). See also (1982MAZZ, 1983OR1D, 1985OR1G, 1985OR1H), (1981GO1H, 1982GO1C, 1982TA03, 1982YA1A, 1983TA1F, 1984TAZS, 1985TA1T) and (1982TO1C, 1983BO24, 1984HA58; theor.).

$$38. \text{}^{14}\text{C}(^3\text{He}, t)^{14}\text{N} \quad Q_m = 0.1379$$

At $E(^3\text{He}) = 44.8 \text{ MeV}$, triton groups are observed corresponding to all known levels of ^{14}N with $E_x < 7.1 \text{ MeV}$. Triton groups were also seen to unresolved states with $E_x = 8.0 \rightarrow 9.5 \text{ MeV}$, to $^{14}\text{N}^*(10.43)$ and to excited states with $E_x = 12.49 \pm 0.04, 12.83 \pm 0.05$ and $13.70 \pm 0.04 \text{ MeV}$. 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 $^{14}\text{N}^*(2.31, 3.95, 13.7)$, $L = 1$ to $^{14}\text{N}^*(5.11)$, $L = 2$ to $^{14}\text{N}^*(0, 7.03, 10.43)$ and $L = 3$ to $^{14}\text{N}^*(5.83)$ (1969BA06).

39. (a) $^{14}\text{C}(^6\text{Li}, ^6\text{He})^{14}\text{N}$ $Q_m = -3.350$
 (b) $^{14}\text{C}(^7\text{Li}, ^7\text{He})^{14}\text{N}$ $Q_m = -11.05$

Angular distributions have been studied at $E(^6\text{Li}) = 34$ MeV (1981CU02; to $^{14}\text{N}^*(0, 3.95, 5.11)$), at 62 MeV (1980WH03; to $^{14}\text{N}^*(0, 2.31, 3.95, 5.11, 5.83, 6.20, 7.03, 8.49)$), and at 210 MeV (1985AN1H; to $^{14}\text{N}^*(3.95)$; prelim.). At $E(^6\text{Li}) = 93$ MeV and $E(^7\text{Li}) = 78$ MeV (1984GL06) report the population of a number of states: the most intense groups are to $^{14}\text{N}^*(0, 3.95, 5.0, 7.0, 8.5)$. (1980WH03) have measured the total GT strength up to $E_x \approx 12$ MeV. See also (1981AJ01), (1982AL1F, 1983AL1L) and (1983GA12; theor.).

40. (a) $^{14}\text{N}(\gamma, n)^{13}\text{N}$ $Q_m = -10.5535$
 (b) $^{14}\text{N}(\gamma, p)^{13}\text{C}$ $Q_m = -7.55062$
 (c) $^{14}\text{N}(\gamma, d)^{12}\text{C}$ $Q_m = -10.27239$

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. 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: see (1981AJ01). 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}N g.s. Some evidence is found for the existence of $J^\pi = 0^-$ strength at the peak of the giant resonance and for a small amount of isospin $T = 0$ mixing near 22.5 MeV: see (1981AJ01).

The (γ, p_0) and (γ, p_2) cross sections and angular distributions have been measured in the giant resonance region. The giant dipole states [$(p_{3/2})^{-1}(2s1d)$] which decay by p_0 emission to $^{13}\text{C}^*(3.68)$ appear to 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: see (1976AJ04) and (1983VA1K).

For reaction (c) see (1980IS1E) and reaction 42. See also (1982JU03) and (1982VI07; applied).

41. $^{14}\text{N}(\gamma, \gamma)^{14}\text{N}$

See (1981BI17) and Table 14.12. See also (1985SM1G) and (1983ZH1D; theor.).

42. (a) $^{14}\text{N}(e, e')^{14}\text{N}$

(b) $^{14}\text{N}(e, d)^{12}\text{C}$

$$Q_m = -10.27239$$

Form factors have been determined at many energies in the range $E_e = 60.7$ to 300 MeV: see (1981AJ01) for the earlier references and (1984HU07; $q = 0.80$ fm $^{-1}$ to 3.33 fm $^{-1}$; to $^{14}\text{N}^*(0, 2.31)$) and (1984BE13; see Table 14.22 and below). In addition to the states above $E_x = 11$ MeV reported in Table 14.22, (1984BE13) have populated $^{14}\text{N}^*(12.50, 13.17, 13.71, 15.43, 15.7, 17.2, 17.8)$ but not the 5^- states at $E_x = 14.66$ and 17.46 MeV which are thus presumably $T = 0$. (1984BE13) report that within the triplet of 5^- states at $14.66, 16.91, 17.46$ MeV, they can account for $\approx 60\%$ of the isovector 5^- strength but only 35% of the isoscalar strength. There is no other significant M4 strength up to $E_x \approx 28$ MeV (1984BE13). See (1981AJ01) for the earlier work.

For reaction (b) see (1980TA15) and reaction 40. See also (1984DO20, 1984LI25, 1985HI04) and (1981DE1T, 1981IS11, 1981KE15, 1983AL04, 1983DE13, 1983GM1A, 1984VO1G; theor.).

43. $^{14}\text{N}(\pi^\pm, \pi^\pm)^{14}\text{N}$

Angular distributions at $E_{\pi^\pm} = 162$ MeV have been studied to the states listed in Table 14.23 (1983GE03). See the the “GENERAL” section here.

44. $^{14}\text{N}(n, n')^{14}\text{N}^*$

Angular distributions of elastically and inelastically scattered neutrons are displayed in Table 14.23 of (1970AJ04). See also (1984TEZZ; $n_0; 11, 14, 17$ MeV). Observed γ -rays are shown in Table 14.25 of (1976AJ04).

45. (a) $^{14}\text{N}(p, p')^{14}\text{N}^*$

(b) $^{14}\text{N}(p, p\alpha)^{10}\text{B}$

$$Q_m = -11.6123$$

Angular distributions of elastically and inelastically scattered protons have been studied at many energies up to $E_p = 155$ MeV [see (1981AJ01)] and at $E_{\bar{p}} = 21$ MeV (1982AO05; p_0, p_1, p_2) and 159.4 MeV (1983TA12; p_0, p_1, p_2), as well as at $E_p = 800$ MeV (1982BL08; p_0, p_2 and p to $^{14}\text{N}^*(5.83, 7.03, 7.97, 8.49)$: see Table 14.24. The spin-flip probability has been measured at $E_{\bar{p}} = 32$ MeV to $^{14}\text{N}^*(2.31)$ by (1981CO08). For reaction (b) see (1984VD1C; $E_p = 50$ MeV). See also (1981AJ01), ^{15}O , (1983BE1R, 1984DE1F), (1983SC1G), (1984HA1Q; applied), (1984BO1Q; astrophys.) and (1981FE04, 1981IS11, 1983GO10, 1983IK1B, 1984HUZY; theor.).

Table 14.23: States of ^{14}N from $^{14}\text{N}(\pi^\pm, \pi^\pm)$ (1983GE03)

E_x (MeV)	$J^\pi; T$	Mult.	$B(E\lambda) \uparrow (e^2 \cdot \text{fm}^{2\lambda})$
0			
3.95		E2	2.8 ± 0.4
4.92			
5.11		E3	74 ± 10
5.69			
5.83		E3	117 ± 18
7.03		E2	3.95 ± 0.7
8.49			
11.24		E3	110 ± 12
12.79		E3	151 ± 17
13.14		E3	31 ± 8^b
14.66	$5^-; 0 + 1$		
15.10			
15.57	$2, 3, 4^-; 0$	E3	$10(2J + 1)$
16.06	$3^-; 0$		
16.86	$5^-; 1 + 0$		
17.46	$5^-; 0 + 1$		
17.89	$2^- + 4^-; 0$		
a			
18.70	$(3^-); 0 + 1$		
20.10	$(3^-); 0 + 1$		

^a States at $E_x = 18.2$ and 18.4 MeV are also populated.

^a $J^\pi = 2^-$ assumed.

Table 14.24: ^{14}N levels from $^{14}\text{N}(p, p')$, (d, d') , $(^3\text{He}, ^3\text{He}')$ and (α, α') ^a

$^{14}\text{N}^*$ (MeV \pm keV)				L	Dominant config.	$J^\pi; T$
(p, p') ^b	(d, d')	$(^3\text{He}, ^3\text{He}')$	(α, α')			
2.31 ^c	see text	e	see text		$(p_{1/2})^2$	$0^+; 1$
3.95	e	e	e	2	$(p_{1/2})^2 + \text{c.e.}$ ⁱ	$1^+; 0$
4.92	e	e	e,h	1	$p_{1/2}s_{1/2}$	$0^-; 0$
5.11	e	e	e,h	3	$p_{1/2}d_{5/2}$	$2^-; 0$
5.69	e	e	e,h	1	$p_{1/2}s_{1/2}$	$1^-; 0$
5.83	e	e	e,h	3	$p_{1/2}d_{5/2}$	$3^-; 0$
6.20 ^d	e	e	e,f		$(s_{1/2})^2$	$1^+; 0$
6.45 ^d	e		e,f		$s_{1/2}d_{5/2}$	$3^+; 0$
7.03	e	e	e	2	c.e. ⁱ	$2^+; 0$
7.97			e,h	1	$p_{1/2}d_{3/2}$	$2^-; 0$
8.06 ^c		8.0 \rightarrow 11.0 ^g			$p_{1/2}s_{1/2}$	$1^-; 1$
8.49			e,h	3		$4^-; 1$
8.62					$(s_{1/2})^2$	$0^+; 1$
8.91					$p_{1/2}d_{5/2}$	$3^-; 0$
			9.12 ^h	3		$2^-; 0^j$
9.17					c.e. ⁱ	$2^+; 1$
9.39			e,h	3		$2^-, 3^-; 0$
9.51					$p_{1/2}d_{5/2}$	$1^+; 0$
9.70					$(p_{1/2})^2$	$1^+; 0$
10.1					$s_{1/2}d_{5/2}$	$2^+, 1^+; 0$
			10.98 ^h	3		
11.2 \pm 200	f	11.22 \pm 50	11.21 ^h	3		(3^-)
			12.59 ^h	3		3^-
12.8 \pm 400	f	12.77 \pm 50	12.78 ^h	3		4^-
			13.13 ^h	3		2^-
			15.41 ^h	3		$\pi = -$
17						
21.5						

- ^a For references see Tables 14.20 in (1981AJ01) and 14.27 in (1976AJ04). Most of the L -values shown here are from the (α, α') work of (1982PE05).
- ^b See text of reaction 47 in (1981AJ01) and reactions 45 here.
- ^c Not observed at $E_p = 800$ MeV (1982BL08).
- ^d Weakly populated at $E_p = 800$ MeV (1982BL08).
- ^e Observed.
- ^f Relatively low cross section due to two-nucleon transition.
- ^g Unresolved structure.
- ^h (1982PE05): $E_\alpha = 34.85$ MeV.
- ⁱ c.e. = compound elastic.
- ^j See, however, Table 14.12.

46. $^{14}\text{N}(d, d')^{14}\text{N}^*$

Angular distributions of elastically and inelastically scattered deuterons have been studied to $E_d = 52$ MeV: see (1981AJ01) and Table 14.24 for the listing of the observed states. The deuteron group to the $0^+, T = 1$ state $^{14}\text{N}^*(2.31)$ is isospin forbidden: its cross section is 1 – 2 orders of magnitude less than that to $^{14}\text{N}^*(3.95) [J^\pi; T = 1^+; 0]$. It is summarized for $E_d = 6$ 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.

47. $^{14}\text{N}(^3\text{He}, ^3\text{He}')^{14}\text{N}^*$

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

At $E(^3\text{He}) = 44.6$ MeV, twelve ^3He groups are reported corresponding to states in ^{14}N : see Table 14.24. 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 $^{14}\text{N}(^3\text{He}, t)^{14}\text{O}(\text{g.s.})$, $^{14}\text{N}(^3\text{He}, ^3\text{He}')^{14}\text{N}^*(2.31)$ and $^{14}\text{C}(^3\text{He}, t)^{14}\text{N}(0)$ [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: see (1976AJ04).

48. $^{14}\text{N}(\alpha, \alpha')^{14}\text{N}^*$

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, 1981AJ01), as well

as (1982PE05; $E_\alpha = 34.85$ MeV) in Table 14.24 here. Generally the intensity of the α_1 group is weak: see also ^{18}F in (1983AJ01). See also (1983SA07) and (1980SP1E, 1982BU1D, 1983GO27; theor.).

49. (a) $^{14}\text{N}(^6\text{Li}, ^6\text{Li})^{14}\text{N}$
 (b) $^{14}\text{N}(^7\text{Li}, ^7\text{Li})^{14}\text{N}$
 (c) $^{14}\text{N}(^6\text{Li}, \alpha d)^{14}\text{N}$ $Q_m = -1.4751$

Elastic angular distributions have been measured at $E(^6\text{Li}) = 19.5$ and 32 MeV [see (1981AJ01)] and at 36 MeV (1983ET02) as well as at $E(^7\text{Li}) = 36$ MeV: see (1981AJ01). See also (1979KN1A). For reaction (c) see ^{18}F in (1987AJ02), (1983ET02).

50. $^{14}\text{N}(^9\text{Be}, ^9\text{Be})^{14}\text{N}$

For fusion cross sections see (1984MA28).

51. (a) $^{14}\text{N}(^{10}\text{B}, ^{10}\text{B})^{14}\text{N}$
 (b) $^{14}\text{N}(^{11}\text{B}, ^{11}\text{B})^{14}\text{N}$

Elastic angular distributions have been measured for reaction (a) at $E(^{10}\text{B}) = 100$ MeV and $E(^{14}\text{N}) = 73.9$ and 93.6 MeV [see (1981AJ01)] as well as at 86 MeV (1982OR02). Those for reaction (b) have been studied at $E(^{14}\text{N}) = 41, 77$ and 113 MeV: see (1981AJ01). For fusion and other yield measurements see (1980PA19, 1982BE54, 1982OR02) for (a) and (1983DA10) for (b). See also (1981AJ01), (1982HO1F), (1983BI1A, 1984FR1A, 1984HA53) and (1981AB1A, 1983GO13, 1984HA43, 1984IN03; theor.).

52. $^{14}\text{N}(^{12}\text{C}, ^{12}\text{C})^{14}\text{N}$

Elastic and inelastic angular distributions have been studied in the range $E(^{14}\text{N}) = 21.3$ to 155 MeV: see (1981AJ01). For fusion cross-section measurements and for yield measurements see (1981AJ01) and (1981CO11, 1984GO1C, 1985CA01). For evaporation studies see (1982BO1M, 1983QU02). See also (1981DIZW, 1983CA1N, 1983DA10), (1981ST1P, 1983BI1A, 1983DU13, 1984FR1A, 1984HA53) and (1981CH23, 1981CU06, 1981DE13, 1981VA1E, 1981VA1H, 1982BL12, 1982HA42, 1982HA56, 1982HU1G, 1982LO13, 1983CI08, 1983GO13, 1984HA43, 1984MAZT; theor.).

53. $^{14}\text{N}(^{13}\text{C}, ^{13}\text{C})^{14}\text{N}$

Elastic angular distributions have been measured at $E(^{14}\text{N}) = 19.3$ MeV [see (1981AJ01)] and 28 and 35 MeV (1983SR01) as well as at $E(^{13}\text{C}) = 105$ MeV (1980PR09). For fusion studies see (1980WI09, 1982DI13). See also (1983BI1A, 1984FR1A, 1984HA53) and (1983GO13; theor.).

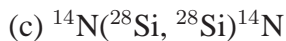
54. $^{14}\text{N}(^{14}\text{N}, ^{14}\text{N})^{14}\text{N}$

Elastic angular distributions have been studied for $E(^{14}\text{N}) = 4.99$ to 20.22 MeV: see (1981AJ01). For fusion and reaction cross-section measurements see (1981AJ01) and (1982DE39, 1982TR1C). See also (1983DA10), (1981ST1P, 1983BI1A, 1984FR1A, 1984HA53) and (1981AB1A, 1982HA42, 1982LO13, 1984HA43, 1984IN03; theor.).

55. $^{14}\text{N}(^{16}\text{O}, ^{16}\text{O})^{14}\text{N}$

Elastic angular distributions have been studied for $E(^{14}\text{N}) = 8.08$ to 155 MeV: see (1981AJ01). For fusion cross-section measurements see (1981AJ01) and (1981VO01). See also (1982FI1G, 1983DA10), (1981ST1P, 1983BI1A, 1983DU13, 1984FR1A) and (1982HA42, 1982LO13, 1983CI08, 1984HA43, 1984IN03; theor.).

56. For other heavy-ion reactions see (1981AJ01).



Elastic angular distributions are reported at $E(^{14}\text{N}) = 53.03$ MeV for reaction (a), 52.29 MeV for (b) and 53.40 MeV for (c) (1981MA02) and at $E(^{14}\text{N}) = 40, 46$ and 56 MeV for reactions (b, c, d) (1983CR1B; prelim.). For fusion and fragmentation studies see (1981BI10, 1981TA22, 1983CR1B, 1984GU05, 1985GU1M). See also (1981AJ01) and (1982DM1A, 1984SHZY), (1983BI1A) and (1980BI13, 1982FR1Q, 1983CE1C, 1985BE09, 1985BL09; theor.).

57. $^{14}\text{O}(\beta^+)^{14}\text{N}$

$$Q_m = 5.1431$$

$^{14}\text{O}_{\text{g.s.}}$ decays predominantly to its analog state $^{14}\text{N}^*(2.31)$: $E_x = 2312.798 \pm 0.011$ keV (1982WA16): see reaction 1 in ^{14}O .

58. $^{15}\text{N}(\gamma, n)^{14}\text{N}$ $Q_m = -10.8333$

For cross sections see (1982JU03, 1983WA03) in ^{15}N . See also (1981AJ01).

59. $^{15}\text{N}(\text{p}, \text{d})^{14}\text{N}$ $Q_m = -8.6087$

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

60. $^{15}\text{N}(^3\text{He}, \alpha)^{14}\text{N}$ $Q_m = 9.7445$

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

61. $^{15}\text{N}(^{13}\text{C}, ^{14}\text{C})^{14}\text{N}$ $Q_m = -2.6568$

At $E(^{15}\text{N}) = 30, 32$ and 45 MeV the angular distributions involving $^{14}\text{N}^*(0, 2.31)$ have been studied: they are symmetric about 90° for the transition to the $T = 1$ analog state $^{14}\text{N}^*(2.31)$: see (1981AJ01).

62. (a) $^{16}\text{O}(\pi^+, 2\text{p})^{14}\text{N}$ $Q_m = 117.3888$
 (b) $^{16}\text{O}(\pi^-, 2\text{n})^{14}\text{N}$ $Q_m = 115.8241$

At $E_{\pi^+} = 59.6$ MeV $^{14}\text{N}^*(0, 2.31, 3.95, \approx 7, \approx 11)$ are populated (1985WH01): the $^{14}\text{N}_{\text{g.s.}}$ form factor shows a large $L = 0$ component. For reaction (b) see (1980BA31) and (1981AJ01).

63. (a) $^{16}\text{O}(\gamma, \text{d})^{14}\text{N}$ $Q_m = -20.7363$
 (b) $^{16}\text{O}(\text{p}, \text{pd})^{14}\text{N}$ $Q_m = -20.7363$

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

$$64. \ ^{16}\text{O}(p, \ ^3\text{He})^{14}\text{N} \quad Q_m = -15.2428$$

Angular distributions have been measured in the range $E_p = 27$ to 54.1 MeV: see (1981AJ01). Comparisons have been made of the ratio of (p, ^3He) to the $T = 1$ state at 2.31 MeV and of (p, t) to the analog $^{14}\text{O}_{g.s.}$: see ^{17}F in (1982AJ01).

$$65. \ ^{16}\text{O}(d, \ \alpha)^{14}\text{N} \quad Q_m = 3.1104$$

Angular distributions have been measured at many energies up to $E_d = 40$ MeV: see (1981AJ01). The yield of the isospin-forbidden α_1 group [to $^{14}\text{N}^*(2.31)$] has been studied for $E_d = 2$ to 15 MeV: 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%. At $E_d = 50$ MeV, the intensity of $^{14}\text{N}^*(2.31)$ is 0.1–0.2% that of $^{14}\text{N}_{g.s.}$. See also (1981KA21, 1982AOZZ) and ^{18}F in (1983AJ01). See also (1983GO2D, 1983LIIT; applied).

$$66. \ ^{16}\text{O}(\alpha, \ ^6\text{Li})^{14}\text{N} \quad Q_m = -19.2611$$

At $E_\alpha = 42$ MeV the transitions involving ($^{14}\text{N}_{g.s.}$ and $^6\text{Li}^*(0, 3.56)$), ($^{14}\text{N}^*(2.31) + ^6\text{Li}_{g.s.}$) and ($^{14}\text{N}^*(3.95) + ^6\text{Li}_{g.s.}$) have been studied: see (1976AJ04).

$$67. \ ^{19}\text{F}(d, \ ^7\text{Li})^{14}\text{N} \quad Q_m = -6.1218$$

The ground-state angular distribution (involving $^7\text{Li}^*(0, 0.48)$) has been measured at $E_d = 13.6$ MeV by (1980GA27). See also (1984NE1A).

¹⁴O
(Figs. 8 and 9)

GENERAL: (See also (1981AJ01).)

Nuclear models: (1982SA1U, 1983SH38, 1984SA37).

Electromagnetic transitions: (1982LA26, 1982RI04, 1984MA2J, 1985LA06).

Astrophysical questions: (1981GU1D, 1981WA1Q, 1984MA2J, 1985LA06).

Applied work: (1982HI1H).

Complex reactions involving ¹⁴C: (1985WO1B).

Reactions involving pions (See also reactions 5, 7 and 10.): (1979ME2A, 1980BE35, 1981AU1C, 1981DU1H, 1981SI09, 1982COZV, 1982GR1K, 1982MU09, 1983SH31, 1983TR1J, 1983VI01, 1984CO1V, 1984JA1F, 1984MI15, 1985ALZX).

Hypernuclei: (1981WA1J, 1982KA1D, 1983SH38).

Other topics: (1982NG01, 1983FR1A, 1983OL1A, 1984BA1H).

Ground state of ¹⁴O: (1982NG01, 1983ANZQ).

1. ¹⁴O(β^+)¹⁴N $Q_m = 5.1431$

The best value of $\tau_{1/2} = 70.606 \pm 0.018$ sec: see (1978WI04). See also (1976AJ04). ¹⁴O decays predominantly to its analog state ¹⁴N*(2.31) [$J^\pi; T = 0^+; 1; E_x = 2312.798$ (11) keV, $E_\gamma = 2312.593$ (11) keV (1982WA16)]. The branching ratio to the state is $(99.336 \pm 0.010)\%$. This value is obtained by adopting $(0.61 \pm 0.01)\%$ (1966SI05) and $(0.054 \pm 0.002)\%$ [the weighted mean of the values of (1980WI13, 1981HE19)] for the branching ratios to ¹⁴N*(0, 3.95) [both $1^+; 0$ states]. $\log f^R t = 3.4892$ (2) for the $0^+ \rightarrow 0^+$ transition (1981WH03), using the Wapstra masses for the atomic mass excess of ¹⁴N, ¹H and n; $E_{\text{thresh.}}$ for the ¹⁴N(p, n) threshold (1981WH03) and E_x shown above for ¹⁴N*(2.31) (1982WA16). See (1983WA09) for other calculations of $\log f^R t$. For the transitions to ¹⁴N*(0, 3.95) $\log ft = 7.266 \pm 0.009$ (1980WI13) and 3.15 ± 0.02 , respectively. See also (1982KO28), (1980WI1N, 1982SZ1A, 1983KO2A, 1985HA1T), (1982RA1M, 1984BO1Q; astrophys.) and (1981SZ01, 1983SZ01, 1984BO03, 1984HA58, 1984HO1L, 1984SZ04; theor.).

2. ¹²C(³He, n)¹⁴O $Q_m = -1.1466$

Observed neutron groups are displayed in Table 14.26. Angular distributions have been measured at $E(^3\text{He}) = 15, 18, 20,$ and 25.4 MeV: see (1981AJ01) and ¹⁵O. See also (1984SUZZ).

Table 14.25: Energy levels of ^{14}O

E_x (MeV \pm keV)	$J^\pi; T$	$\tau_{1/2}$ or $\Gamma_{\text{c.m.}}$ (sec) (keV)	Decay	Reactions
g.s.	$0^+; 1$	$\tau_{1/2} = 70.606 \pm 0.018$ sec	β^+	1, 2, 4, 5, 7, 8, 9, 10, 11
5.173 ± 10	$1^-; 1$	$\Gamma = 38.1 \pm 1.8$ keV		2, 4, 6, 9, 11
5.920 ± 10	$0^+; 1$	≤ 50	p	2, 4, 9, 11
6.272 ± 10	$3^-; 1$	103 ± 6	p	2, 3, 4, 9, 11
6.590 ± 10	$2^+; 1$	≤ 60	p	2, 9, 11
(6.79 ± 30)	$\pi = -$			9
7.768 ± 10	$2^+; 1$	76 ± 10	p	2, 8, 9, 11
(8.72 ± 40)				4, 9, 11
9.715 ± 20	$(2^+); 1$			2, 4, 9, 11
9.915 ± 20	$4^+; 1$	100 ± 50		2, 3, 4
10.89 ± 50				9
11.24 ± 50				9
11.97^a				9
12.84 ± 50				9
13.01 ± 50				9
14.15 ± 40				9
14.64 ± 60				9
17.40 ± 60				9

^a Possibly more than one level.

Table 14.26: Levels of ^{14}O from $^{12}\text{C}(^3\text{He}, \text{n})^{14}\text{O}$ ^a

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

^a For references see Table 14.22 in (1981AJ01).

^b See Table 14.30 in (1976AJ04).

^c $E_x = 5905 \pm 12$ keV has also been reported.

^d 6585 ± 5 keV has also been reported.

^e $J = 2$ follows from an np coincidence study. The J shown for $^{14}\text{O}^*(5.92, 6.27, 7.77)$ are in accord with this work.

$$\begin{aligned} 3. \text{ (a) } & ^{12}\text{C}(^{10}\text{B}, ^8\text{Li})^{14}\text{O} & Q_m = -16.901 \\ & \text{(b) } & ^{12}\text{C}(^{11}\text{B}, ^9\text{Li})^{14}\text{O} & Q_m = -24.292 \end{aligned}$$

At $E(^{10}\text{B}) = 100$ MeV angular distributions have been studied to $^{14}\text{O}^*(6.27, 9.92)$, the states preferentially excited. At $E(^{11}\text{B}) = 114$ MeV these two states [$J^\pi = 3^-, 4^+$] are also dominant: see (1981AJ01).

$$\begin{aligned} 4. \text{ (a) } & ^{12}\text{C}(^{12}\text{C}, ^{10}\text{Be})^{14}\text{O} & Q_m = -20.6136 \\ & \text{(b) } & ^{12}\text{C}(^{14}\text{N}, ^{12}\text{B})^{14}\text{O} & Q_m = -18.513 \end{aligned}$$

At $E(^{12}\text{C}) = 114$ MeV [reaction (a)], the population of $^{14}\text{O}^*(0, 6.27, 9.9)$ is reported: it is suggested that $^{14}\text{O}^*(9.9)$ has a $(d_{5/2})_{4^+;1}^2$ configuration. $^{14}\text{O}_{\text{g.s.}}$ is weakly populated: see (1976AJ04). At $E(^{14}\text{N}) = 118$ MeV, the population of $^{14}\text{O}^*(6.27, 9.9)$ is reported. At $E(^{14}\text{N}) = 155$ MeV there is some evidence for the excitation of $^{14}\text{O}^*(5.17, 5.92, 8.72, 9.72)$: see (1981AJ01).

$$5. \text{ } ^{13}\text{C}(\text{p}, \pi^-)^{14}\text{O} \quad Q_m = -137.1598$$

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 (1980HO20). At $E_p = 183$ to 205 MeV cross sections and analyzing powers for the ground-state transition have been studied by (1982JA05). An angular distribution is also reported by (1982VI05) to the states centered at $E_x \approx 6.5$ MeV. See also (1983THZZ, 1984KOZU) and the “GENERAL” section in ^{14}N here.

6. $^{13}\text{N}(p, \gamma)^{14}\text{O}$ $Q_m = 4.6280$

This reaction is important in the hot-CNO cycle when its rate is dominated by $l = 0$ capture through $^{14}\text{O}^*(5.17)$. For $\Gamma_{\text{c.m.}}$ see reaction 9 (1985CH06). Calculations have recently been reported: $\Gamma_{\text{c.m.}} = 34.7$ keV, $\Gamma_\gamma = 2.4$ eV (1984MA2J); $\Gamma_{\text{c.m.}} = 40.1$ keV, $\Gamma_\gamma = 1.9$ eV (1985LA06). See also (1983FO1D).

7. $^{14}\text{C}(\pi^+, \pi^-)^{14}\text{O}$ $Q_m = -4.9867$

Angular distributions for the transition to $^{14}\text{O}_{\text{g.s.}}$ have been measured at $E_{\pi^+} = 164$ and 292 MeV [also to the unresolved structure at $E_x \approx 5.9$ MeV at 164 MeV] (1984SE14) as well as at $E_{\pi^+} = 50$ MeV (1985LE05) and 140 and 200 MeV (1984MOZU). See also (1985SEZZ). At the lower energy the differential cross sections for the DIAS transition are larger than expected from an extrapolation of the higher-energy data (1985LE05). For other cross-section measurements see (1984NA01, 1984SE14). See also (1985KA04; theor.).

8. $^{14}\text{N}(p, n)^{14}\text{O}$ $Q_m = -5.9255$
 $E_{\text{thresh.}} = 6353.04 \pm 0.08$ keV (1981WH03).

Ground-state angular distributions have been measured at $E_p = 144$ MeV (1980MO10; and to $^{14}\text{O}^*(7.77)$) as well as at $E_p = 35.2$ MeV (1984TA02). See also (1980DU16; theor.).

9. $^{14}\text{N}(^3\text{He}, t)^{14}\text{O}$ $Q_m = -5.1617$

Triton groups have been observed at $E(^3\text{He}) = 44.6$ MeV to the first six states shown in Table 14.25 and to levels with $E_x = 6.79 \pm 0.03$, 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 47 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.] $\Gamma_{\text{c.m.}}$ of $^{14}\text{O}^*(5.17) = 38.1 \pm 1.8$ keV (1985CH06). See also (1982HAZM, 1982KO28).

10. $^{16}\text{O}(\pi^+, d)^{14}\text{O}$ $Q_m = 113.6879$

See (1982DO01).

11. $^{16}\text{O}(p, t)^{14}\text{O}$ $Q_m = -20.4045$

Angular distributions of ground-state tritons have been studied to $E_p = 54.1$ MeV: see (1981AJ01). For comparison with the (p, ^3He) results see reaction 64 in ^{14}N .

Triton groups have also been observed to states with $E_x = 5.21 \pm 0.04, 5.92 \pm 0.06, 6.28 \pm 0.05, 6.59, 7.77, 8.69 \pm 0.06$ [weak, not observed in reaction 2], and 9.65 ± 0.06 MeV. Angular distributions have been studied with polarized protons at $E_p = 43.8$ MeV to $^{14}\text{O}^*(0, 5.17, 6.27, 6.59, 7.77, 9.72)$: see (1976AJ04).

^{14}F

(Not illustrated)

^{14}F has not been observed: its atomic mass excess is predicted to be 32.98 MeV which would make it unstable with respect to decay into $^{13}\text{O} + p$ by 2.58 MeV: see (1981AJ01). See also (1985WA02) and (1983ANZQ); theor.).

$^{14}\text{Ne}, ^{14}\text{Na}, ^{14}\text{Mg}$

(Not illustrated)

$^{14}\text{Ne}, ^{14}\text{Na}$ and ^{14}Mg have not been observed. See (1983ANZQ; theor.).

References

(Closed 01 June 1985)

- 1959AJ76 F. Ajzenberg and T. Lauritsen, Nucl. Phys. 11 (1959) 1
- 1959GI47 J.H. Gibbons and R.L. Macklin, Phys. Rev. 114 (1959) 571
- 1961DA09 P. Dagley, W. Haeberli and J.X. Saladin, Nucl. Phys. 24 (1961) 353
- 1966SI05 G.S. Sidhu and J.B. Gerhart, Phys. Rev. 148 (1966) 1024
- 1966SW01 C.P. Swann, Phys. Rev. 148 (1966) 1119
- 1967BA13 G.C. Ball and J. Cerny, Phys. Rev. 155 (1967) 1170
- 1968AL12 K.W. Allen, T.K. Alexander and D.C. Healey, Can. J. Phys. 46 (1968) 1575
- 1969BA06 G.C. Ball and J. Cerny, Phys. Rev. 177 (1969) 1466
- 1969SN04 J.L. Snelgrove and E. Kashy, Phys. Rev. 187 (1969) 1259
- 1970AJ04 F. Ajzenberg-Selove, Nucl. Phys. A152 (1970) 1
- 1971DU03 J.R. Duray and C.P. Browne, Phys. Rev. C3 (1971) 1867
- 1971GO40 N.B. Gove and M.J. Martin, Nucl. Data Tables A10 (1971) 205
- 1971RI15 H.T. Richards and H.V. Smith, Jr., Phys. Rev. Lett. 27 (1971) 1735
- 1972CR1A Crannell et al., Sedai (1972) 375
- 1972RE10 M.J. Renan, J.P.F. Sellschop, R.J. Keddy and D.W. Mingay, Nucl. Phys. A193 (1972) 470
- 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
- 1973DA37 S. Dahlgren, P. Grafstrom, B. Hoistad and A. Asberg, Phys. Lett. B47 (1973) 439
- 1973KL12 F.J. Kline, H. Crannell, J.T. O'Brien, J. McCarthy and R.R. Whitney, Nucl. Phys. A209 (1973) 381
- 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
- 1974JO01 P.L. Jolivette, Phys. Rev. C9 (1974) 16
- 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
- 1975RA22 V.K. Rasmussen and F.R. Metzger, Phys. Rev. C12 (1975) 706
- 1975SE04 H.P. Seiler, R. Kulesa, P.M. Cockburn, P. Marmier and P.H. Barker, Nucl. Phys. A241 (1975) 159
- 1975WI04 S.J. Wilson, Phys. Rev. C11 (1975) 1071
- 1976AJ04 F. Ajzenberg-Selove, Nucl. Phys. A268 (1976) 1
- 1976GR02 H. Grawe, J. Herholz and K. Kandler, Z. Phys. A276 (1976) 351
- 1976TE03 R.K. Tenhaken and P.A. Quin, Nucl. Phys. A271 (1976) 173
- 1977BI07 M. Bister, A. Anttila and J. Keinonen, Phys. Rev. C16 (1977) 1303
- 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
- 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
- 1978AJ02 F. Ajzenberg-Selove, E.R. Flynn and O. Hansen, Phys. Rev. C17 (1978) 1283.
- 1978CO13 J.D. Cossairt, S.B. Talley, D.P. May, R.E. Tribble and R.L. Spross, Phys. Rev. C18 (1978) 23
- 1978HA10 M. Hamm and K. Nagatani, Phys. Rev. C17 (1978) 586; Erratum Phys.Rev. C17, 2258 (1978)
- 1978KE03 J. Keinonen, A. Anttila and M. Bister, Nucl. Phys. A294 (1978) 1
- 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. (John Wiley and Sons, Inc., New York, 1978)
- 1978MO07 S. Mordechai, H.T. Fortune, G.E. Moore, M.E. Cobern, R.V. Kollarits and R. Middleton, J. Phys. 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
- 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. G4 (1978) 1593
- 1978WE13 H.R. Weller, J. Szucs, P.G. Ikossi, J.A. Kuehner, D.T. Petty and R.G. Seyler, Phys. Rev. C18 (1978) 1120
- 1978WI04 D.H. Wilkinson, A. Gallmann and D.E. Alburger, Phys. Rev. C18 (1978) 401
- 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
- 1979AU07 G.F. Auchampaugh, S. Plattard and N.W. Hill, Nucl. Sci. Eng. 69 (1979) 30
- 1979BA48 J.K. Bair and J. Gomez del Campo, Nucl. Sci. Eng. 71 (1979) 18

- 1979EN01 N. Ensslin, L.W. Fagg, R.A. Lindgren, W.L. Bendel and E.C. Jones, Jr., Phys. Rev. C19 (1979) 569
- 1979GL12 H. Glattli, G.L. Bacchella, M. Fourmond, A. Malinovski, P. Meriel, M. Pinot, P. Roubeau and A. Abragam, J. Phys. (Paris) 40 (1979) 629
- 1979KN1A Knopfle et al., Nucl. Int., Canberra, Australia (Springer-Verlag 1979) 442; Phys. Abs. 13440 (1980)
- 1979KO26 L. Koester, K. Knopf and W. Waschkowski, Z. Phys. A292 (1979) 95
- 1979ME2A D.F. Measday and G.A. Miller, Ann. Rev. Nucl. Part. Sci. 29 (1979) 121
- 1979PE1B Pearson, Radiocarbon 21 (1979) 1
- 1979PR07 G. Proudfoot and W.D.M. Rae, Nucl. Phys. A329 (1979) 271
- 1979TA1B Tans and Mook, Radiocarbon 21 (1979) 22
- 1980AN1E Antoni et al., Izv. Akad. Nauk SSSR Ser. Fiz. 44 (1980) 1031
- 1980BA31 B. Bassalleck, H.D. Engelhardt, W.D. Klotz, C.W. Lewis, F. Takeutchi, H. Ullrich and M. Furic, Nucl. Phys. A343 (1980) 365
- 1980BE24 Ya.A. Berdnikov and Yu.R. Gismatullin, Yad. Fiz. 31 (1980) 1139; Sov. J. Nucl. Phys. 31 (1980) 588
- 1980BE35 M. Betz and A.K. Kerman, Nucl. Phys. A345 (1980) 493
- 1980BE56 Ya.A. Berdnikov, Yu.R. Gismatullin and A.A. Melentev, Yad. Fiz. 31 (1980) 1433; Sov. J. Nucl. Phys. 31 (1980) 744
- 1980BI13 R. Billerey, C. Cerruti, A. Chevarier, N. Chevarier, B. Cheynis, A. Demeyer and O. Zohni, Z. Phys. A297 (1980) 317
- 1980BO21 K. Bodek, M. Hugi, L. Jarczyk, B. Kamys, J. Lang, R. Muller, M. Porebska, J. Sromicki, A. Strzalkowski, E. Ungricht et al., J. Phys. G6 (1980) 1017
- 1980BO31 V.I. Bogatin, E.A. Ganza, O.V. Lozhkin, Yu.A. Murin and V.S. Oplavin, Yad. Fiz. 32 (1980) 27; Sov. J. Nucl. Phys. 32 (1980) 14
- 1980CE1B Cerruti et al., Proc. Int. Conf. on Nucl. Phys. (Berkeley) (1980) 583
- 1980CO10 T.M. Cormier and B.R. Fulton, Phys. Rev. C22 (1980) 565
- 1980CO1R Cook, Stone and Vogl, Astrophys. J. 238 (1980) L97
- 1980DE28 R.M. DeVries and J.C. Peng, Phys. Rev. C22 (1980) 1055
- 1980DU16 O. Dumbrajs, Phys. Rev. C22 (1980) 2151
- 1980EL1B Elmore et al., Bull. Amer. Phys. Soc. 25 (1980) 784
- 1980EL1C Elmore et al., Proc. Int. Conf. on Nucl. Phys. (Berkeley) (1980) 655
- 1980GA27 A.S. Gass, O.Yu. Goryunov, V.N. Dobrikov, M.G. Makowska-Rzeszutko, O.F. Nemets, A.T. Rudchik and V.A. Stepanenko, Yad. Fiz. 31 (1980) 574; Sov. J. Nucl. Phys. 31 (1980) 298; Erratum Sov. J. Nucl. Phys. 31 (1980) 719

- 1980GO1M Goodman et al., Proc. Int. Conf. on Nucl. Phys. (Berkeley) (1980) 709
- 1980GO1Q Gorbатов, Krylov and Solovei, Yad. Fiz. 32 (1980) 636
- 1980GR10 R.E.L. Green and R.G. Korteling, Phys. Rev. C22 (1980) 1594
- 1980HA1N Han et al., Proc. Int. Conf. on Nucl. Phys. (Berkeley) (1980) 907
- 1980HA1X Han et al., Phys. Energ. Fortis Phys. Nucl. 4 (1980) 210, 227
- 1980HA56 F. Hachenberg, H.C. Chiang and J. Hufner, Phys. Lett. B97 (1980) 183
- 1980HO18 K. Hosono, M. Kondo, T. Saito, N. Matsuoka, S. Nagamachi, T. Noro and H. Shimizu, Nucl. Phys. A343 (1980) 234
- 1980HO20 B. Hoistad, P.H. Pile, T.P. Sjoreen, R.D. Bent, M.C. Green and F. Soga, Phys. Lett. B94 (1980) 315
- 1980IS1E Ishkanov, Morkeev, Novikov and Piskarev, Yad. Fiz. 32 (1980) 11
- 1980IW1A Iwao, Lett. Nuovo Cim. 29 (1980) 40
- 1980KA01 J. Kallne, A.N. Anderson, J.L. Beveridge, J. Rogers, D.A. Hutcheon and W.J. McDonald, Phys. Rev. C21 (1980) 675
- 1980KA28 K.-K. Kan, Phys. Rev. C22 (1980) 2228
- 1980KO23 D. Konnerth, K.G. Bernhardt, K.A. Eberhard, R. Singh, A. Strzalkowski, W. Trautmann and W. Trombik, Phys. Rev. Lett. 45 (1980) 1154
- 1980MA32 N. Matsuoka, M. Kondo, A. Shimizu, T. Saito, S. Nagamachi, H. Sakaguchi, A. Goto and F. Ohtani, Nucl. Phys. A345 (1980) 1
- 1980MC1H McKlveen, Bull. Amer. Phys. Soc. 25 (1980) 771
- 1980MO10 G.L. Moake, L.J. Gutay, R.P. Scharenberg, P.T. Debevec and P.A. Quin, Phys. Rev. C21 (1980) 2211
- 1980PA19 R.L. Parks, S.T. Thornton, L.C. Dennis and K.R. Cordell, Nucl. Phys. A348 (1980) 350
- 1980PR09 G. Proudfoot, H.S. Bradlow, P.S. Fisher, N.S. Godwin, J. King, D. Sinclair and W.D.M. Rae, Nucl. Phys. A345 (1980) 278
- 1980RI06 W.A. Richter and P.R. de Kock, Z. Phys. A297 (1980) 343
- 1980SC18 L.A. Schaller, L. Schellenberg, A. Ruetschi and H. Schneuwly, Nucl. Phys. A343 (1980) 333
- 1980SC1L Schramm, Nukleonika 25 (1980) 1543
- 1980SE1E Sellschop, Bull. Amer. Phys. Soc. 25 (1980) 800
- 1980SH1Q Shea, Conlon, Asher and Read, Radiocarbon 22 (1980) 830
- 1980SO05 F. Soga, R.D. Bent, P.H. Pile, T.P. Sjoreen and M.C. Green, Phys. Rev. C22 (1980) 1348

1980SO1D Sowinski and Marvis, Santa Fe (1980) 76
 1980SP1E J. Speth and J. Wambach, Nucl. Phys. A347 (1980) 389
 1980ST1K Strikman and Frankfurt, Yad. Fiz. 32 (1980) 1403
 1980ST25 K. Stricker, J.A. Carr and H. McManus, Phys. Rev. C22 (1980) 2043
 1980TA15 H. Taneichi, H. Ueno, K. Shoda, Y. Kawazoe and T. Tsukamoto, Nucl. Phys. A350 (1980) 157
 1980TO05 M. Toulemonde, K.H. Souw, J.C. Adloff and N. Schulz, Phys. Rev. C22 (1980) 553
 1980VA17 J. Van Driel, R. Kamermans and R.J. De Meijer, Nucl. Phys. A350 (1980) 109
 1980WE1D Weller and Roberson, Rev. Mod. Phys. 52 (1980) 699
 1980WH03 W.R. Wharton, C.D. Goodman and D.C. Hensley, Phys. Rev. C22 (1980) 1138
 1980WI09 J.P. Wieleczko, S. Harar, M. Conjeaud and F. Saint-Laurent, Phys. Lett. B93 (1980) 35
 1980WI13 H.S. Wilson, R.W. Kavanagh and F.M. Mann, Phys. Rev. C22 (1980) 1696
 1980WI1N Wilkinson, Transactions of the N.Y. Acad. of Sci. 40 (1980) 236
 1981AB1A Abe, RIFP-421 (1981) 428
 1981AB1E Abdel Khadi et al., Proc. Samarkand Conf. (1981) p. 669
 1981AD1F Adams and Smith, Astrophys. J. 247 (198) L123
 1981AJ01 F. Ajzenberg-Selove, Nucl. Phys. A360 (1981) 1.
 1981AL1K Alma-ata et al., Sov. J. Nucl. Phys. 33 (1981) 552
 1981AU1C Auld, Santa Fe 1980, AIP Conf. Proc. 69 (1981) 93
 1981AV02 I.K. Averyanov, A.I. Golubev and A.A. Sadovoy, Yad. Fiz. 33 (1981) 66
 1981BA1G Basak et al., Santa Fe 1980, AIP Conf. Proc. 69 (1981) 593
 1981BA1H Bart et al., Bull. Amer. Phys. Soc. 26 (1981) 605
 1981BA2F Barnes, Prog. Part. Nucl. Phys. 6 (1981) 235
 1981BE2K Becker and Cox, Nucl. At. Theor. Astrophys. (1981)
 1981BE2P Berdnikov et al., Sov. J. Nucl. Phys. 34 (1981) 794
 1981BE63 V.B. Belyaev and O.P. Solovtsova, Yad. Fiz. 33 (1981) 699; Sov. J. Nucl. Phys. 33 (1981) 363
 1981BH02 R.K. Bhowmik, E.C. Pollacco, J.B.A. England, G.C. Morrison and N.E. Sanderson, Nucl. Phys. A363 (1981) 516
 1981BI10 R. Billerey, C. Cerruti, A. Chevarier, N. Chevarier, B. Cheynis, A. Demeyer and M.N. Namboodiri, Phys. Rev. Lett. 47 (1981) 639
 1981BI17 W. Biesiot and Ph.B. Smith, Phys. Rev. C24 (1981) 2443

- 1981BL1K Blokhintsev, Sov. J. Nucl. Phys. 34 (1981) 525
- 1981BR1E Brooks, Lister, Nelson and Dhuga, Santa Fe 1980, AIP Conf. Proc. 69 (1981) 656
- 1981BR1L Brady, IEEE Trans. Nucl. Sic. NS-28 (1981) 1250
- 1981BR1P Bromley, Int. Workshop on Resonances in Heavy Ion Collisions, Bad Honnef (1981)
- 1981BY01 R.C. Byrd, C.E. Floyd, K. Murphy, P.P. Guss, R.L. Walter and S.R. Cotanch, Nucl. Phys. A351 (1981) 189
- 1981BY1C Byrd and Walter, Bull. Amer. Phys. Soc. 26 (1981) 624
- 1981CH23 R.K. Choudhury, R. Govil and S.S. Kapoor, J. Phys. G7 (1981) 1247
- 1981CI03 M.A. Cirit and F. Yazici, Phys. Rev. C23 (1981) 2627
- 1981CO08 W.D. Cornelius, J.M. Moss and T. Yamaya, Phys. Rev. C23 (1981) 1364
- 1981CO11 K.R. Cordell, C.-A. Wiedner and S.T. Thornton, Phys. Rev. C23 (1981) 2035
- 1981CO1D Conzett, Santa Fe 1980, AIP Conf. Proc. 69 (1981) 1452
- 1981CU02 A. Cunsolo, A. Foti, G. Imme, G. Pappalardo, G. Raciti, N. Saunier and B.T. Kim, Nucl. Phys. A355 (1981) 261
- 1981CU06 R.Y. Cusson, J. Gomez del Campo, J.A. Maruhn and V. Maruhn-Rezwani, Phys. Rev. C23 (1981) 2524
- 1981DA1B Daehnick, Santa Fe 1980, AIP Conf. Proc. 69 (1981) 487
- 1981DE13 J.-L. Dethier and Fl. Stancu, Phys. Rev. C23 (1981) 1503
- 1981DE1T Dementij, Fartushnyj and Afanas'ev, Proc. Versailles Conf. (1981) p.127
- 1981DE2C Delsemme, Bull. Amer. Phys. Soc. 26 (1981) 801
- 1981DIZW D.E. DiGregorio, J. Gomez del Campo, J.A. Biggerstaff, Y.-D. Chan, D.C. Hensley, M.E. Ortiz, P.H. Stelson and D. Shapira, Bull. Amer. Phys. Soc. 26 (1981) 1132
- 1981DR01 D.M. Drake, M. Cates, N. Cindro, D. Pocanic and E. Holub, Phys. Lett. B98 (1981) 36
- 1981DR1D Drenckhahn, Santa Fe 1980, AIP Conf. Proc. 69 (1981) 653
- 1981DU1H Dumbrajs, Fortschr. Phys. 29 (1981) 487
- 1981EG02 Ch. Egelhaaf, H. Fuchs, A. Gamp and H. Homeyer, Phys. Rev. C24 (1981) 759
- 1981FA1E Farwell, Grootes and Schmidt, Bull. Amer. Phys. Soc. 26 (1981) 1159
- 1981FE04 F. Fernandez, Th.A.J. Maris, C. Schneider and C.A.Z. Vasconcellos, Phys. Lett. B106 (1981) 15
- 1981FE2A H.W. Fearing, Prog. Part. Nucl. Phys. 7 (1981) 113
- 1981FR1F Friedman, Proc. Versailles Conf. (1981) p. 349
- 1981FR23 R.M. Freeman, C. Beck, F. Haas, B. Heusch, H. Bohn, U. Kaufl, K.A. Eberhard, H. Puchta, T. Senftleben and W. Trautmann, Phys. Rev. C24 (1981) 2390

- 1981GA1C Garcia-Munoz, Guzik, Simpson and Wefel, Bull. Amer. Phys. Soc. 26 (1981) 557
- 1981GA1H Gabriel and Noels, Astron. Astrophys. 94 (1981) L1
- 1981GI08 M. Giffon, A. Goncalves, P.A.M. Guichon, J. Julien, L. Roussel and C. Samour, Phys. Rev. C24 (1981) 241
- 1981GI15 Yu.R. Gismatullin, Izv. Akad. Nauk SSSR Ser. Fiz. 45 (1981) 674
- 1981GI1E Gismatulin, Lantsev and Ostroumov, Proc. Samarkand Conf. (1981) p. 533
- 1981GO1D Goulding et al., Bull. Amer. Phys. Soc. 26 (1981) 623
- 1981GO1H Goodman et al., Proc. Versailles Conf. (1981) p. 539
- 1981GU1D Guzik, Astrophys. J. 244 (1981) 695
- 1981HA18 F. Haas and Y. Abe, Phys. Rev. Lett. 46 (1981) 1667
- 1981HA1L Harvey et al., Bull. Amer. Phys. Soc. 26 (1981) 582
- 1981HA1V Haas, Bull. Amer. Phys. Soc. 26 (1981) 1132
- 1981HE08 B. Heusch, C. Beck, J.P. Coffin, R.M. Freeman, A. Gallmann, F. Haas, F. Rami, P. Wagner and D.E. Alburger, Phys. Rev. C23 (1981) 1527
- 1981HE19 A.M. Hernandez and W.W. Daehnick, Phys. Rev. C24 (1981) 2235
- 1981HO14 D.B. Holtkamp, S.J. Seestrom-Morris, S. Chakravarti, D. Dehnhard, H.W. Baer, C.L. Morris, S.J. Greene and C.J. Harvey, Phys. Rev. Lett. 47 (1981) 216
- 1981IB1A Iben, Astrophys. 246 (1981) 278
- 1981IR1A Irom et al., Proc. Versailles Conf. (1981) 546
- 1981IS11 B.S. Ishkhanov, I.M. Kapitonov, V.G. Neudachin and R.A. Eramzhyan, Fiz. Elem. Chastits At. Yadra 12 (1981) 905; Sov. J. Part. Nucl. 12 (1981) 362
- 1981JO02 P.L. Jolivette, Nucl. Phys. A370 (1981) 256
- 1981KA21 J.E. Kammeraad and L.D. Knutson, Nucl. Phys. A365 (1981) 237
- 1981KE15 B.K. Kerimov, M.Ya. Safin and I.M. Al-Khamisi, Yad. Fiz. 34 (1981) 996; Sov. J. Nucl. Phys. 34 (1981) 554
- 1981KH1E Kholnov et al., Proc. Samarkand Conf. (1981) p. 609
- 1981KI04 Yu.V. Kirichenko, V.Yu. Gonchar, E.V. Inopin and V.N. Tarasov, Ukr. Fiz. Zh. 26 (1981) 904
- 1981KN06 W. Knupfer and A. Richter, Phys. Lett. B101 (1981) 375
- 1981KO07 J.J. Kolata, C. Beck, R.M. Freeman, F. Haas and B. Heusch, Phys. Rev. C23 (1981) 1056
- 1981KO08 R.L. Kozub, J. Lin, J.F. Mateja, C.J. Lister, D.J. Millener and E.K. Warburton, Phys. Rev. C23 (1981) 1571

- 1981LA05 R.O. Lane, H.D. Knox, P. Hoffmann-Pinther, R.M. White and G.F. Auchampaugh, Phys. Rev. C23 (1981) 1883
- 1981LA1L Lambert and Ries, Astrophys. J. 248 (1981) 228
- 1981LI06 R.P. Liljestrang, J.M. Cameron, D.A. Hutcheon, R. Macdonald, W.J. McDonald, C.A. Miller, W.C. Olsen, J.J. Kraushaar, J.R. Shepard, J.G. Rogers et al., Phys. Lett. B99 (1981) 311
- 1981LI1K Litherland et al., Nucl. Sci. 28 (1981) 1469
- 1981LI23 P.W. Lisowski, R.C. Byrd, G. Mack, W. Tornow, R.L. Walter, T.B. Clegg and F.D. Santos, Phys. Rev. C24 (1981) 1852
- 1981MA02 J.F. Mateja, D.P. Stanley, L.V. Theisen, A.D. Frawley, P.L. Pepmiller, L.R. Medsker and P.B. Nagel, Nucl. Phys. A351 (1981) 509
- 1981MA14 G. Mairle, G.J. Wagner, K.T. Knopfle, Ken Pao Liu, H. Riedesel, V. Bechtold and L. Friedrich, Nucl. Phys. A363 (1981) 413
- 1981MA1P Mann and Primakoff, Origins of Life 11 (1981) 255
- 1981MA26 V.S. Mathur and R. Prasad, J.Phys. G7 (1981) 1455
- 1981MA27 M. May, H. Piekarz, R.E. Chrien, S. Chen, D. Maurizio, H. Palevsky, R. Sutter, Y.Xu, P. Barnes, B. Bassalleck et al., Phys. Rev. Lett. 47 (1981) 1106
- 1981ME02 H.O. Meyer, P. Schwandt, G.L. Moake and P.P. Singh, Phys. Rev. C23 (1981) 616
- 1981ME13 M.C. Mermaz, J. Barrette and H.E. Wegner, Phys. Rev. C24 (1981) 2148
- 1981MU1C Murphy et al., Santa Fe 1980, AIP Conf. Proc. 69 (1981) 1472
- 1981MU1D Murphy et al., Santa Fe 1980, AIP Conf. Proc. 69 (1981) 1478
- 1981MU1E Mukhopadhyay and Hintermann, Santa Fe 1980, AIP Conf. Proc. 69 (1981) 1068
- 1981MUZQ S.F. Mughabghab, M. Divadeenam and N.E. Holden, Neutron Cross Sections Part A, Z=1-60 (Academic Press, New York, 1981)
- 1981NA1H Naulin et al., in Helsingor, June 1981 Conf., CERN 81-09 (1981) 376
- 1981NO1B Northcliffe, Cornelius, York and Hiebert, Santa Fe 1980, AIP Conf. Proc. 69 (1981) 1335
- 1981OL1C D.L. Olson, B.L. Berman, D.E. Greiner, H.H. Heckman, P.J. Lindstrom, G.D. Westfall and H.J. Crawford, Phys. Rev. C24 (1981) 1529
- 1981PE01 J.C. Peng, R.M. DeVries and N.J. DiGiacomo, Phys. Lett. B98 (1981) 244
- 1981PE07 R.J. Peterson and J.J. Hamill, Nucl. Phys. A362 (1981) 163
- 1981PH1C Phan et al., Proc. Versailles Conf. (1981) 223
- 1981PR1G Primakoff, HP-1 (1981)
- 1981RO14 P.G. Roos, L. Rees and N.S. Chant, Phys. Rev. C24 (1981) 2647

- 1981SC13 J. Schwenzel, K. Glasner, P. Niermann and E. Kuhlmann, Nucl. Phys. A367 (1981) 145
- 1981SC1D Schmidt, Farwell and Grootes, Bull. Amer. Phys. Soc. 26 (1981) 593
- 1981SE06 M. Seya, M. Kohno and S. Nagata, Prog. Theor. Phys. 65 (1981) 204
- 1981SE1B Seth, in Helsingor, June 1981 Conf., CERN 81-09 (1981) 655
- 1981SH22 S. Shirato, Nucl. Instrum. Meth. Phys. Res. 190 (1981) 29
- 1981SI09 M.K. Singham and F. Tabakin, Ann. Phys. 135 (1981) 71
- 1981SI1D Singham and Tabakin, Proc. Versailles Conf. (1981) 129
- 1981ST1P Stokstad, Nukleonika 26 (1981) 373
- 1981SZ01 L. Szybisz and V.M. Silbergleit, Z. Phys. A299 (1981) 91
- 1981TA08 T. Takaki, Prog. Theor. Phys. 65 (1981) 241
- 1981TA16 S.L. Tabor, L.C. Dennis, K.W. Kemper, J.D. Fox, K. Abdo, G. Neuschaefer, D.G. Kovar and H. Ernst, Phys. Rev. C24 (1981) 960
- 1981TA20 O. Tanimura and U. Mosel, Phys. Lett. B105 (1981) 334
- 1981TA22 S.L. Tabor, L.C. Dennis and K. Abdo, Phys. Rev. C24 (1981) 2552
- 1981VA1E R. Vandenbosch and A.J. Lazzarini, Phys. Rev. C23 (1981) 1074
- 1981VA1H Vaz, Alexander and Satchler, Phys. Rept. 69 (1981) 373
- 1981VO01 C. Volant and S. Gary, J. Phys. (Paris) 42 (1981) 27
- 1981VO06 W. von Oertzen, E.R. Flynn, J.C. Peng, J.W. Sunier and R.E. Brown, Z. Phys. A301 (1981) 365
- 1981WA1J Wang, Zhang, Li and Ruan, Proc. Versailles Conf. (1981) 374
- 1981WA1N Wannier, Linke and Penzias, Astrophys. J. 247 (1981) 522; Erratum Astrophys. J. 254 (1982) 419
- 1981WA1Q R.K. Wallace and S.E. Woosley, Astrophys. J. Suppl. 45 (1981) 389
- 1981WE1A Weller and Roberson, Nucl. Sci. 28 (1981) 1268
- 1981WH01 W.R. Wharton and B.D. Keister, Phys. Rev. C23 (1981) 1141
- 1981WH03 R.E. White, H. Naylor, P.H. Barker, D.M.J. Lovelock and R.M. Smythe, Phys. Lett. B105 (1981) 116
- 1981WH1D Wharton et al., Proc. Versailles Conf. (1981) 327
- 1982AB1F Abe, RIFP-473 (1982)
- 1982AJ01 F. Ajzenberg-Selove, Nucl. Phys. A375 (1982) 1
- 1982AL1F Aleksandrov et al., in Kiev (1982) 356
- 1982AL1G Aleksandrov et al., in Kiev (1982) 358

- 1982AO05 Y. Aoki, S. Kunori, K. Nagano, Y. Toba and K. Yagi, Nucl. Phys. A382 (1982) 269
- 1982AOZZ Y. Aoki, E.J. Ludwig, T.B. Clegg, R.E. Anderson, R.L. Varner and B.L. Burks, Bull. Amer. Phys. Soc. 27 (1982) 560, HXa4
- 1982BA03 K. Bangert, U.E.P. Berg, G. Junghans, R. Stock and K. Wienhard, Nucl. Phys. A376 (1982) 15
- 1982BA1R P.D. Barnes, Nucl. Phys. A374 (1982) 415
- 1982BA2G B.F. Bayman, P.J. Ellis and Y.C. Tang, Phys. Rev. Lett. 49 (1982) 532
- 1982BA80 J.N. Bahcall, W.F. Huebner, S.H. Lubow, P.D. Parker and R.K. Ulrich, Rev. Mod. Phys. 54 (1982) 767
- 1982BE1R Berti and Drigo, Nucl. Instrum. Meth. Phys. Res. 201 (1982) 473
- 1982BE54 Yu.A. Berezhnoi, A.P. Klyucharev and N.Ya. Rutkevich, Ukr. Fiz. Zh. 27 (1982) 1475; Phys. Abs. 11339 (1983)
- 1982BH06 R.K. Bhalla and A.R. Poletti, Nucl. Phys. A390 (1982) 189
- 1982BI08 B.L. Birbrair and Yu.A. Kalashnikov, J. Phys. (London) G8 (1982) 1531
- 1982BL08 G.S. Blanpied, M.L. Barlett, G.W. Hoffmann and J.A. McGill, Phys. Rev. C25 (1982) 2550
- 1982BL12 M. Blann and D. Akers, Phys. Rev. C26 (1982) 465
- 1982BO1M Bozek et al., in MSU (1982) 99
- 1982BU03 B.L. Burks, R.E. Anderson, T.B. Clegg, H. Paetz gen.Schieck, E.J. Ludwig, R.L. Varner and J.F. Wilkerson, Phys. Rev. C25 (1982) 1168
- 1982BU1D Burtebeav, Duisebaev and Ivanov, in Kiev (1982) 327
- 1982CH05 J.L. Charvet, R. Dayras, J.M. Fieni, S. Joly and J.L. Uzureau, Nucl. Phys. A376 (1982) 292
- 1982CI1C N. Cindro, Nukleonika 27 (1982) 137
- 1982COZV B. Cottman, A.M. Bernstein, K.I. Blomqvist, S.A. Dytman and J. Nelson, Bull. Amer. Phys. Soc. 27 (1982) 709, BE7
- 1982DA05 J.H. Dave, C.R. Gould, L.W. Seagondollar, C.R. Howell, R.S. Pedroni, F.O. Purser and R.L. Walter, Nucl. Sci. Eng. 80 (1982) 388
- 1982DE1K D. Dehnhard, Nucl. Phys. A374 (1982) 377
- 1982DE1N de Wet, Found. Phys. 12 (1982) 285
- 1982DE39 P.A. DeYoung, J.J. Kolata, L.J. Satkowiak and M.A. Xapsos, Phys. Rev. C26 (1982) 1482
- 1982DI13 D.E. DiGregorio, J. Gomez del Campo, Y.D. Chan, J.L.C. Ford, Jr., D. Shapira and M.E. Ortiz, Phys. Rev. C26 (1982) 1490
- 1982DM1A Dmitriev, Kindukh, Kosmach and Ostroumov, Sov. J. Nucl. Phys. 36 (1982) 227

- 1982DO01 K.G.R. Doss, P.D. Barnes, N. Colella, S.A. Dytman, R.A. Eisenstein, C. Ellegaard, F. Takeuchi, W.R. Wharton, J.F. Amann, R.H. Pehl et al., Phys. Rev. C25 (1982) 962
- 1982ER1E Eramzhyan, Fetisovm Majling and Zofka, Conf. on Hypernucl. Kaon Phys., Heidelberg, June 1982 (1982) 91
- 1982FI1G Fields et al., Bull. Amer. Phys. Soc. 27 (1982) 752
- 1982FO01 H.T. Fortune and G.S. Stephans, Phys. Rev. C25 (1982) 1
- 1982FR1Q Frobrich and Kaufmann, J. Phys. G8 (1982) 1091
- 1982FR1U Freeman, in Bad Honnef Symp. 1981, Springer-Verlag Publ. (1982) 268; Phys. Abs. 107904 (1982)
- 1982GO1C C. Goodman, Nucl. Phys. A374 (1982) 241
- 1982GR1K Green, in "Pion Production and Absorption in Nuclei-Indiana 1981", AIP Conf. Proc. 79 (1982) 131
- 1982GRZY M.C. Green, H.O. Meyer, R.E. Pollock, T.G. Throwe, R.D. Bent, J.R. Hall, W.W. Jacobs, J.J. Kehayias, W.K. Pitts, S.E. Vigdor et al., Bull. Amer. Phys. Soc. 27 (1982) 468, BF11
- 1982HA42 Q. Haider and F.B. Malik, Phys. Rev. C26 (1982) 989
- 1982HA56 K. Hatogai, M. Ohta and S. Okai, Prog. Throe. Phys. 68 (1982) 2014
- 1982HAZM J.C. Hardy, V.T. Koslowsky, R.E. Azuma, G.C. Ball, E.T.H. Clifford, W.G. Davies, E. Hagberg, H. Schmeing, U.J. Schrewe and K.S. Sharma, Bull. Amer. Phys. Soc. 27 (1982) 696, AC4
- 1982HE07 B. Heusch, C. Beck, J.P. Coffin, P. Engelstein, R.M. Freeman, G. Guillaume, F. Haas and P. Wagner, Phys. Rev. C26 (1982) 542
- 1982HI1H R.R. Highfill, Bull. Amer. Phys. Soc. 27 (1982) 777
- 1982HO1F Hoppe et al., in Bad Honnef Symp. 1981, Springer-Verlag (1982) 135; Phys. Abs. 101808 (1982)
- 1982HU1G M.S. Hussein, H M. Nussenzveig, A.C.C. Villari and J.L. Cardoso, Jr, Phys. Lett. B114 (1982) 1
- 1982IB1B Iben and Renzini, Astrophys. J. 263 (1982) L23
- 1982IN1A C.H.Q. Ingram, Nucl. Phys. A374 (1982) 319
- 1982JA05 W.W. Jacobs, T.G. Throwe, S.E. Vigdor, M.C. Green, J.R. Hall, H.O. Meyer, W.K. Pitts and M. Dillig, Phys. Rev. Lett. 49 (1982) 855
- 1982JU03 J.W. Jury, B.L. Berman, J.G. Woodworth, M.N. Thompson, R.E. Pywell and K.G. McNeill, Phys. Rev. C26 (1982) 777
- 1982KA01 S. Kato, K. Okada, M. Kondo, K. Hosono, T. Saito, N. Matsuoka, T. Noro, S. Nagamachi, H. Shimizu, K. Ogino et al., Phys. Rev. C25 (1982) 97

- 1982KA16 G. Kalbermann and J.M. Eisenberg, Nucl. Phys. A382 (1982) 413
- 1982KA1D K. Kar and J.C. Parikh, Pramana 19 (1982) 555
- 1982KA1U Kahana, Conf. on Hypernucl. Kaon Phys., Heidelberg, June 1982 (1982) 97
- 1982KO28 V.T. Koslowsky, J.C. Hardy, R.E. Azuma, G.C. Ball, E.T.H. Clifford, W.G. Davies, E. Hagberg, H. Schmeing, U.J. Schrewe and K.S. Sharma, Phys. Lett. B119 (1982) 57
- 1982LA26 J. Lange, K. Kumar and J.H. Hamilton, Rev. Mod. Phys. 54 (1982) 119
- 1982LE1N R. Legrain, Nucl. Phys. A387 (1982) 219
- 1982LI15 B.J. Lieb, H.S. Plendl, C.E. Stronach, H.O. Funsten and V.G. Lind, Phys. Rev. C26 (1982) 2084
- 1982LO13 M. Lozano, J.I. Escudero and G. Madurga J. Phys. (London) G8 (1982) 1259
- 1982LY1A U. Lynen, H. Ho, W. Kuhn, D. Pelte, U. Winkler W. F.J. Muller, Y. -T. Chu, P. Doll, A. Gobbi, K. Hildenbrand et al., Nucl. Phys. A387 (1982) 129
- 1982MA1H Mazitov, Radiok and Rasulov, in Kiev (1982) 309
- 1982MA22 R. Madey, T. Vilaithong, B.D. Anderson, J.N. Knudson, T.R. Witten, A.R. Baldwin and F.M. Waterman, Phys. Rev. C25 (1982) 3050
- 1982MA25 G. Mairle, G.J. Wagner, P. Grabmayr, K.T. Knopfle, Liu Ken Pao, H. Riedesel, K. Schindler, V. Bechtold, L. Friedrich and P. Ziegler, Nucl. Phys. A382 (1982) 173
- 1982MAZZ T.G. Masterson, C.A. Goulding, J. Rapaport, T.N. Taddeucci, C.D. Goodman, C. Foster, E. Sugarbaker, C. Gaarde, J. Larsen and D. Horen, Bull. Amer. Phys. Soc. 27 (1982) 26, DF8
- 1982MU09 M.V.N. Murthy, G. Ramachandran and S.K. Singh, Z. Phys. A306 (1982) 117
- 1982MU14 S.F. Mughabghab, M.A. Lone and B.C. Robertson, Phys. Rev. C26 (1982) 2698
- 1982NA01 J. Navarro, J. Bernabeu, J.M.G. Gomez and J. Martorell, Nucl. Phys. A375 (1982) 361
- 1982NE04 G.A. Needham, F.P. Brady, D.H. Fitzgerald, J.L. Romero, J.L. Ullmann, J.W. Watson, C. Zanelli, N.S.P. King and G.R. Satchler, Nucl. Phys. A385 (1982) 349
- 1982NG01 Nguyen Tien Nguyen and I. Ulehla, Czech. J. Phys. B32 (1982) 1040
- 1982OG02 Yu.Ts. Oganesyanyan, Yu.E. Penionzhkevich, E. Gierlik, R. Kalpakchieva, T. Pawlat, C. Borcea, A.V. Belozerov, Yu.P. Kharitonov, S.P. Tretyakova, V.G. Subbotin et al., Pisma Zh. Eksp. Teor. Fiz. 36 (1982) 104; JETP Lett. 36 (1982) 129
- 1982OR02 M.E. Ortiz, J. Gomez del Campo, Y.D. Chan, D.E. DiGregorio, J.L.C. Ford, D. Shapira, R.G. Stokstad, J.P.F. Sellschop, R.L. Parks and D. Weiser, Phys. Rev. C25 (1982) 1436
- 1982PE05 R.J. Peterson and J.J. Hamill, Z. Phys. A305 (1982) 275
- 1982RA1L Rahman Khan, Conf. on Hypernucl. Kaon Phys., Heidelberg, June 1982 (1982) 115

- 1982RA1M Ramaty and Lingenfelter, *Ann. Rev. Nucl. Part. Sci.* 32 (1982) 235
- 1982RA28 G.M. Radutsky and V.A. Serdyutsky, *Yad. Fiz.* 36 (1982) 857; *Sov. J. Nucl. Phys.* 36 (1982) 501
- 1982RE1M Rekaló, *Sov. J. Nucl. Phys.* 35 (1982) 682
- 1982REZX D.A. Resler, P.E. Koehler, H.D. Knox, G. Randers-Pehrson and R.O. Lane, *Bull. Amer. Phys. Soc.* 27 (1982) 716, CE2
- 1982REZY D.A. Resler, P.E. Koehler, H.D. Knox and R.O. Lane, *Bull. Amer. Phys. Soc.* 27 (1982) 628, H4
- 1982RI04 L. Ricken, D. Bohle, G. Domogala, K. Glasner and E. Kuhlmann, *Z. Phys.* A306 (1982) 67
- 1982RI1A Rieder et al., *Bull. Amer. Phys. Soc.* 27 (1982) 469
- 1982SA1U Sakai, *Inst. for Nucl. Study (Japan)* (1982)
- 1982SC11 L.A. Schaller, L. Schellenberg, T.Q. Phan, G. Piller, A. Ruetschi and H. Schneuwly, *Nucl. Phys.* A379 (1982) 523
- 1982SZ1A Szybisz and Silbergleit, *Rev. Mex. Fis.* 29 (1982) 27
- 1982TA02 N. Takahashi, T. Yamaya, R.E. Tribble, E. Takada, Y.-W. Lui, D.M. Tanner and K. Nagatani, *Phys. Lett.* B108 (1982) 177
- 1982TA03 T.N. Taddeucci, J. Rapaport, D.E. Bainum, C.D. Goodman, C.C. Foster, C. Gaarde, J. Larsen, C.A. Goulding, D.J. Horen, T. Masterson et al., *Phys. Rev.* C25 (1982) 1094
- 1982TA19 M. Tanifuji, O. Mikoshiba and T. Terasawa, *Nucl. Phys.* A388 (1982) 621
- 1982THZZ T.G. Throwe, W.W. Jacobs, S.E. Vigdor, M.C. Green, J.R. Hall, H.O. Meyer, W.K. Pitts and M. Dillig, *Bull. Amer. Phys. Soc.* 27 (1982) 468, BF12
- 1982TO1C Tolokonnikov and Borzov, in *Kiev* (1982) p. 153
- 1982TR1C Treichel, Isenbugel, Buttlar and Marquardt, in *Bad Honnef Symp. 1981*, Springer-Verlag (1982) p. 137; *Phys. Abs.* 101941 (1982)
- 1982VE02 J.J.M. Verbaarschot, G.A. Timmer and P.J. Brussaard, *Nucl. Phys.* A378 (1982) 280
- 1982VI05 S.E. Vigdor, T.G. Throwe, M.C. Green, W.W. Jacobs, R.D. Bent, J.J. Kehayias, W.K. Pitts and T.E. Ward, *Phys. Rev. Lett.* 49 (1982) 1314
- 1982VI07 J. Visser, C.N.M. Bakker, G.A. Brinkman, B. Proot and E. Jacobs, *Int. J. Appl. Radiat. Isot.* 33 (1982) 1381
- 1982WA16 E.K. Warburton and D.E. Alburger, *Nucl. Phys.* A385 (1982) 189
- 1982WH1A Wharton, in "Pion Production and Absorption in Nucl. - Indiana 1981", *AIP Conf. Proc.* 79 (1982) 371
- 1982YA1A A.I. Yavin, *Nucl. Phys.* A374 (1982) 297
- 1982ZA1C Zabel, *Bull. Amer. Phys. Soc.* 27 (1982) 780

- 1982ZO1B Zofka, Sotona and Fetisov, Proc. Conf. on Hypernuclear and Kaon Phys., Heidelberg, June 1982 (1982) p. 85
- 1983AB01 V.G. Ableev, D.A. Abdushukurov, S.A. Avramenko, Ch. Dimitrov, A. Filipkowski, A.P. Kobushkin, D.K. Nikitin, A.A. Nomofilov, N.M. Piskunov, V.I. Sharov et al., Nucl. Phys. A393 (1983) 491
- 1983AD1B E.G. Adelberger, Proc. NATO Advanced Study Institute on Symmetries in Nucl. Struct., 16-28 Aug. 1982, Dronen, Netherlands; Eds., Abrahams, Allaart and Dieperink (Plenum Press, 1983) 55
- 1983AD1D Adelberger, Proc. Int. Conf. on Nucl. Phys., August-Sept. 1983; Eds., P. Blasi and R.A. Ricci (1983) 499
- 1983AJ01 F. Ajzenberg-Selove, Nucl. Phys. A392 (1983) 1; Erratum Nucl. Phys. A413 (1984) 168
- 1983AL04 G.D. Alkhazov and O.A. Domchenkov, Yad. Fiz. 37 (1983) 84; Sov. J. Nucl. Phys. 37 (1983) 46
- 1983AL1L Aleksandrov et al., in Moscow (1983) p. 363
- 1983AL1M Almeida and Kappeler, Astrophys. J. 265 (1983) 417
- 1983AM1A G. Amsel and J.A. Davies, Nucl. Instrum. Meth. Phys. Res. 218 (1983) 177
- 1983AN05 B.D. Anderson, A. Fazely, R.J. McCarthy, P.C. Tandy, J.W. Watson, R. Madey, W. Bertozzi, T.N. Buti, J.M. Finn, J. Kelly et al., Phys. Rev. C27 (1983) 1387
- 1983ANZQ Y. Ando, M. Uno and M. Yamada, JAERI-M-83-025 (1983)
- 1983AR11 K.P. Artemov, V.Z. Gol'dberg, M.S. Golovkov, B.G. Novatskii, I.P. Petrov, V.P. Rudakov, Serikov and V.A. Timofeev, Yad. Fiz. 37 (1983) 1351; Sov. J. Nucl. Phys. 37 (1983) 805
- 1983AS01 D. Ashery, D.F. Geesaman, R.J. Holt, H.E. Jackson, J.R. Specht, K.E. Stephenson, R.E. Segel, P. Zupranski, H.W. Baer, J.D. Bowman et al., Phys. Rev. Lett. 50 (1983) 482
- 1983AU1A Auerbach et al., Ann. Phys. 148 (1983) 381
- 1983AZ1B Azimov et al., Sov. J. Nucl. Phys. 37 (1983) 887
- 1983BA1V Bandyopadhyay and Mahalanobis, Phys. Rev. C27 (1983) 628
- 1983BA36 H.W. Baer, J.A. Bistirlich, K.M. Crowe, W. Dahme, C. Joseph, J.P. Perroud, M. Lebrun, C.J. Martoff, U. Straumann and P. Truol, Phys. Rev. C28 (1983) 761
- 1983BA38 D. Baye and P.-H. Heenen, Nucl. Phys. A403 (1983) 433
- 1983BE1R Berdnikov, in Moscow (1983) p. 468
- 1983BH09 R. Bhanja, N.A.L. Devi, R.R. Joseph, I.D. Ojha, M. Shyam and S.K. Tuli, Nucl. Phys. A411 (1983) 507
- 1983BI1A J.R. Birkelund and J.R. Juizenga, Ann. Rev. Nucl. Part. Sci. 33 (1983) 265

- 1983BL11 M. Blecher, K. Gotow, R.L. Burman, M.V. Hynes, M.J. Leitch, N.S. Chant, L. Rees, P.G. Roos, F.E. Bertrand, E.E. Gross et al., Phys. Rev. C28 (1983) 2033
- 1983BO1F Boyd, Wiescher, Newsom and Collins, (1983)
- 1983BO24 I.N. Borzov and S.V. Tolokonnikov, Izv. Akad. Nauk. SSSR Ser. Fiz. 47 (1983) 901
- 1983BR1Q Brown et al., Radiocarbon 25 (1983) 701
- 1983CA07 G. Calvi, M. Lattuada, C. Spitaleri, F. Riggi, D. Vinciguerra, C.M. Sutura and A. Pantaleo, Lett. Nuovo Cim. 36 (1983) 475
- 1983CA1N Carlin et al., in Florence (1983) 590
- 1983CE01 F.E. Cecil, R.F. Fahlsing, N. Jarmie, R.A. Hardekopf and R. Martinez, Phys. Rev. C27 (1983) 6
- 1983CE1C Cerruti, Guinet and Demeyer, in Florence (1983) p. 587
- 1983CH1T Chen, Zhuang, Jin and King, in Florence (1983) 44, 45
- 1983CH23 B. Chambon, D. Drain, C. Pastor, A. Dauchy, A. Giorni and C. Morand, Z. Phys. A312 (1983) 125
- 1983CI08 O. Civitarese, B.V. Carlson, M.S. Hussein and A. Szanto de Toledo, Phys. Lett. B125 (1983) 22
- 1983CO09 E.R. Cohen and A.H. Wapstra, Nucl. Instrum. Meth. 211 (1983) 153
- 1983CR1B Crema and Acquadro, in Florence (1983) p. 544
- 1983CS03 J. Cseh, A.Z. Kiss, E. Koltay, B. Nyako and E. Pintye, Nucl. Phys. A410 (1983) 147
- 1983CU03 A. Cunsolo, A. Foti, G. Imme, G. Pappalardo, G. Raciti and N. Saunier, Lett. Nuovo Cim. 37 (1983)193
- 1983DA10 B. Dasmahapatra, B. Cujec and F. Lahlou, Can. J. Phys. 61 (1983) 657
- 1983DA22 J.H. Dave and C.R. Gould, Phys. Rev. C28 (1983) 2212
- 1983DE13 S.V. Dementii, Sov. J. Nucl. Phys. 37 (1983) 370; Yad. Fiz. 37 (1983) 621
- 1983DE26 P.A. De Young, J.J. Kolata, L.J. Satkowiak and M.A. Xapsos, Phys. Rev. C28 (1983) 692
- 1983DO1H Donahue et al., Radiocarbon 25 (1983) 719
- 1983DO1K Donahue, Jull, Zabel and Damon, Nucl. Instrum. Meth. Phys. Res. 218 (1983) 425
- 1983DU13 G.G. Dussel, A.O. Gattone and E.E. Maqueda, Phys. Rev. Lett. 51 (1983) 2366
- 1983DU1D Dunham et al., (1983)
- 1983EN04 Y.M. Engel and R.D. Levine, Phys. Rev. C28 (1983) 2321
- 1983ET02 M.C. Etchegoyen, D. Sinclair, A. Etchegoyen and E. Belmont Moreno, Nucl. Phys. A402 (1983) 87
- 1983FA1B Farwell et al., in Florence (1983) 752

- 1983FA1H Farwell et al., Radiocarbon 25 (1983) 711
- 1983FE07 V.N. Fetisov, L. Majling, J. Zofka and R.A. Eramzhyan, Z. Phys. A314 (1983) 239
- 1983FI1C D. Fink, Nucl. Instrum. Meth. Phys. Res. 218 (1983) 456
- 1983FI1L Fink et al., Nucl. Instrum. Meth. Phys. Res. 218 (1983) 171
- 1983FO1D Fowler, Bull. Amer. Phys. Soc. 28 (1983) 710
- 1983FR17 R.M. Freeman, C. Beck, F. Haas, B. Heusch and J.J. Kolata, Phys. Rev. C28 (1983) 437
- 1983FR1A W.A. Friedman and W.G. Lynch, Phys. Rev. C28 (1983) 950
- 1983FR23 H. Friedrich and K. Langanke, Phys. Rev. C28 (1983) 1385
- 1983GA12 F.A. Gareev, S.A. Goncharov, S.N. Ershov, G.S. Kazacha and E. Bang, Yad. Fiz. 38 (1983) 73; Sov. J. Nucl. Phys. 38 (1983) 41
- 1983GA17 A. Gal, Phys. Rev. C28 (1983) 2186
- 1983GE03 D.F. Geesaman, D. Kurath, G.C. Morrison, C. Olmer, B. Zeidman, R.E. Anderson, R.L. Boudrie, H.A. Thiessen, G.S. Blanpied, G.R. Burleson et al., Phys. Rev. C27 (1983) 1134
- 1983GE12 P.M. Gensini, Lett. Nuovo Cim. 38 (1983) 469
- 1983GI1E Gillespie, Hedges and White, Radiocarbon 25 (1983) 729
- 1983GM1A M. Gmitro, H.R. Kissener, P. Truol and R.A. Eramzhyan, Fiz. Elem. Chastits At. Yadra 14 (1983) 773; Sov. J. Part. Nucl. 14 (1983) 323
- 1983GO10 N.F. Golovanova, E.T. Ibraeva and V.G. Neudachin, Sov. J. Nucl. Phys. 37 (1983) 526; Yad. Fiz. 37 (1983) 883
- 1983GO13 J. Gomez del Campo and G.R. Satchler, Phys. Rev. C28 (1983) 952
- 1983GO1B Goncharova, Kissener and Eramzhyan, in Orsay (1983) 61
- 1983GO1H C.R. Gould, J. Dave and R.L. Walter, Proc. Int. Conf. on Nucl. Data for Sci. and Tech., Antwerp, Belgium, 6-10 Sept. 1982 (Reidel, 1983) 766
- 1983GO1R Gontcharova, Kissener and Eramzhian, in Moscow (1983) 188
- 1983GO27 V.G. Gonchar and V.V. Tokarevsky, Izv. Akad. Nauk. SSSR Ser. Fiz. 47 (1983) 2156; Bull. Acad. Sci. USSR Phys. Ser. 47 (1983) 69
- 1983GO2C Goodman, in Florence (1983) p. 165
- 1983GO2D Gossett, Nucl. Instrum. Meth. Phys. Res. 218 (1983) 149
- 1983IK1B Ikebata and Kudo, Proc. RCNP Int. Symp. on Light Ion Reaction Mechanism, Osaka (1983) p. 512; Phys. Abs. 112215 (1983)
- 1983IM1A Imai et al., Proc. RCNP Int. Symp. on Light Ion Reaction Mechanism, Osaka (1983) p. 129; Phys. Abs. 112224 (1983)

- 1983IR04 F. Irom, J.R. Comfort, R. Jeppesen, J.J. Kraushaar, R.A. Ristinen, W. Tew, J.L. Ullmann, H.W. Baer, J.D. Bowman, M.D. Cooper et al., Phys. Rev. C28 (1983) 2565
- 1983JA05 U. Jahnke, G. Ingold, H. Homeyer, M. Burgel, Ch. Egelhaaf, H. Fuchs and D. Hilscher, Phys. Rev. Lett. 50 (1983) 1246
- 1983JI04 Jiang Chenglie, Han Shukui, Guo Qingjiang and Li Qingli, Chin. Phys. 3 (1983) 675; Chin. J. Nucl. Phys. 5 (1983) 8
- 1983JU1B Jull, Donahue and Zabel, Nucl. Instrum. Meth. Phys. Res. 218 (1983) 509
- 1983KA1K Kadmenski and Tschuvilski, in Moscow (1983) p. 181
- 1983KAZF J.V. Kane, Bull. Amer. Phys. Soc. 28 (1983) 661, AY5A
- 1983KH1F Khrapan, Oravets and Florek, Acta Phys. Univ. Comenianae 23 (1983) 129; Phys. Abs. 73897 (1984)
- 1983KO15 S.K. Korotky, K.A. Erb, R.L. Phillips, S.J. Willett and D.A. Bromley, Phys. Rev. C28 (1983) 168
- 1983KO16 R. Konnecke, W. Greiner and W. Scheid, Phys. Rev. Lett. 51 (1983) 366
- 1983KO2A Koslowsky et al., in Florence (1983) p. 712
- 1983KR1B Kruse, Bull. Amer. Phys. Soc. 28 (1983) 44
- 1983KRZZ J.J. Kraushaar, R. Jeppesen, R.A. Ristinen, W. Tew, J.L. Ullmann, F. Irom, J. Comfort, H.W. Baer, J.D. Bowman, M.D. Cooper et al., Bull. Amer. Phys. Soc. 28 (1983) 672, BG6
- 1983KU1C Kutschera, Radiocarbon 25 (1983) 677
- 1983LE17 P.M. Lewis, O. Karban, J.M. Barnwell, J.D. Brown, P.V. Drumm, J.M. Nelson and S. Roman, Nucl. Phys. A404 (1983) 205
- 1983LI1A Litherland, in Florence (1983) 697
- 1983LI1G Liu, Bull. Amer. Phys. Soc. 28 (1983) 746
- 1983LI1T C.-D. Lien, L. Wielunski and M.-A. Nicolet, Nucl. Instrum. Meth. Phys. Res. 213 (1983) 463
- 1983LIZW P.M. Lister, F.D. Brooks and J.M. Nelson, Bull. Amer. Phys. Soc. 28 (1983) 658, AX5
- 1983MA06 S. Marsh, Phys. Lett. B121 (1983) 238
- 1983MA35 F.J. Margetan and J.P. Vary, Phys. Rev. C28 (1983) 907
- 1983MA63 L. Majling, J. Zofka, V.N. Fetisov and R.A. Eramzhyan, Phys. Lett. B103 (1983) 235
- 1983MIZY C. Mishra, B.M. Preedom, G.S. Blanpied, B.G. Ritchie, S. Moore, M. Blecher, K. Gotow, M. Artuso, R.L. Burman, M. Hynes et al., Bull. Amer. Phys. Soc. 28 (1983) 719, GG8
- 1983NE1A Nelson et al., Radiocarbon 25 (1983) 693
- 1983NO08 E. Norbeck, P.T. Wu, C.R. Chen and R.R. Carlson, Phys. Rev. C28 (1983) 1140

- 1983OL1A D.L. Olson, B.L. Berman, D.E. Greiner, H.H. Heckman, P.J. Lindstrom and H.J. Crawford, Phys. Rev. C28 (1983) 1602
- 1983OR1D Orihara et al., Proc. RCNP Int. Symp. on Light Ion Reaction Mech., Osaka, Japan (1983) 176; Phys. Abs. 112208 (1983)
- 1983OS03 A. Osman, Int. J. Theor. Phys. 22 (1983) 341
- 1983PAZT S.J. Padalino and L.C. Dennis, Bull. Amer. Phys. Soc. 28 (1983) 974, BB5
- 1983PE14 R.J. Peterson, Phys. Scr. T5 (1983) 190
- 1983PL1A F. Plasil, Nucl. Phys. A400 (1983) 417
- 1983PR1B Pruneau, Rangacharyulu, Chatterjee and St-Pierre, in Florence (1983) 239
- 1983QU02 J.L. Quebert, D. Bertault, M. Boumart, P. Humbert and J.N. Scheurer, Nucl. Phys. A403 (1983) 166
- 1983RE1B Reedy, Arnold and Laa, Science 219 (1983) 127
- 1983RI1C Rieder et al., Bull. Amer. Phys. Soc. 28 (1983) 705
- 1983RO07 R.M. Rockmore, Phys. Rev. C27 (1983) 2150
- 1983RO22 S. Roman, O. Karban, M. Barnwell, J.D. Brown, P.V. Drumm, P.M. Lewis and J.M. Nelson, Phys. Rev. C28 (1983) 2515
- 1983SA06 M. Sato, M. Sasagase, Y. Nagashima, J. Schimizu, T. Nakagawa, Y. Fukuchi and T. Mikumo, Phys. Rev. C27 (1983) 2621
- 1983SA07 M. Sasagase, M. Sato, S. Hanashima, K. Furuno, Y. Nagashima, Y. Tagishi, S.M. Lee and T. Mikumo, Phys. Rev. C27 (1983) 2630
- 1983SC1B Schell, Science 219 (1983) 1068
- 1983SC1G Schwandt, AIP Conf. Proc. 97 (1983) 110
- 1983SE16 U. Sennhauser, E. Piasetzky, H.W. Baer, J.D. Bowman, M.D. Cooper, H.S. Matis, H.J. Ziock, J. Alster, A. Erell, M.A. Moinester et al., Phys. Rev. Lett. 51 (1983) 1324
- 1983SH1E Y.-J. Shi and F. Zhuang, Phys. Energ. Fortis Phys. Nucl. 7 (1983) 605
- 1983SH31 B. Sherrill, K. Beard, W. Benenson, B.A. Brown, E. Kashy, W.E. Ormand, H. Nann, J.J. Kehayias, A.D. Bacher and T.E. Ward, Phys. Rev. C28 (1983) 1712
- 1983SH38 Y.-J. Shi, Phys. Rev. C28 (1983) 2452
- 1983SI1B J.A. Simpson, Ann. Rev. Nucl. Part. Sci. 33 (1983) 323
- 1983SO08 L.G. Sobotka, M.L. Padgett, G.J. Wozniak, G. Guarino, A.J. Pacheco, L.G. Moretto, Y. Chan, R.G. Stokstad, I. Tserruya and S. Wald, Phys. Rev. Lett. 51 (1983) 2187
- 1983SP06 Ts.P. Spasov, Ch.M. Chernev, Yu.A. Batusov and R.A. Eramzhyan, Blug. J. Phys. 10 (1983) 581
- 1983SR01 J. Sromicki, M. Hugi, J. Lang, R. Muller, E. Ungricht, L. Jarczyk, B. Kamys, A. Magiera, Z. Rudy, A. Strzalkowski et al., Nucl. Phys. A406 (1983) 390

- 1983SU04 T. Suzuki and H. Narumi, Phys. Lett. B125 (1983) 251
- 1983SU07 T.S. Subramanian, J.L. Romero, F.P. Brady, J.W. Watson, D.H. Fitzgerald, R. Garrett, G.A. Needham, J.L. Ullmann, C.I. Zanelli, D.J. Brenner et al., Phys. Rev. C28 (1983) 521
- 1983SU1C Suter et al., IEEE Trans. Nucl. Sci. 30 (1983) 1528
- 1983SZ01 L. Szybisz, V.M. Silbergleit and J.I. Sidelnik, Phys. Lett. B122 (1983) 131
- 1983TA12 T.N. Taddeucci, J. Rapaport, C.C. Foster and J.R. Comfort, Phys. Rev. C28 (1983) 969
- 1983TA1F Taddeucci, AIP Conf. Proc. 97 (1983) 228
- 1983TA1Q Tagishi et al., Proc. RCNP Int. Symp. on Light Ion Reaction Mech., Osaka, Japan (1983) 502; Phys. Abs. 112228 (1983)
- 1983THZZ T.G. Throwe, S.E. Vigdor, W.W. Jacobs, M.C. Green, C.W. Glover, B.P. Hichwa and T.E. Ward, Bull. Amer. Phys. Soc. 28 (1983) 672, BG9
- 1983TO17 G. Toker and F. Tabakin, Phys. Rev. C28 (1983) 1725
- 1983TR1J Truol, in Florence (1983) 247
- 1983TU1C Tucker, Woefli, Bonani and Suter, Science 219 (1983) 1320
- 1983VA1E A. Van Der Schaaf, E.A. Hermes, R.J. Powers, F.W. Schleputz, R.G. Winter, A. Zglin-ski, T. Kozlowski, W. Bertl, L. Felawka, W. H.A. Hesselink et al., Nucl. Phys. A408 (1983) 573
- 1983VA1K Van Otten et al., in Florence (1983) 347
- 1983VA31 A.G.M. van Hees and P.W.M. Glaudemans, Z. Phys. A314 (1983) 323
- 1983VI01 S.E. Vigdor, T.G. Throwe, M.C. Green, W.W. Jacobs, R.D. Bent, J.J. Kehayias, W.K. Pitts and T.E. Ward, Nucl. Phys. A396 (1983) 61c
- 1983VO1B G. Vourvopoulos et al., in Florence (1983) 639
- 1983WA03 J.D. Watson, J.W. Jury, P.C.-K. Kuo, W.F. Davidson, N.K. Sherman and K.G. Mc-Neill, Phys. Rev. C27 (1983) 506
- 1983WA09 R.E. Warner, K. Blum, D. Friesel, P. Schwandt, P.P. Singh and A. Galonsky, Nucl. Phys. A401 (1983) 521
- 1983WI12 D. Wintgen, H. Friedrich and K. Langanke, Nucl. Phys. A408 (1983) 239
- 1983WI1A Wilczynski, in Florence (1983) 305
- 1983YA1D Yamaya et al., Proc. RCNP Int. Symp. on Light Ion Reaction Mech., Osaka, Japan (1983) 498; Phys. Abs. 112227 (1983)
- 1983ZH1D Zhivopistev and Slivoi, in Moscow (1983) 354
- 1984AA01 E.H.L. Aarts, R.A.R.L. Malfliet, R.J. De Meijer and S.Y. Van Der Werf, Nucl. Phys. A425 (1984) 23

- 1984AB1A Abe and Park, RIFP-508 (1984)
- 1984AB1F Abe et al., RIFP-509 (1984)
- 1984AD04 E.G. Adelberger, P. Hoodbhoy and B.A. Brown, Phys. Rev. C30 (1984) 456
- 1984AD1E E.G. Adelberger, AIP Conf. Proc. 123 (1984) 300
- 1984AJ01 F. Ajzenberg-Selove, Nucl. Phys. A413 (1984) 1
- 1984AL1L Alma-Ata et al Collaboration, in Panic (1984) N11
- 1984AL34 D.V. Aleksandrov, A.F. Belyatsky, Yu.A. Glukhov, E.Yu. Nikolsky, B.G. Novatsky, A.A. Ogloblin and D.N. Stepanov, JETP Lett. 40 (1984) 909; Pisma Zh. Eksp. Teor. Fiz. 40 (1984) 152
- 1984AN1B Anagnostatos, in Panic (1984) I56
- 1984AN1P Andree et al., Nucl. Instrum. Meth. Phys. Res. B233 (1984) 385
- 1984AN1Q Andrews et al., Nucl. Instrum. Meth. Phys. Res. B233 (1984) 134
- 1984AS05 D. Ashery, D.F. Geesaman, R.J. Holt, H.E. Jackson, J.R. Specht, K.E. Stephenson, R.E. Segel, P. Zupranski, H.W. Baer, J.D. Bowman et al., Phys. Rev. C30 (1984) 946
- 1984AS07 Y.I. Assafiri and I. Morrison, Nucl. Phys. A427 (1984) 460
- 1984AS1D F. Asai, H. Bando and M. Sano, Phys. Lett. B145 (1984) 19
- 1984BA1H I. Bang and Yu.V. Gaponov, Izv. Akad. Nauk. SSSR Ser. Fiz. 48 (1984) 129; Bull. Acad. Sci. USSR Phys. Ser. 51 (1984) 130
- 1984BA1N B. Bassalleck, AIP Conf. Proc. 123 (1984) 867
- 1984BA31 D.P. Balamuth, W.K. Wells, T. Chapuran, D.P. Bybell and C.M. Laymon, Phys. Lett. B140 (1984) 295
- 1984BAZZ N.L. Back, F.S. Dietrich, J.G. Woodworth, I.D. Proctor, C.H. Poppe, H.E. Conzett and C. Rioux, Bull. Amer. Phys. Soc. 29 (1984) 640, AK8
- 1984BE13 J.C. Bergstrom, R. Neuhausen and G. Lahm, Phys. Rev. C29 (1984) 1168
- 1984BE1H J. Beer, M. Andree, H. Oeschger, U. Siegenthaler, G. Bonani, H. Hofmann, E. Morenzoni, M. Nessi, M. Suter, W. Wolfli, et al., Nucl. Instrum. Meth. Phys. Res. B233 (1984) 380
- 1984BE22 C. Beck, F. Haas, R.M. Freeman, B. Heusch, J.P. Coffin, G. Guillaume, F. Rami and P. Wagner, Phys. Rev. C29 (1984) 1942
- 1984BI10 M. Bini, P.G. Bizzeti and P. Sona, Lett. Nuovo Cim. 41 (1984) 191
- 1984BI1E Bill et al., Nucl. Instrum. Meth. Phys. Res. B233 (1984) 317
- 1984BO03 A.I. Boothroyd, J. Markey and P. Vogel, Phys. Rev. C29 (1984) 603
- 1984BO1Q Boyd, Newsom, Collins and Wiescher, Science 225 (1984) 508
- 1984BO1T Bonani et al., Nucl. Instrum. Meth. Phys. Res. B233 (1984) 284

- 1984BR25 B.A. Brown, C.R. Bronk and P.E. Hodgson, *J. Phys. (London)* G10 (1984) 1683
- 1984BU1Q Bursak, Gorbatov, Krilov and Rudiak, in *Alma Ata* (1984) 220
- 1984CA1D T.A. Cahill, Y. Matsuda, D. Shadoan, R.A. Eldred and B.H. Kusko, *Nucl. Instrum. Meth. Phys. Res.* B231 (1984) 263
- 1984CH1G H.Z. Chen, F. Zhuang, X.J. Shi and X.N. Jin, *Chin. J. Nucl. Phys.* 6 (1984) 303
- 1984CL08 M.E. Clark and K.W. Kemper, *Nucl. Phys.* A425 (1984) 185
- 1984CO1H Cook, Stone and Vogt, *Astrophys. J.* 279 (1984) 827
- 1984CO1V Comfort, in *AIP Conf. proc.* 123 (1984) 675
- 1984COZW B.H. Cottman, K. Min, P. Stoler, P.K. Teng, E.J. Winhold, M. Yamazaki, P.F. Yergin, A.M. Bernstein, K.I. Blomqvist, J.J. Comuzzi et al., *Bull. Amer. Phys. Soc.* 29 (1984) 708, F18
- 1984CU1A Currie, Klouda and Voorhees, *Nucl. Instrum. Meth. Phys. Res.* B233 (1984) 371
- 1984DA03 C.B. Daskaloyannis, M.E. Grypeos, C.G. Koutroulos, S.E. Massen and D.S. Saloupis, *Phys. Lett.* B134 (1984) 147
- 1984DA17 B. Dasmahapatra, B. Cujec and F. Lahlou, *Nucl. Phys.* A427 (1984) 186
- 1984DE1F Descroix, Unpublished Thesis, Univ. Lyon, France (1984)
- 1984DE53 P. De Bievre, M. Gallet, N.E. Holden and I.L. Barnes, *J. Phys. Chem. Ref. Data* 13 (1984) 809
- 1984DO1B D.J. Donahue, A.J.T. Jull and T.H. Zabel, *Nucl. Instrum. Meth. Phys. Res.* B233 (1984) 162
- 1984DO20 T.W. Donnelly and I. Sick, *Rev. Mod. Phys.* 56 (1984) 461
- 1984EL1B D. Elmore, P.W. Kubick, L.E. Tubbs, H.E. Gove, R. Teng, T. Hemmick, B. Chrnyk and N. Conard, *Nucl. Instrum. Meth. Phys. Res.* B233 (1984) 109
- 1984EL1C D. Elmore, N. Conrad, P.W. Kubik and J. Fabryka-Martin, *Nucl. Instrum. Meth. Phys. Res.* B233 (1984) 233
- 1984EP1A Epherre, *Ann. Physique* 9 (1984) 717
- 1984ER1A Eramzhyan, Majling, Zofka and Fetisov, in *Panic* (1984) M21
- 1984FA1G Farwell, Grootes, Leach and Schmidt, *Nucl. Instrum. Meth. Phys. Res.* B233 (1984) 144
- 1984FI17 D.J. Fields, W.G. Lynch, C.B. Chitwood, C.K. Gelbke, M.B. Tsang, H. Utsunomiya and J. Aichelin, *Phys. Rev.* C30 (1984) 1912
- 1984FR13 H. Friedrich, *Phys. Lett.* B146 (1984) 135
- 1984FR1A P. Frobrich, *Phys. Rept.* 116 (1984) 337
- 1984GA38 S. Gales, E. Hourani, M. Hussonnois, J.P. Schapira, L. Stab and M. Vergnes, *Phys. Rev. Lett.* 53 (1984) 759

- 1984GI09 R. Gilman, H.T. Fortune, L.C. Bland, R.R. Kiziah, C.F. Moore, P.A. Seidl, C.L. Morris and W.B. Cottingham, *Phys. Rev. C*30 (1984) 958
- 1984GI1K Gillespie, Hedges and Perry, *Nucl. Instrum. Meth. Phys. Res. B*233 (1984) 167
- 1984GI1L Giger et al., *Nucl. Instrum. Meth. Phys. Res. B*233 (1984) 394
- 1984GI1M Gillespie and Hedges, *Nucl. Instrum. Meth. Phys. Res. B*233 (1984) 294
- 1984GL06 Yu.A. Glukhov, A.S. Demyanova, A.A. Ogloblin, S.B. Sakuta and V.V. Sukharevsky, *Yad. Fiz.* 40 (1984) 62; *Sov. J. Nucl. Phys.* 40 (1984) 41
- 1984GL1G Glukov et al., in *Alma Ata* (1984) 385
- 1984GO1C J. Gomez del Campo, J.A. Biggerstaff, R.A. Dayras, D. Shapira, A.H. Snell, P.H. Stelson and R.G. Stokstad, *Phys. Rev. C*29 (1984) 1722
- 1984GO1J Golzov, Goncharova and Kissener, in *Panic* (1984) A60
- 1984GO1M Goncharova, Kissener and Eramzhain, in *Alma Ata* (1984) 152
- 1984GR08 R.E.L. Green, R.G. Korteling and K.P. Jackson, *Phys. Rev. C*29 (1984) 1806
- 1984GR27 S.J. Greene, C.J. Harvey, P.A. Seidl, R. Gilman, E.R. Siciliano and M.B. Johnson, *Phys. Rev. C*30 (1984) 2003
- 1984GU05 D. Guinet, R. Billerey, C. Cerruti, S. Chiodelli and A. Demeyer, *Phys. Lett. B*137 (1984) 318
- 1984HA1Q Hannien and raisanen, *Nucl. Instrum. Meth. Phys. Res. B*233 (1984) 34
- 1984HA26 K. Hatanaka, N. Matsuoka, T. Saito, K. Hosono, M. Kondo, S. Kato, T. Higo, S. Matsuki, Y. Kadota and K. Ogino, *Nucl. Phys. A*419 (1984) 530
- 1984HA43 Q. Haider and B. Cujec, *Nucl. Phys. A*429 (1984) 116
- 1984HA53 Q. Haider and F.B. Malik, *At. Data Nucl. Data Tables* 31 (1984) 185
- 1984HA58 J.C. Hardy and I.S. Towner, *J. Phys. (Paris)* 45 (1984) 417
- 1984HE1B R.E.M. Hedges, *Nucl. Instrum. Meth. Phys. Res.* 220 (1984) 211
- 1984HE1G Hedges and Gowlett, *Nature* 308 (1984) 403
- 1984HE20 W. Heeringa, H.O. Klages, H. Dobiash, R. Fischer, B. Haesner, P. Schwarz, J. Wilczynski and B. Zeitnitz, *Nucl. Instrum. Meth. Phys. Res. A*227 (1984) 509
- 1984HI1A A.S. Hirsch, A. Bujak, J.E. Finn, L.J. Gutay, R.W. Minich, N.T. Porile, R.P. Scharenberg and B.C. Stringfellow, *Phys. Rev. C*29 (1984) 508
- 1984HO1L Holstein, *Phys. Rev. C*29 (1984) 623
- 1984HO23 H. Homeyer, M. Burgel, Ch. Egelhaaf, H. Fuchs and G. Thoma, *Z. Phys. A*319 (1984) 143
- 1984HU07 R.L. Huffman, R.S. Hicks, J. Dubach, B. Parker, M.A. Plum, G. Lahm, R. Neuhausen and J.C. Bergstrom, *Phys. Lett. B*139 (1984) 249

- 1984HUZY R.L. Huffman, J. Dubach, R.S. Hicks and M.A. Plum, Bull. Amer. Phys. Soc. 29 (1984) 715, GG1
- 1984IN03 M. Inoue and S.E. Koonin, Phys. Rev. C30 (1984) 175
- 1984JA1F Jacobs, AIP Conf. Proc. 123 (1984) 1090
- 1984KA1J Karol, Science 226 (1984) 1425
- 1984KA1R Kaihola et al., Nucl. Instrum. Meth. Phys. Res. B233 (1984) 436
- 1984KE1D Kerimov and Agalarov, in Alma Ata (1984) p. 487
- 1984KL1E Klouda et al., Nucl. Instrum. Meth. Phys. Res. B233 (1984) 265
- 1984KNZY J.N. Knudson, J.R. Comfort, P. Alons, J. Kraushaar, J. Mitchell, R. Ristinen, J.L. Ullman, H.W. Baer, J.D. Bowman, D. Fitzgerald et al., Bull. Amer. Phys. Soc. 29 (1984) 670, DE1
- 1984KO1Q Kong Xiang-jing, Xie Xian-liang and Sun Chung-wei, Phys. Energ. Fortis Phys. Nucl. 8 (1984) 199
- 1984KO1U Koshigiri, Ohtsubo and Morita, in Panic (1984) H3
- 1984KOZU E. Korkmaz, S.E. Vigdor, W.W. Jacobs, J.D. Brown, P.L. Jolivette, T.G. Throwe and M.C. Green, Bull. Amer. Phys. Soc. 29 (1984) 1050, DD1
- 1984KU07 D. Kurath and R.D. Lawson, Phys. Rev. C29 (1984) 2303
- 1984KU1K Kutschera, Nucl. Instrum. Meth. Phys. Res. B233 (1984) 420
- 1984LA01 K. Langanke, R. Stademann and D. Frekers, Phys. Rev. C29 (1984) 40
- 1984LI1R Lister et al., Nucl. Instrum. Meth. Phys. Res. B233 (1984) 389
- 1984LI25 R.A. Lindgren, J. Phys. 34 C-4 (1984) 433
- 1984MA28 J.F. Mateja, J. Garman, D.E. Fields, R.L. Kozub, A.D. Frawley and L.C. Dennis, Phys. Rev. C30 (1984) 134
- 1984MA2H Mariotti, Nature 311 (1984) 251
- 1984MA2J Mathews and Dietrich, Astrophys. J. 287 (1984) 969
- 1984MAZT F.B. Malik and Q. Haider, Bull. Amer. Phys. Soc. 29 (1984) 1047, DB1
- 1984MI15 G.A. Miller, Phys. Rev. Lett. 53 (1984) 2008
- 1984MI1L Miller, in Panic (1984) E42
- 1984MI1M Mishra et al., in Panic (1984) F5
- 1984MO1T Mook, Nucl. Instrum. Meth. Phys. Res. A224 (1984) 297
- 1984MOZU C.F. Moore, D.S. Oakley, P.A. Seidl, K. Dhuga, H.T. Fortune, R. Gilman, H. Baer, S.J. Greene, C.L. Morris, L.C. Bland et al., Bull. Amer. Phys. Soc. 29 (1984) 1052, DD11

- 1984NA01 I. Navon, M.J. Leitch, D.A. Bryman, T. Numao, P. Schlatter, G. Azuelos, R. Poutissou, R.A. Burnham, M. Hasinoff, J.M. Poutissou et al., Phys. Rev. Lett. 52 (1984) 105
- 1984NA06 T. Nakamura and Y. Uwamino, Phys. Rev. C29 (1984) 1317; Erratum Phys. Rev. C30 (1984) 413
- 1984NA12 Y. Nagame, H. Nakahara, K. Sueki, H. Kudo, I. Kohno and M. Yanokura, Z. Phys. A317 (1984) 31
- 1984NA1R Nakai et al., Nucl. Instrum. Meth. Phys. Res. B233 (1984) 171
- 1984NE1A Nemets, Rudchik and Chuvilski, in Alma Ata (1984) 334
- 1984NE1C D.E. Nelson, J.R. Southon, J.S. Vogel, R.G. Korteling and T.L. Ku, Nucl. Instrum. Meth. Phys. Res. B233 (1984) 139
- 1984NE1E M. Nessi, E. Morenzoni, M. Suter, G. Bonani, H.J. Hofmann, C. Stoller and W. Wolfli, Nucl. Instrum. Meth. Phys. Res. B233 (1984) 238
- 1984OH06 H. Ohnuma, F. Irom, B. Aas, M. Haji-Saeid, G.J. Igo, G. Pauletta, A.K. Rahbar, A.T.M. Wang, C.A. Whitten, Jr., M.M. Gazzaly et al., Phys. Lett. B147 (1984) 253
- 1984PE24 R.J. Peterson, H.C. Bhang, J.J. Hamill and T.G. Masterson, Nucl. Phys. A425 (1984) 469
- 1984PL02 M.A. Plum, R.A. Lindgren, J. Dubach, R.S. Hicks, R.L. Huffman, B. Parker, G.A. Peterson, J. Alster, J. Lichtenstadt, M.A. Moinester et al., Phys. Lett. B137 (1984) 15
- 1984PO11 D.N. Poenaru and M. Ivascu, J. Phys. (Paris) 45 (1984) 1099
- 1984PO1C G. Possnert, Nucl. Instrum. Meth. Phys. Res. B233 (1984) 159
- 1984PO1L Polach, Nucl. Instrum. Meth. Phys. Res. B233 (1984) 259
- 1984RA17 W.D.M. Rae and R.K. Bhowmik, Nucl. Phys. A427 (1984) 142
- 1984RU1C Rubin, Mysen and Polach, Nucl. Instrum. Meth. Phys. Res. B233 (1984) 272
- 1984SA37 M. Sakai, At. Data Nucl. Data Tables 31 (1984) 399
- 1984SC04 H.R. Schelin, E. Farrelly Pessoa, W.R. Wylie, E.W. Cybulska, K. Nakayama, L.M. Fagundes and R.A. Douglas, Nucl. Phys. A414 (1984) 67
- 1984SE12 S.J. Seestrom-Morris, M.A. Franey, D. Dehnhard, D.B. Holtkamp, R.L. Boudrie, J.F. Amann, G.C. Idzorek and C.A. Goulding, Phys. Rev. C30 (1984) 270
- 1984SE14 P.A. Seidl, M.D. Brown, R.R. Kiziah, C.F. Moore, H. Baer, C.L. Morris, G.R. Burleson, W.B. Cottingham, S.J. Greene, L.C. Bland et al., Phys. Rev. C30 (1984) 973
- 1984SE16 R.G. Seyler and H.R. Weller, Phys. Rev. C30 (1984) 1146
- 1984SH04 K. Shin, K. Hibi, M. Fujii, Y. Uwamino and T. Nakamura, Phys. Rev. C29 (1984) 1307

- 1984SH1J M. Shoeb and M.Z. Khan, *J. Phys. (London)* G10 (1984) 1047
- 1984SHZY B. Shivakumar, D. Shapira, J. Gomez del Campo, J.L.C. Ford, Jr., P.H. Stelson, B.A. Harmon and S.T. Thornton, *Bull. Amer. Phys. Soc.* 29 (1984) 626, AE15
- 1984SI15 S.H. Simon, P.L. Gonthier, R.K. Choudhury, M.N. Namboodiri, K. Hagel, S. Kniffen, R. Patton, L. Adler and J.B. Natowitz, *Nucl. Phys.* A430 (1984) 249
- 1984SP1B R.J. Sparks, G. Wallace, C.M. Bartle, G.E. Coote, R.G. Ditchburn, D.C. Lowe, W.J. McCabe and K.P. Pohl, *Nucl. Instrum. Meth. Phys. Res.* B233 (1984) 155
- 1984SU07 T. Suzuki and H. Narumi, *Nucl. Phys.* A426 (1984) 413
- 1984SU1B Suter et al., *Bull. Amer. Phys. Soc.* 29 (1984) 1115
- 1984SU1J Suter et al., *Nucl. Instrum. Meth. Phys. Res.* B233 (1984) 117
- 1984SUZZ E. Sugarbaker, R.N. Boyd, W. Chang, D. Krofcheck, C.D. Zafiratos, D.A. Lind, T. Masterson, T.N. Taddeucci, C.C. Foster and W.P. Alford, *Bull. Amer. Phys. Soc.* 29 (1984) 1051, DD5
- 1984SZ04 L. Szybisz, *Phys. Lett.* B145 (1984) 305
- 1984TA02 T.N. Taddeucci, R.R. Doering, A. Galonsky and S.M. Austin, *Phys. Rev.* C29 (1984) 764
- 1984TA07 T.N. Taddeucci, T.A. Carey, C. Gaarde, J. Larsen, C.D. Goodman, D.J. Horen, T. Masterson, J. Rapaport, T.P. Welch and E. Sugarbaker, *Phys. Rev. Lett.* 52 (1984) 1960
- 1984TA1P Taylor, Payen and Slota, *Nucl. Instrum. Meth. Phys. Res.* B233 (1984) 312
- 1984TAZS T.N. Taddeucci, *Bull. Amer. Phys. Soc.* 29 (1984) 1032, BA4
- 1984TEZZ J.A. Templon, J.H. Dave, C.R. Gould, L.W. Seagondollar, C.S. Whisnant, G.M. Honore and S.S. Singkarat, *Bull. Amer. Phys. Soc.* 29 (1984) 131, DC9
- 1984TR1C J.W. Truran, *Ann. Rev. Nucl. Part. Sci.* 34 (1984) 53
- 1984TS03 M.B. Tsang, D.R. Klesch, C.B. Chitwood, D.J. Fields, C.K. Gelbke, W.G. Lynch, H. Utsunomiya, K. Kwiatkowski, V.E. Viola, Jr. and M. Fatyga, *Phys. Lett.* B134 (1984) 169
- 1984TU1D Turkevich, Wielgoz and Economou, *Phys. Rev.* D30 (1984) 1876
- 1984VA06 A.G.M. van Hees and P.W.M. Glaudemans, *Z. Phys.* A315 (1984) 223
- 1984VA1D K. van der Borg, C. Alderliesten, H. Haitjema, G. Hut and N.A. van Zwol, *Nucl. Instrum. Meth. Phys. Res.* B233 (1984) 150
- 1984VD1C Vdovin et al., in *Alma Ata* (1984) p. 313
- 1984VO1G Voitsekhovskii et al., in *Alma Ata* (1984) p. 364, 365
- 1984VO1J Vogel, Southon, Nelson and Brown, *Nucl. Instrum. Meth. Phys. Res.* B233 (1984) 289

- 1984WE04 E. Wesolowski, J. Phys. (London) G10 (1984) 321
- 1984YA03 M. Yasue, J.J. Hamill, H.C. Bhang, M.A. Rumore and R.J. Peterson, Phys. Rev. C30 (1984) 770
- 1984ZW1A Zwarts, Unpublished Ph.D. Thesis, Utrecht (1984)
- 1985AG1A M.M. Aggarwal and P.L. Jain, Phys. Rev. C31 (1985) 1233
- 1985AH1A I. Ahmad, M. Mian and M.Z. Rahman Khan, Phys. Rev. C31 (1985) 1590
- 1985AJ01 F. Ajzenberg-Selove, Nucl. Phys. A433 (1985) 1; Erratum Nucl. Phys. A449 (1986) 155.
- 1985ALZX P.W.F. Alons, J.L. Ullmann and E.R. Siciliano, Bull. Amer. Phys. Soc. 30 (1985) 794
- 1985AN1H Anataraman et al., Bull. Amer. Phys. Soc. 30 (1985) 707
- 1985BAZZ N.L. Back, F.S. Dietrich, J.G. Woodworth, I.D. Proctor, C.H. Poppe, H.E. Conzett and C. Rioux, Bull. Amer. Phys. Soc. 30 (1985) 702
- 1985BE09 M.A. Bernstein and W.A. Friedman, Phys. Rev. C31 (1985) 843
- 1985BH02 R. Bhanja, M. Shyam and S.K. Tuli, Nucl. Phys. A438 (1985) 740
- 1985BL09 M. Blann, Phys. Rev. Lett. 54 (1985) 2215
- 1985BO1D Body and Mihaly, INDC (HUN)-22/L (1985)
- 1985CA01 N. Carlin Filho, M.M. Coimbra, J.C. Acquadro, R. Liguori Neto, E.M. Szanto, E. Farrelly-Pessoa and A. Szanto de Toledo, Phys. Rev. C31 (1993) 152
- 1985CH06 T.E. Chupp, R.T. Kouzes, A.B. McDonald, P.D. Parker, T.F. Wang and A. Howard, Phys. Rev. C31 (1985) 1023
- 1985DI1B F.S. Dietrich and F. Petrovich, AIP Conf. Proc. 124 (1985) 90
- 1985DR1A Drossart, Encrenaz and Combes, Astron. Astrophys. 146 (1985) 181
- 1985DY1C Dytman and Tabakin, Bull. Amer. Phys. Soc. 30 (1985) 766
- 1985FEZY P.B. Fernandez, C.A. Gossett, J.L. Osborne, V.J. Zeps and E.G. Adelberger, Bull. Amer. Phys. Soc. 30 (1985) 1161, GX9
- 1985GI1J Gibbs, Kaufmann and Siegel, Bull. Amer. Phys. Soc. 30 (1985) 707
- 1985GU1A Guzik et al., Bull. Amer. Phys. Soc. 30 (1985) 762
- 1985GU1M Guinet et al., in Visby (1985) 66
- 1985HA18 S.S. Hanna and J.W. Hugg, Hyperfine Interactions 21 (1985) 59
- 1985HA1J H.J. Hauser, T. Rohwer, F. Hoyler, G. Staudt, S. Abd el-Kariem, P. Grasshoff, H.V. Klapdor, A. Korber, W. Leitner, V. Rapp et al., AIP Conf. Proc. 125 (1985) 701
- 1985HA1T Hardy, Science 227 (1985) 993
- 1985HI04 R.S. Hicks, Nucl. Phys. A434 (1985) 97c

- 1985HO07 D.B. Holtkamp, S.J. Seestrom-Morris, D. Dehnhard, H.W. Baer, C.L. Morris, S.J. Greene, C.J. Harvey, D. Kurath and J.A. Carr, Phys. Rev. C31 (1985) 957; Erratum Phys. Rev. C41 (1990) 1319
- 1985JA1B B.V. Jacak, D. Fox and G.D. Westfall, Phys. Rev. C31 (1985) 704
- 1985KA04 T. Karapiperis and M. Kobayashi, Phys. Rev. Lett. 54 (1985) 1230
- 1985KNZZ J.N. Knudson, J.R. Comfort, P.W.F. Alons, J.J. Kraushaar, J.H. Mitchell, R.J. Peterson, R.A. Ristinen, J.L. Ullmann, H.W. Baer, J.D. Bowman et al., Bull. Amer. Phys. Soc. 30 (1985) 783, GH1
- 1985KO04 D. Konnerth, W. Trombik, K.G. Bernhardt, K.A. Eberhard, R. Singh, A. Strzalkowski and W. Trautmann, Nucl. Phys. A436 (1985) 538
- 1985KU01 P.C-K. Kuo, K.G. McNeill, N.K. Sherman, S. Landsberger, W.F. Davidson, J.W. Jury and J.R.C. Lafontaine, Phys. Rev. C31 (1985) 318
- 1985LA06 K. Langanke, O.S. Van Roosmalen and W.A. Fowler, Nucl. Phys. A435 (1985) 657; Erratum Nucl. Phys. A446 (1985) 750
- 1985LE05 M.J. Leitch, E. Piassetzky, H.W. Baer, J.D. Bowman, R.L. Burman, B.J. Dropesky, P.A.M. Gram, F. Irom, D. Roberts, G.A. Rebka, Jr. et al., Phys. Rev. Lett. 54 (1985) 1482
- 1985LI1B Lindstrom et al., Bull. Amer. Phys. Soc. 30 (1985) 747
- 1985MA1L Mahalanobis and Bandyopadhyay, Phys. Rev. C31 (1985) 1241
- 1985MC03 M.A. McMahan, L.G. Moretto, M.L. Padgett, G.J. Wozniak, L.G. Sobotka and M.G. Mustafa, Phys. Rev. Lett. 54 (1985) 1995
- 1985MO08 M. Morjean, J.L. Charvet, J.L. Uzureau, Y. Patin, A. Peghaire, Y. Pranal, L. Sinopoli, A. Billerey, A. Chevarier, N. Chevarier et al., Nucl. Phys. A438 (1985) 547
- 1985OR1G Orihara, Bull. Amer. Phys. Soc. 30 (1985) 115
- 1985OR1H Orihara, in AIP Conf. Proc. 124 (1985) 139
- 1985PR01 P.B. Price, J.D. Stevenson, S.W. Barwick and H.L. Ravn, Phys. Rev. Lett. 54 (1985) 297
- 1985PR1G Price, Bull. Amer. Phys. Soc. 30 (1985) 800
- 1985RI1C Ricken, Sandorfi, Dowell and Paul, in AIP Conf. Proc. 125 (1985) 705
- 1985RO05 K. Rohrich, L. Tiator, G. Kobschall, Ch. Reifferscheid, Ch. Schmitt, V.H. Walther, K. Weinand and L.E. Wright, Phys. Lett. B153 (1985) 203
- 1985SA02 A. Sandulescu, D.N. Poenaru, W. Greiner and J.H. Hamilton, Phys. Rev. Lett. 54 (1985) 490
- 1985SA16 H. Sakamoto, M. Nakamura, H. Sakaguchi, H. Ogawa, S. Kobayashi, S. Kato, N. Matsuoka, K. Hatanaka and T. Noro, Phys. Lett. B155 (1985) 227

- 1985SEZZ P.A. Seidl, C.F. Moore, S. Mordechai, C.L. Morris, J.A. Faucett, G.R. Burleson, R. Gilman, K.S. Dhuga, H.T. Fortune and J.D. Zumbro, Bull. Amer. Phys. Soc. 30 (1985) 783, GH3
- 1985SH01 Y.-J. Shi and W.J. Swiatecki, Phys. Rev. Lett. 54 (1985) 300
- 1985SH07 Y.-J. Shi and W.J. Swiatecki, Nucl. Phys. A438 (1985) 450
- 1985SM1G Smith, in AIP Conf. Proc. 125 (1985) 192
- 1985ST1J Stephans et al., Bull. Amer. Phys. Soc. 30 (1985) 746
- 1985TA1T Taddeucci, in AIP Conf. Proc. 124 (1985) 394
- 1985WA02 A.H. Wapstra and G. Audi, Nucl. Phys. A432 (1985) 1
- 1985WA1R M. Wahlen and T. Yoshinari, Nature 313 (1985) 780
- 1985WE02 W.-M. Wendler and M. Micklinghoff, Nucl. Phys. A436 (1985) 477
- 1985WH01 W.R. Wharton, P.D. Barnes, B. Bassalleck, R.A. Eisenstein, G. Franklin, R. Grace, C. Maher, P. Pile, R. Rieder, J. Szymanski et al., Phys. Rev. C31 (1985) 526
- 1985WI1B D. Wilkinson, Nucl. Phys. A434 (1985) 573
- 1985WO1B Woods et al., ANU-P/903 (1984)
- 1985WR01 M.C. Wright, H. Kitazawa, N.R. Roberson, H.R. Weller, M. Jensen and D.R. Tilley, Phys. Rev. C31 (1985) 1125
- 1987AJ02 F. Ajzenberg-Selove, Nucl. Phys. A475 (1987) 1