Energy Levels of Light Nuclei
$A = 18$

F. Ajzenberg-Selove

University of Pennsylvania, Philadelphia, Pennsylvania 19104-6396

Abstract: An evaluation of $A = 18$–20 was published in *Nuclear Physics A*475 (1987), p. 1. This version of $A = 18$ 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, 1987)

Table of Contents for $A = 18$

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. The introductory Table 2 is also available via the link.

^{18}He
(Not illustrated)

Not observed: see (1982AV1A, 1983ANZQ; theor.).

^{18}Be
(Not illustrated)

^{18}Be has not been observed. It is predicted to have a mass excess of 78.43 MeV: see (1978AJ03). ^{18}Be is then unstable with respect to breakup into ^{16}Be + 2n, ^{15}Be + 3n, ^{14}Be + 4n, ^{13}Be + 5n, ^{12}Be + 6n, ^{11}Be + 7n and ^{10}Be + 8n by, respectively, 3.1, 3.0, 6.0, 3.1, 4.9, 1.8 and 1.3 MeV, using the masses for the residual nuclei adopted by (1985WA02, 1986AJ01, 1986AJ04). See also (1983ANZQ; theor.).

^{18}B
(Not illustrated)

^{18}B has not been observed in the bombardment of Ta by 44 MeV/A Ar ions (1985DE60, 1985LA03, 1986PO13) or in the bombardment of Be by 12 MeV/A ^{56}Fe ions (1984MU27). ^{18}B has been predicted to have a mass excess of 53.85 MeV. It would then be unstable with respect to ^{17}B + n by 1.8 MeV: see (1978AJ03, 1985WA02). ^{18}B is calculated to have $J^\pi = 4^-$ and to have excited states at 0.62, 0.86 and 1.59 MeV with $J^\pi = 1^-$, 2^- and 2^- (1985PO10). See also (1985AN1B) and (1983ANZQ; theor.).

^{18}C
(Fig. 4)

GENERAL: (See also (1978AJ03, 1983AJ01).)

See (1983ANZQ, 1983FR1A, 1983WI1A, 1984SA37, 1986AN07, 1986AV1B, 1986GU1D, 1987SA15).

Mass of ^{18}C: The atomic mass excess of ^{18}C is 24.923 ± 0.030 MeV, based on the Q-value of the ^{48}Ca(^{18}O, ^{18}C)^{48}Ti reaction. ^{18}C is then bound by 4.187 MeV with respect to breakup into ^{17}C + n (1982FI10). See also (1986PI09).

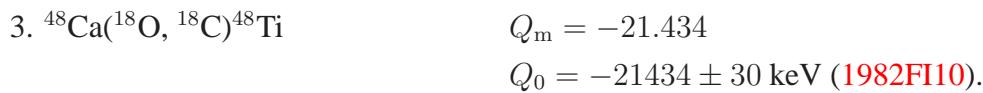1. ^{18}C(β^-)^{18}N $\hspace{3cm}$ $Q_\mathrm{m} = 11.806$

The half-life of ^{18}C, $\tau_{1/2} = 66^{+25}_{-15}$ msec, $P_\mathrm{n} \approx 25\%$ (1987MU1J; prelim.). See also (1984KL06; theor.).

Table 18.1: Energy levels of ^{18}C

E_x in ^{18}C (MeV ± keV)	$J^\pi; T$	Decay	Reactions
0	$(0^+); 3$	(β^-)	$2, 3$
1.62 ± 20	$(2^+); 3$		$2, 3$

2. ^{18}O$(\pi^-, \pi^+)^{18}$C $\qquad\qquad\qquad Q_\mathrm{m} = -25.705$

The angular distribution of the π^+ to the ground state of ^{18}C has been measured at $E_{\pi^-} = 164$ MeV by (1984GI10) [see also for excitation function at $\theta = 5°$ for $E_{\pi^-} \approx 140$ to 240 MeV]. There is also some indication of the population of an excited state at $E_\mathrm{x} = 1.55$ MeV (1984GI10). See also (1983AJ01).

3. ^{48}Ca$(^{18}$O, ^{18}C$)^{48}$Ti $\qquad\qquad\qquad Q_\mathrm{m} = -21.434$
$\qquad\qquad\qquad\qquad\qquad\qquad\qquad\quad Q_0 = -21434 \pm 30$ keV (1982FI10).

At $E(^{18}$O$) = 112$ MeV the ground state and an excited state at 1.62 ± 0.02 MeV are observed by (1982FI10). See also (1983AJ01).

^{18}N
(Figs. 1 and 4)

GENERAL: (See also (1983AJ01).)

See (1981NAZQ, 1983ANZQ, 1983FR1A, 1983SH44, 1983WI1A, 1984AS1D, 1984HI1A, 1986AN07, 1986BI1A, 1986HA1B, 1986MA48, 1986ME1F, 1987RI03).

Mass of ^{18}*N:* The atomic mass excess derived from the Q-value of the ^{18}O$(^7$Li, ^{7}Be$)^{18}$N reaction is 13.117 ± 0.020 MeV (1983PU01). ^{18}N is then stable with respect to breakup into ^{17}N + n by 2.825 MeV. See (1983AJ01) for the earlier work.

1. ^{18}N$(\beta^-)^{18}$O $\qquad\qquad\qquad Q_\mathrm{m} = 13.899$

The half-life of ^{18}N is 0.624 ± 0.012 sec (1982OL01). The decay branches are displayed in Table 18.9. The nature of the decay leads to $J^\pi = 1^-$ for the ^{18}N ground state (1982OL01). See also (1983SN03).

Table 18.2: Energy levels of ^{18}N

E_x (MeV $\pm$ keV)	$J^\pi; T$	$\tau_{1/2}$ (msec)	Decay	Reactions
0	$1^-; 2$	624 ± 12	β^-	1, 3, 4, 5, 6
0.121 ± 10	2^- [a]			3, 4, 6
0.575 ± 25	2^- [a]			3, 6, 7
0.747 ± 10	3^- [a]			6
[b]				
2.21				6
2.42				6

[a] Suggested by (1984BA24). See also (1982OL01).

[b] See (1984BA24) for a calculation suggesting additional states.

2. ^{14}C(^{7}Li, ^{3}He)^{18}N $\qquad\qquad Q_m = -10.122$

The work described in (1983AJ01) has not been published.

3. ^{14}C(^{18}O, ^{14}N)^{18}N $\qquad\qquad Q_m = -13.743$

At $E(^{18}$O$) = 92.2$ MeV groups are observed to the ground state of ^{18}N (unresolved) and to an excited state at $E_x = 575 \pm 25$ keV (1980NA14).

4. ^{18}O(π^-, π^0)^{18}N $\qquad\qquad Q_m = -9.295$

See (1983AS01, 1984AS05).

5. ^{18}O(t, ^{3}He)^{18}N $\qquad\qquad Q_m = -13.881$

See (1983AJ01).

6. ^{18}O(^{7}Li, ^{7}Be)^{18}N $\qquad\qquad Q_m = -14.761$

$\qquad\qquad\qquad\qquad\qquad\qquad Q_0 = -14761 \pm 20$ keV (1983PU01).
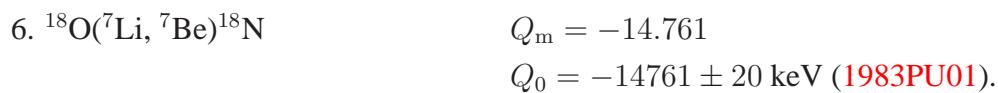
At $E(^7\mathrm{Li}) = 52$ MeV, $^7\mathrm{Be}$ groups are observed corresponding to the excitation of the states displayed in Table 18.2 (1983PU01).

7. $^{18}\mathrm{O}(^{11}\mathrm{B}, {}^{11}\mathrm{C})^{18}\mathrm{N}$ $Q_m = -15.881$

See (1983PU01).

<div align="center">

^{18}**O**

(Figs. 1 and 4)

</div>

GENERAL: (See also (1983AJ01).)

Shell model: (1978WI1B, 1982ZH01, 1983BR29, 1983WA17, 1983KI13, 1984AS07, 1984BA24, 1984CH1V, 1985LE1K, 1985SA29, 1986HAZY, 1986YU1B, 1987WA1H).

Cluster, collective and deformed models: (1983BE1W, 1983CL1B, 1983ME12, 1984AS04, 1984BA55, 1984GA1T, 1984SA37, 1985BA1A, 1985DE24, 1985RO1G, 1985SU10, 1986CA1T, 1986KA1D, 1986YU1B).

Special states: (1978WI1B, 1982BA62, 1982BE1Z, 1982ZH01, 1983BE1W, 1983BR29, 1983LI10, 1983ME12, 1983WA17, 1983KI13, 1984AS07, 1984BA24, 1984BA55, 1984CH1V, 1984GA1T, 1984GE1A, 1984HA14, 1984SA37, 1984ST1E, 1984WI17, 1985BR20, 1985CA1Q, 1985DE24, 1985LE1K, 1985LE1L, 1985MA1Q, 1985MA1R, 1985RO1G, 1985SA29, 1985SO12, 1985SU10, 1985YU1B, 1986AN10, 1986AN07, 1986CA1T, 1986CA27, 1986GU1A, 1986KA1D, 1986YU1B, 1987WA1H, 1987YA03).

Electromagnetic transitions and giant resonances: (1982AL30, 1982BA62, 1982BR24, 1982RI04, 1983BR29, 1983IS1F, 1983KA28, 1983KI13, 1984AS04, 1984AS07, 1984BA55, 1984BR1L, 1984GA1T, 1984HA14, 1984ST02, 1985AL21, 1985DE24, 1985LE1L, 1985SU10, 1985WI17, 1986AN10, 1986CA27, 1986ER1A, 1986HAZY).

Astrophysical questions: (1981WA1Q, 1982BU1A, 1982CA1A, 1982RO1A, 1982WI1B, 1982WO1A, 1983CO1K, 1984BL1J, 1984HA1R, 1984HA1Z, 1984LA1J, 1985HA1Z, 1985HA1R, 1986CO2C, 1986DO1L, 1986LA1C, 1986WI1L, 1987HA1C, 1987HA1D, 1987PR1A, 1987WI11).

Applications: (1982MA1Q, 1982PI1H, 1983AM1A, 1983AM1D, 1983GR1L, 1983KI1D, 1983KU1C, 1983LI1T, 1983TA1P, 1984LE1G, 1984SH2A, 1985WA1R, 1985YO1B, 1985ZA1A, 1986CO2B, 1986DR1E, 1986DU1Q, 1986EN1A, 1986HO1Q, 1986HO1L, 1986NI1C, 1986XU1C).

Complex reactions involving ^{18}*O:* (1981IC02, 1982MO1K, 1982SA1Q, 1983DE26, 1983EN04, 1983FR17, 1983FR1A, 1983GR10, 1983GR28, 1983LI10, 1983OL1A, 1983SA06, 1983VA23, 1983WI1A, 1984GR08, 1984HI1A, 1984HO23, 1984NA1D, 1985DE60, 1985GAZT, 1985HO05, 1985KAZQ, 1985MA1Q, 1985PO11, 1986AN1F, 1986HA1B, 1986IR01, 1986MA19, 1986ME06, 1986PO06, 1986SA30, 1986SC28, 1986SC29, 1986SO10, 1986VAZZ, 1987LI04, 1987RI03).

Muon capture: (1983GM1A, 1987SU06).

Pion capture and reactions (See also reaction 23): (1981SEZR, 1982BI08, 1982LI15, 1982LI1M, 1982LI1N, 1983AM1C, 1983AS01, 1983BE1W, 1983GE12, 1983HO02, 1983JO06, 1983LI08, 1983LI1U, 1983MA16, 1983ME1H, 1983OS1E, 1983RO07, 1983SE16, 1983ZE1C, 1984AL20, 1984AS05, 1984BL17, 1984GR27, 1984HU1C, 1984JO01, 1984KA26, 1984SC09, 1984TR15, 1985AL15, 1985BI01, 1985CA1Q, 1985CH23, 1985GI01, 1985GM01, 1985KE1A, 1985SE08, 1985SE21, 1986BA1C, 1986FO06, 1986GE06, 1986GM01, 1986RO03, 1986SCZX, 1986SI11, 1987TE01).

<div align="center">

7

</div>

Table 18.3: Energy levels of ^{18}O [a]

E_x (MeV $\pm$ keV)	$J^\pi; T$	τ_m [b] or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
0	$0^+; 1$	—	stable	2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48
1.98207 ± 0.09	2^+	τ_m=2.80±0.07 psec g=−0.287±0.015	γ	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 13, 15, 17, 18, 19, 22, 23, 24, 25, 26, 27, 29, 30, 36, 37, 39, 41, 42, 44, 45, 46, 47, 48
3.55484 ± 0.40	4^+	τ_m=24.8±1.2 psec g=−0.62±0.10	γ	2, 3, 6, 8, 9, 13, 14, 15, 17, 18, 19, 22, 25, 30, 36, 37, 47, 48
3.63376 ± 0.11	0^+	$\tau_m = 1.38 \pm 0.16$ psec	γ	2, 3, 6, 8, 9, 13, 17, 19, 22, 25, 30, 36, 37, 46, 47, 48
3.92044 ± 0.14	2^+	26.5 ± 2.9 fsec	γ	2, 3, 6, 8, 9, 13, 17, 19, 22, 25, 30, 36, 47
4.45554 ± 0.10	1^-	65 ± 15 fsec	γ	2, 3, 6, 8, 9, 13, 17, 19, 25, 30, 36, 37, 46, 47
5.09778 ± 0.54	3^-	62 ± 25 fsec	γ	2, 3, 6, 8, 9, 13, 17, 19, 22, 23, 24, 25, 30, 36, 37, 42, 47, 48
5.2604 ± 1.2	2^+	10.1 ± 0.5 fsec	γ	2, 3, 6, 8, 9, 13, 15, 17, 22, 25, 30, 46, 47
5.3364 ± 0.6	0^+	200 ± 40 fsec	γ	2, 3, 8, 13, 17, 22, 30, 47
5.3778 ± 1.2	3^+	< 30 fsec	γ	2, 3, 13, 17, 47
5.53024 ± 0.29	2^-	< 25 fsec	γ	2, 3, 13, 19, 25, 30, 47
6.19822 ± 0.40	1^-	3.7 ± 0.6 fsec	γ	2, 3, 8, 13, 17, 19, 21, 30, 47
6.3513 ± 0.6	(2^-)	< 35 fsec	γ	2, 3, 13, 17, 19, 30, 47, 48
6.4044 ± 1.2	3^-	30 ± 15 fsec	γ	2, 3, 13, 30, 47
6.88045 ± 0.27	0^-	< 25 fsec	γ	2, 3, 13, 19, 30, 46, 47

Table 18.3: Energy levels of ^{18}O [a] (continued)

E_x (MeV $\pm$ keV)	J^π; T	τ_m [b] or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
7.1169 ± 1.2	4^+	< 25 fsec	γ, α	2, 3, 6, 8, 9, 13, 15, 17, 22, 25, 30, 34, 36, 37, 47
7.619 ± 3	1^-	< 2.5		2, 3, 6, 8, 13, 30, 34, 36, 37, 47
7.77107 ± 0.50	2^-		γ	2, 3, 13, 19, 47
7.864 ± 5	5^-		γ	2, 3, 6, 8, 9, 13, 17, 22, 30, 34, 36, 37, 47, 48
7.977 ± 4	$(3^+, 4^-)$		γ	2, 3, 13, 17, 47
8.039 ± 2	1^-	< 2.5	γ, α	2, 3, 6, 7, 13, 14, 15, 34, 36, 37, 47
8.125 ± 2	5^-		γ, α	2, 3, 6, 8, 9, 13, 47
8.213 ± 4	2^+	1.0 ± 0.8	γ, n, α	2, 3, 6, 7, 13, 25, 30, 34, 36, 37, 47
8.282 ± 3	3^-	8 ± 1	γ, n, α	2, 3, 6, 7, 8, 9, 13, 30, 47
8.410 ± 8		8 ± 6	n, α	7, 13, 47
8.521 ± 6				13, 47
8.660 ± 6				13, 47
8.817 ± 12	(1^+)	70 ± 12	n, α	7, 25, 30
8.955 ± 4		43 ± 3	n, α	7, 13, 30
9.03				13, 17, 30
(9.10)				30
9.361 ± 6	(3^-)	27 ± 15	γ, n, α	7, 9, 13, 22, 30, 34, 36, 37
9.414 ± 18		≈ 120	n, α	7, 9, 13, 30
9.48 ± 24		≈ 65	n, α	7, 13
9.672 ± 7	(3^-)	60 ± 30	n, α	7, 13, 30, 34, 36, 37
9.713 ± 7				13, 30
9.890 ± 11		≈ 150	n, α	7, 13, 30
10.118 ± 10	3^-	16 ± 4	n, α	7, 8, 13, 30
10.295 ± 14	4^+		n, α	7, 8, 9, 13, 14, 30, 34, 36, 37
10.396 ± 9	3^-		n, α	7, 13, 30

Table 18.3: Energy levels of ^{18}O [a] (continued)

E_x (MeV $\pm$ keV)	J^π; T	τ_m [b] or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
10.595 ± 15			n, α	7, 13
10.82 ± 20			n, α	7
10.91 ± 20			n, α	7, 9
10.99 ± 20			n, α	7
11.13 ± 20			n, α	7, 9, 46
11.39 ± 20	(2^+)		n, α	7, 8
11.41 ± 20	(4^+)		n, α	7, 8
11.62 ± 20	5^-	76 ± 8	γ, n, α	7, 8, 9, 22, 30, 34, 36, 37
11.69 ± 20	6^+		n, α	7, 8, 9, 30
11.82 ± 20	(3^-)		n, α	7
12.04 ± 20	(2^+)	28 ± 6	γ, n, α	7, 8, 22
12.25 ± 20	(1^-)		n, α	7, 8
12.33 ± 20	5^-		n, α	7, 8, 9
12.50 ± 20	4^+		n, α	7, 34, 36, 37
12.53 ± 20	6^+		n, α	7, 8, 9, 34, 36, 37
13.1 [c]	1^-	700	γ, n	20
13.8	1^-	600	γ, n	20
14.7	1^-	800	γ, n	20
15.8	1^-	700	γ, n	20
16.210 ± 10	$1^{(-)}$		γ	22
16.315 ± 10	$(3, 2)^-$		γ	22
16.399 ± 5	2^-; 2	< 20	γ	22, 25
16.948 ± 10	$(3, 2)^-$		γ	22
17.025 ± 10	(> 2); 2	20 ± 6	γ	22
17.05	(7^-)	≈ 350		8
17.398 ± 10	1^-; (2)	600	γ, n, p	20, 22
17.450 ± 10	$(2, 1, 3)^-$		γ	22
17.5		≈ 150	γ	22
17.502 ± 10	$(1, 2, 3)^-$		γ	22
(17.6 ± 200)	(8^+)			8

Table 18.3: Energy levels of ^{18}O ^{a} (continued)

E_x (MeV $\pm$ keV)	$J^\pi; T$	τ_m ^{b} or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
17.635 ± 10			γ	22
18.049 ± 10			γ	22
18.2		≈ 150	γ	22
18.5		≈ 4300	γ	22
18.70 ± 20	$(4^-); 2$	< 20	γ	22
18.871 ± 5	$1^+; 2$		γ	22
18.927 ± 10	$(1, 2^+)$		γ	22
18.95	(7^-)	≈ 350		8
19.027 ± 10	$(1, 3)^-$		γ	22
19.150 ± 10	$(1^-, 2^+, 3^-)$		γ	22
19.24 ± 20	$(> 2); 2$	< 20	γ	22
19.4	$1^-; (2)$	900	γ, p	20
19.7		≈ 200	γ	22
20.2		≈ 180	γ	22
20.36 ± 20	$(4^-); 2$	< 20	γ	22
21.0	$1^-; (1)$	≈ 150	γ, n, p	20, 22
22.39 ± 40	(4^-)	74 ± 7	γ	22
22.7	1^-		γ, n, p	20
23.8	$1^-; (1)$	≈ 1500	γ, n, p	20, 22
27	$1^-; (2)$		γ, n, p	20
30			γ, n	20
36			γ	20

^{a} See also Tables 18.4 and 18.11 here and 18.2 in (1983AJ01).

^{b} See Table 18.4 in (1978AJ03) for a display of τ_m measurements.

^{c} For additional states with $12.9 \leq E_x \leq 23.1$ MeV see (1983CU03) [reaction 8].

K-mesons and other meson interactions: (1983MA1V, 1983TO21, 1986MO1Q, 1986MO1A).

Anti-proton interactions: (1983GR11, 1984GI11, 1984SU07, 1985DU05, 1985LI16, 1986DU10, 1986FR10, 1986RO23, 1987BA18, 1987SP05).

Hypernuclei: (1984AS1D, 1984MO1N, 1985YA1C, 1986MO1Q, 1986MO1A).

Other topics: (1978WI1B, 1981CL05, 1982CA12, 1982VE02, 1983AR1J, 1983BR29, 1983CL1B, 1983JO1C, 1983MA35, 1983SH32, 1983UE01, 1984WI17, 1985AL21, 1985AN28, 1985CH23, 1985MA56, 1985YU1B, 1986GU1A).

Ground and 1.98 MeV states of ^{18}O: (1978WI1B, 1982BA62, 1982CA12, 1982LO13, 1983ANZQ, 1983AR1J, 1984ANZW, 1984BA55, 1984FR13, 1984HA14, 1984ST1E, 1984WE04, 1985AN28, 1985BA1A, 1985DE24, 1986CA27, 1986RO03, 1987AB03, 1987SA15).

Isotopic abundance $= (0.200 \pm 0.012)\%$ (1984DE53).
$\langle r^2 \rangle^{1/2} = 2.784 \pm 0.020$ fm: see reaction 22.

$^{18}O^*(1.98)$

g $= -0.287 \pm 0.015$ [see (1983AJ01)]
$Q = -4.2 \pm 0.8\ e \cdot \text{fm}^2$ [weighted mean of -3.6 ± 0.9 and
$\quad -5.8 \pm 1.5\ e \cdot \text{fm}^2$: see (1983GR28); see also (1983AJ01)].
$B(\text{E2}; 0^+ \to 2^+) = 39.0 \pm 1.8\ e^2 \cdot \text{fm}^4$ [(1979FE06, 1983GR10); see also (1983AJ01)];
$\quad = 44.8 \pm 1.3\ e^2 \cdot \text{fm}^4$ (1982NO04);
$\quad = 47.6 \pm 1.0\ e^2 \cdot \text{fm}^4$ (1982BA06); see also (1987RA01).
For a discussion of the hexadecapole deformation see (1983GR10). See also (1987RA01).

1. (a) ^{10}B(^{9}Be, p)^{18}O $\qquad\qquad Q_m = 16.8917$
   (b) ^{11}B(^{9}Be, d)^{18}O $\qquad\qquad Q_m = 7.6621$

See (1986CU02) for production cross sections of 1.98 MeV γ-rays.

2. ^{12}C(^{7}Li, p)^{18}O $\qquad\qquad\qquad Q_m = 8.400$

Observed proton groups are displayed in Table 18.5. See also (1983AJ01, 1986SM01).

3. ^{13}C(^{6}Li, p)^{18}O $\qquad\qquad\qquad Q_m = 10.704$

Angular distributions of proton groups have been measured to the states shown in Table 18.5 at $E(^6\text{Li}) = 28$ MeV (1986SM01). It is found that when σ_{tot} to a particular state in ^{18}O is large in this reaction, it is also large in the ^{12}C(^{7}Li, p) reaction. The relationship between the cross sections in this reaction and in reaction 1 depends on the parity of the final states (1986SM01).

Table 18.4: Radiative decays in ^{18}O [a]

E_i (MeV)	J_i^π	E_f (MeV)	Branch (%)	δ
1.98	2^+	0	100	
3.55	4^+	1.98	100	
3.63	0^+	0	0.30 ± 0.06	
		1.98	99.70 ± 0.06	
3.92 [b,c,d]	2^+	0	11.4 ± 0.5 [e]	
		1.98	88.6 ± 0.5	[f]
4.46 [b,c,d]	1^-	1.98	28.6 ± 1.1	[f]
		3.63	68.9 ± 0.7	
		3.92	2.5 ± 0.6	
5.10 [b,c,d]	3^-	1.98	76.3 ± 0.6	[f]
		3.55	5.8 ± 0.6	[f]
		3.92	17.9 ± 0.4	[f]
5.26 [b,d]	2^+	0	30.3 ± 0.9	[f]
		1.98	56.0 ± 1.0	0.15 ± 0.04
		3.55	1.1 ± 0.6	
		3.63	0.9 ± 0.6	
		3.92	8.7 ± 0.4	
		4.46	3.0 ± 0.3	
5.34	0^+	0	[g]	
		1.98	60 ± 2	
		4.46	40 ± 2	[f]
5.38	3^+	1.98	86.5 ± 2.2	[f]
		3.92	13.5 ± 2.2	[f]
5.53	2^-	1.98	49 ± 2	[f]
		3.92	24 ± 2	
		4.46	27 ± 2	[f]
6.20 [b,d]	1^-	0	88.7 ± 0.9	
		3.63	2.5 ± 0.3	
		4.46	4.1 ± 0.4	
		5.26	3.6 ± 0.4	
		5.34	1.1 ± 0.3	

Table 18.4: Radiative decays in ^{18}O [a] (continued)

E_i (MeV)	J_i^π	E_f (MeV)	Branch (%)	δ
6.35	(2^-)	1.98	32 ± 2	f
		3.92	55 ± 2	f
		4.46	12 ± 2	f
6.40 [b,d]	3^-	1.98	68.1 ± 1.8	f
		3.55	7.4 ± 1.2	
		3.92	6.3 ± 1.0	f
		4.46	2.8 ± 1.0	
		5.10	9.8 ± 0.9	
		5.26	5.6 ± 0.9	
6.88	0^-	4.46	100	f
7.12 [b,d,i]	4^+	1.98	27.0 ± 0.5	$-(0.052 \pm 0.035)$
		3.55	70.0 ± 6.0 [h]	
		3.92	1.8 ± 0.4	
		5.10	1.2 ± 0.3	
7.62 [i]	1^-	0	23 ± 2	
		1.98	62 ± 3 [j]	$-(0.027 \pm 0.008)$
		4.46	8 ± 1	$-(0.21 \pm 0.03)$
		5.34	6 ± 1	
		6.20	1 ± 1	
7.77	2^-	1.98	53 ± 3	
		4.46	11 ± 2	
		5.10	36 ± 3	
7.86 [i]	5^-	3.55	> 75	
7.98	$(3^+, 4^-)$	3.55	67 ± 2	
		5.10	12 ± 2	
		5.38	21 ± 2	
8.04 [i]	1^-	0	16 ± 1	
		1.98	70 ± 2 [k]	
		3.63	10 ± 1	
		5.26	4 ± 1	
8.13 [i]	5^-	3.55	99 ± 1 [l]	

Table 18.4: Radiative decays in ^{18}O [a] (continued)

E_i (MeV)	J_i^π	E_f (MeV)	Branch (%)	δ
		5.10	1 ± 1	
8.21 [i]	2^+	0	19 ± 4	
		1.98	29 ± 3	
		3.55	3 ± 1	
		3.92	3 ± 1	
		4.46	29 ± 3	
		5.10	17 ± 1	
8.28 [i]	3^-	3.55	61 ± 3	
		4.46	3 ± 3	
		5.26	36 ± 3	

[a] For references and additional information see Tables 18.3 in (1978AJ03, 1983AJ01). Upper limits for other transitions are not shown.

[b] M. Ruscev and M. Gai, private communication.

[c] Weighted means of results in Table 18.3 and in ref. [b].

[d] See also Table 3 in (1978AJ03).

[e] $\Gamma_\pi/\Gamma = (3.0 \pm 0.6) \times 10^{-3}$.

[f] δ is consistent with 0.

[g] $\Gamma_\pi/\Gamma \leq 2.3 \times 10^{-3}$.

[h] $\Gamma_\gamma/\Gamma_\alpha = 0.9 \pm 0.1$.

[i] Adopted by (1987GA15): see for upper limits for the branching ratio to other states.

[j] $\Gamma_\alpha\Gamma_\gamma/\Gamma = 0.34$ eV.

[k] $\Gamma_\alpha\Gamma_\gamma/\Gamma = 0.89$ eV.

[l] $\Gamma_\alpha\Gamma_\gamma/\Gamma = 0.22$ eV.

4. ^{13}C(^{9}Be, α)^{18}O $\qquad\qquad Q_m = 12.8300$

See (1983AJ01, 1983VO1A).

5. ^{13}C(^{17}O, ^{12}C)^{18}O $\qquad\qquad Q_m = 3.098$

See (1983AJ01) and (1984AB1A; theor.).

Table 18.5: States of ^{18}O from ^{12}C(^{7}Li, p) and ^{13}C(^{6}Li, p)

E_x (keV) [a]	σ_tot [b] (μb)	σ_tot [c] (μb)
0	41.7 ± 1.7	6.1 ± 0.3
1982.4 ± 4.2	243 ± 4	39 ± 1
$\equiv 3555.0$	429 ± 5	56 ± 1
3636.1 ± 3.5	58.5 ± 1.0	13 ± 1
3922.4 ± 3.1	209 ± 3	36 ± 1
4457.8 ± 3.0	164 ± 2	46 ± 1
5099.3 ± 3.8	387 ± 5	74 ± 1
5252.1 ± 4.9	353 ± 4	44 ± 1
5331.6 ± 3.8 5377.6 ± 3.6	217 ± 2	35 ± 1
5532.2 ± 3.7	218 ± 3	45 ± 1
6194.9 ± 3.8	103 ± 2	37 ± 1
6351.1 ± 4.5 [d] 6402.1 ± 4.5	521 ± 4	131 ± 2
6888.1 ± 6.1	33.8 ± 0.7	5.3 ± 0.4
7119.8 ± 5.1 [e]	892 ± 10	208 ± 2
7619.4 ± 5.0	124 ± 2	33 ± 1
7779.3 ± 4.8 [f]	262 ± 3	37 ± 1
7858.7 ± 4.9 [g]	487 ± 6	101 ± 1
7972.7 ± 4.8	380 ± 4	84 ± 1
8041.5 ± 5.0	80 ± 1	19 ± 1
8133.9 ± 5.3	500 ± 6	140 ± 2
8218.3 ± 5.2	508 ± 6	48 ± 1
8291.7 ± 5.6	368 ± 4	103 ± 2

[a] (1978FO29): ^{12}C(^{7}Li, p)^{18}O. See also Table 18.4 in (1983AJ01).

[b] σ_tot $(0-180°)$ from ^{12}C(^{7}Li, p) at $E(^7\mathrm{Li}) = 18.0$ MeV (1978FO29). Angular distributions were also measured at 16.0 MeV. The total cross sections generally agree with a $(2J + 1)$ relationship (1978FO29). For discussions of the deviations from this relationship see (1978FO29, 1984FO15).

[c] ^{13}C(^{6}Li, p)^{18}O at $E(^6\mathrm{Li}) = 28.0$ MeV (1986SM01).

[d] 2^- is suggested.

[e] May be an unresolved doublet.

[f] $J = (2, 3)$.

[g] $J^\pi = (4^+, 5^-)$.

Table 18.6: Resonances in $^{14}C(\alpha, \gamma)^{18}O$ and $^{14}C(\alpha, \alpha)^{14}C$ [a]

E_α (MeV $\pm$)	Γ_{lab} (keV)	Particles out	$^{18}O*$ (MeV)	J^π
1.140 ± 2 [b]		γ	7.114	4^+
1.790 ± 2 [b]	< 3	γ	7.619	1^-
2.10 [b]		γ	7.86	5^-
2.330 ± 2 [b]	< 3	γ, α_0	8.039	1^-
2.440 ± 2 [b]		γ	8.125	5^-
2.554 ± 4 [b]	1.3 ± 1	γ, n, α_0	8.213	2^+
2.643 ± 3 [b]	10 ± 1	γ, n, α_0	8.282	3^-
2.800 ± 7	10 ± 7	n	8.404	
3.330 ± 12	90 ± 15	n, α_0	8.817	
3.508 ± 4	55 ± 3	n, α_0	8.955	
4.030 ± 15	35 ± 20	$n, (\alpha_0)$	9.361	
4.07 ± 40	≈ 150	$n, (\alpha_0)$	9.39	
4.17 ± 40	≈ 70	$n, (\alpha_0)$	9.47	
4.434 ± 10	80 ± 40	$n, (\alpha_0)$	9.675	
4.70 ± 40	≈ 200	$n, (\alpha_0)$	9.88	
5.004 ± 10	21 ± 5	n, α_0	10.118	3^-
5.23 [c]	[d]	n, α_0	10.29	4^+
5.34	[d]	n, α_0	10.38	3^-
5.60	[e]	n, α_0	10.58	
5.90	[f]	n, α_0	10.82	
6.02	[f]	n, α_0	10.91	
6.13	[f]	n, α_0	10.99	
6.30	[e]	n, α_0	11.13	
6.64	[d]	n, α_0	11.39	(2^+)
6.67	[d]	n, α_0	11.41	(4^+)
6.93	[d]	n, α_0	11.62	5^-
7.03	[d]	n, α_0	11.69	6^+
7.19	[f]	n, α_0	11.82	(3^-)
7.47	[f]	n, α_0	12.04	(2^+)
7.75	[g]	n, α_0	12.25	$(0^+, 1^-)$
7.85	[d]	n, α_0	12.33	5^-

Table 18.6: Resonances in ^{14}C$(\alpha, \gamma)^{18}$O and ^{14}C$(\alpha, \alpha)^{14}$C [a] (continued)

E_α (MeV $\pm$ keV)	Γ_{lab} (keV)	Particles out	^{18}O* (MeV)	J^π
8.06	[d]	n, α_0	12.50	4^+
8.10	[d]	n, α_0	12.53	6^+

[a] See also Table 18.4. For references see Table 18.5 in (1978AJ03). I am grateful to E.K. Warburton for his comments.

[b] (1987GA15): $\Gamma_\gamma = 0.095 \pm 0.020$, 0.41 ± 0.08, 0.043 ± 0.009, 1.07 ± 0.22, 0.27 ± 0.05, 0.41 ± 0.09 and 0.49 ± 0.13 eV, respectively for ^{18}O*(7.11, 7.62, 7.86, 8.04, 8.13, 8.21, 8.28).

[c] ± 10–20 keV for this and all higher resonances (G.E. Mitchell, private communication).

[d] Γ_α, large; Γ_{n}, large.

[e] Γ_α, small; Γ_{n}, small.

[f] Γ_α, small; Γ_{n}, large.

[g] Γ_α, large; Γ_{n}, small.

6. ^{14}C$(\alpha, \gamma)^{18}$O $\qquad\qquad Q_{\mathrm{m}} = 6.2270$

Resonances in the yield of capture γ-rays are observed at $E_\alpha = 1.14$, 1.79, 2.09, 2.33, 2.44, 2.55 and 2.64 MeV: see Tables 18.6 here and 18.5 in (1978AJ03). Gamma-ray angular distribution and correlation measurements lead to $J^\pi = 4^+$, 1^-, 1^- and 5^- for ^{18}O*(7.11, 7.62, 8.04, 8.13), as well as to J^π assignments for lower states involved in the cascade decay. See also (1982AL30, 1983GA02, 1985GA1J) and (1986HA2D; astrophysics).

7. (a) ^{14}C$(\alpha, \alpha)^{14}$C $\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad E_{\mathrm{b}} = 6.2270$
   (b) ^{14}C$(\alpha, \mathrm{n})^{17}$O $\qquad\qquad Q_{\mathrm{m}} = -1.8172$
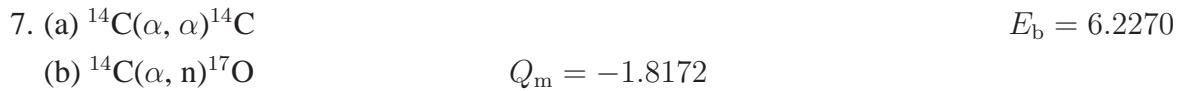
Observed anomalies in the scattering [reaction (a)] for $E_\alpha = 2$ to 8.2 MeV and the resonances in the relative neutron yield [reaction (b)] for $E_\alpha = 2.3$ to 8.5 MeV are displayed in Table 18.6. See also (1978AJ03) and (1985DE24, 1988UM1A; theor.).

8. (a) ^{14}C$(^6$Li, d$)^{18}$O $\qquad\qquad Q_{\mathrm{m}} = 4.752$
   (b) ^{14}C$(^6$Li, d$\alpha)^{14}$C $\qquad\qquad Q_{\mathrm{m}} = -1.4751$

At $E(^6\text{Li}) = 34$ MeV angular distributions have been measured for the deuteron groups to many states of ^{18}O (1981CU07) [see also (1983AJ01)] including ^{18}O*(17.6 ± 0.2) (1982CU01). $J^\pi = 4^+, 2^+, 2^+, (4^+)$ and (4^+) are suggested for ^{18}O*(7.86, 8.9, 12.04, 14.6, 17.0) (1981CU07). The 2^+, 4^+, 6^+ and 8^+ members of the $K^\pi = O_2^+$ rotational band based on ^{18}O*(3.62) are ^{18}O*(5.26, 7.12, 11.69, 17.6) (1981CU07, 1982CU01).

Angular correlations have been measured at $E(^6\text{Li}) = 34$ MeV; these lead to the assignment of $J^\pi = 8^+$ to ^{18}O*(17.6) (1982CU01) and to the assignment of $J^\pi = 4^+, 5^-, 6^+, 7^-$ and 8^+ to sixteen states in ^{18}O with $11.4 \leq E_x \leq 23.1$ MeV (1983CU03) [see also for assignment of ^{18}O states to bands]. At $E(^6\text{Li}) = 32$ MeV (1983AR11) find that the strongest groups are those to (unresolved) structures at $E_x = 17.05$ and 18.95 MeV [each $\Gamma \approx 0.35$ MeV] dominated by $J^\pi = 7^-$. ^{18}O*(11.6, 12.6) with $J^\pi = (6^+, 5^-)$ and 5^- are also observed (1983AR11). [See, however, the density of states]. See also (1985KO1B; theor.).

9. ^{14}C(^{7}Li, t)^{18}O $Q_m = 3.759$

At $E(^7\text{Li}) = 20.4$ MeV, triton groups are observed corresponding to a number of states of ^{18}O with $E_x < 12.6$ MeV. Angular distributions were obtained for some of these, including ^{18}O*(0, 1.98, 7.12, 11.69) with $J^\pi = 0^+, 2^+, 4^+, 6^+$. The latter two are the most strongly populated in this reaction: they appear to be part of the ground-state rotational band: see (1972AJ02). See also (1983GA02, 1984RU1A).

10. ^{14}C(^{14}C, ^{10}Be)^{18}O $Q_m = -5.785$

See (1985KO04).

11. ^{14}C(^{16}O, ^{12}C)^{18}O $Q_m = -0.9349$

See (1978AJ03).

12. ^{15}N(^{13}C, ^{10}B)^{18}O $Q_m = -8.0421$

See (1983AJ01).

13. ^{16}O(t, p)^{18}O $Q_m = 3.7061$

Table 18.7: States in ^{18}O from ^{16}O(t, p) [a]

E_x (MeV $\pm$ keV)	L	J^π	E_x (MeV $\pm$ keV)	E_x (MeV $\pm$ keV)
0	0	0^+	7623 ± 18	9713 ± 7
1986 ± 4	2	2^+	7782 ± 6	9890 ± 11
3556 ± 2	4	4^+	7871 ± 2 [d]	10120 ± 40
3634 [b]	0	0^+	7983 ± 3 [d]	10300 ± 20
3915 ± 2	2	2^+	8046 ± 7	10400 ± 10
4458 ± 3	1	1^-	8140 ± 10	10610 ± 20
5105 ± 2	3	3^-	8233 ± 9	
5258 ± 6	2	2^+	8294 ± 5 [d]	
5340 ± 4	0	0^+	8430 ± 12	
5382 ± 4			8521 ± 3 [d]	
5530 ± 4			8660 ± 6	
6197 ± 3	1	1^-	9030 ± 15 [e]	
6356 ± 7	1, 2	$(1^-, 2^+)$ [c]	9362 ± 5 [d]	
6399 ± 3	3	3^-	9420 ± 20	
6885 ± 9			9480 ± 30	
7123 ± 7	4	4^+	9671 ± 8	

[a] (1981CO13): $E_t = 15$ MeV; DWBA analysis. See also Table 18.6 in (1978AJ03).

[b] Nominal energy.

[c] See, however, Table 18.9.

[d] Comparisons of E_x shown here with those displayed in Table 18.3 for ^{18}O*(3.92, 5.10, 6.40, 7.77) suggest that the uncertainty shown may be low: $\pm$ 6 keV was arbitrarily used in calculating the best value for E_x for this state in Table 18.3.

[e] This is the "average" of several unresolved levels. (1985FO11) state that the main components are at 8.96 and 9.03 MeV. [Comment: It is not clear whether these states are actually resolved.]

Proton groups corresponding to states of ^{18}O are displayed in Table 18.7 (1981CO13). See (1976LA13) for a general discussion of the properties of the states of ^{18}O. Lifetime measurements are reported in Table 18.4 of (1978AJ03). See also reaction 17, (1982AN12, 1985AN17) and (1985BA1A; theor.).

14. ^{16}O(α, 2p)^{18}O $\qquad\qquad\qquad$ $Q_m = -16.1080$

At $E_\alpha = 65$ MeV, the angular distribution to ^{18}O*(3.55) [$J^\pi = 4^+$] has been studied. In addition ^{18}O*(8.04, 9.15, 10.3) are also populated: see (1983AJ01).

15. (a) ^{16}O(^{10}B, ^{8}B)^{18}O $\qquad\qquad$ $Q_m = -14.824$
    (b) ^{16}O(^{13}C, ^{11}C)^{18}O $\qquad\qquad$ $Q_m = -11.480$

At $E(^{10}$B$) = 100$ MeV, ^{18}O*(3.55) [first $(d_{5/2})^2_{4+}$ state] is preferentially populated. ^{18}O*(1.98, 5.26, 7.12, 8.0, 8.3, 9.1) are also observed. At $E(^{13}$C$) = 105$ MeV the angular distribution to ^{18}O*(3.55) has been measured. See (1983AJ01) and (1983OS07; theor.).

16. (a) ^{17}O(n, γ)^{18}O $\qquad\qquad\qquad$ $Q_m = 8.0443$
    (b) ^{17}O(n, n)^{17}O $\qquad\qquad\qquad\qquad\qquad\qquad$ $E_b = 8.0443$
    (c) ^{17}O(n, α)^{14}C $\qquad\qquad\qquad$ $Q_m = 1.8172$
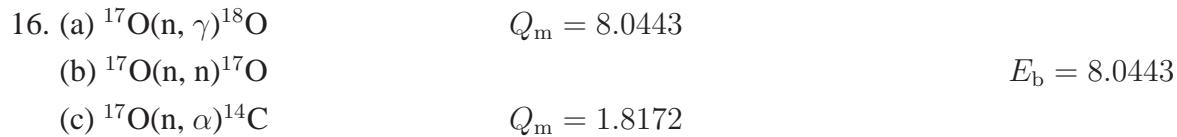
For reaction (a) see (1983AJ01). [The work reported there has not been published.] The scattering amplitude (bound) $a = 5.62 \pm 0.45$ fm, $\sigma_{\text{free}} = 3.55 \pm 0.25$ b. The thermal cross section for reaction (c) is 235 ± 10 mb. See (1983AJ01) for references.

17. ^{17}O(d, p)^{18}O $\qquad\qquad\qquad\qquad$ $Q_m = 5.8197$

Observed proton groups are displayed in Table 18.8. At $E_d = 12$ MeV a strong, asymmetric peak is observed corresponding to $E_x = 9.0$ MeV. On the basis of this work and the measurement of the cross section to a peak at about the same energy observed in the ^{16}O(t, p) reaction, (1985FO11) assign $J^\pi = 4^+$ and a $(1d_{5/2})(1d_{3/2})$ configuration to ^{18}O*(9.0). Proton-γ coincidence measurements are shown in Table 18.4.

18. ^{17}O(^{12}C, ^{11}C)^{18}O $\qquad\qquad$ $Q_m = -10.677$

Table 18.8: States of ^{18}O from ^{17}O(d, p) [a]

E_{x} (MeV ± keV) [b]	l_{n} [b]	J^{π} [b]	S [b]
0	2	0^+	1.22
1.982 ± 10	$0 + 2$	2^+	$0.21 + 0.83$
3.552 ± 10	2	4^+	1.57
3.63	2	0^+	0.28
3.92	$0 + 2$	2^+	$0.35 + 0.66$
4.46	1	1^-	0.03
5.10	3	3^-	0.03
5.255 ± 10	0	2^+	0.35
5.34	2	0^+	0.16
5.375 ± 10	0	3^+	1.01
6.20	1	1^-	0.03
6.35	1	$\leq 3^{(-)}$	$0.03 - 0.04$
7.110 ± 15	2	4^+	
7.855 ± 20			
7.962 ± 20			
9.0 [c]		4^+	

[a] See references in Tables 18.7 in (1972AJ02) and in (1978AJ03).

[b] E_{x} values without uncertainties are nominal. J are consistent with l_{n} and are used to calculate S.

[c] (1985FO11). See text.

Table 18.9: Branching in ^{18}N$(\beta^-)^{18}$O [a]

Decay to ^{18}O* [b] (keV)	J^π	Branch (%)	$\log ft$ [c]
1982.05 ± 0.09 [d]	2^+	3.9 ± 1.5	6.73 ± 0.17
3554.13 ± 0.80	4^+	< 0.6	> 7.22
3633.70 ± 0.11	0^+	< 0.35	> 7.43
3920.42 ± 0.14	2^+	< 0.43	> 7.29
4455.52 ± 0.10	1^-	54.6 ± 1.1	5.107 ± 0.033
5097.60 ± 0.60	3^-	< 0.43	> 7.03
5530.17 ± 0.32	2^-	3.1 ± 0.4	6.10 ± 0.06
6198.22 ± 0.40	1^-	1.4 ± 0.2	6.28 ± 0.07
6349.76 ± 1.0	(2^-)	2.2 ± 0.3	6.04 ± 0.07
6880.45 ± 0.27	0^- [e]	14.8 ± 0.8	5.066 ± 0.040
7771.07 ± 0.50	2^- [e]	5.0 ± 0.5	5.26 ± 0.06

[a] (1982OL01).

[b] For γ-ray branchings see Table 18.4.

[c] It is estimated that (15 ± 6)% of the transitions are to states of ^{18}O which do not γ-decay. The uncertainty in this number is reflected in the $\log ft$ values but not in the branching ratios. The $\log ft$ values were calculated using 13899 ± 20 keV for the ^{18}N$(\beta^-)^{18}$O Q-value (see also "mass of ^{18}N" in the "General" section of ^{18}N) and the $\tau_{1/2}$ value given in reaction 1 of ^{18}N, 624 ± 12 msec (1982OL01). I am indebted to Dr. E.K. Warburton for his calculations of the $\log ft$ values.

[d] $E_\gamma = 1981.933 \pm 0.09$ keV is adopted by (1982OL01).

[e] See (1982OL01).

Angular distributions involving ^{18}O*(0, 1.98, 3.55) have been studied at $E(^{12}$C$) = 115$ MeV: see (1983AJ01).

19. ^{18}N$(\beta^-)^{18}$O $\qquad\qquad\qquad Q_m = 13.899$

The transitions observed in the β^- decay are displayed in Table 18.9 (1982OL01).

20. (a) ^{18}O$(\gamma, n)^{17}$O $\qquad\qquad\qquad Q_m = -8.0443$
    (b) ^{18}O$(\gamma, 2n)^{16}$O $\qquad\qquad\qquad Q_m = -12.1879$

23

(c) ^{18}O$(\gamma, p)^{17}$N $\qquad Q_m = -15.942$
(d) ^{18}O$(\gamma, t)^{15}$N $\qquad Q_m = -15.8336$
(e) ^{18}O$(\gamma, \alpha)^{14}$C $\qquad Q_m = -6.2270$

Table 18.10: Resonances in ^{18}O $+ \gamma$

E_x (MeV) [a]				σ (mb)	Γ (MeV)
(γ, tot)	(γ, n)	$(\gamma, 2\text{n})$	(γ, p)		
9.1	9.1			1.1 [b]	0.6
10.3	10.3			5.3 [b]	0.9
11.4	11.4			9.0 [b]	0.7
13.1	13.1	13.2		8.6 [b]	0.7
13.8	13.8	13.9		6.9 [b]	0.6
14.7	14.7	14.8		13.1 [b]	0.8
15.8	15.7	15.8		10.9 [b]	0.7
17.3 [c]	17.1		17.5	10.1 [b], 1.2 [e]	0.6
19.4 [c]		(19.1)	19.4	10.0 [b], 1.8 [e]	0.9
21.1 [d]		21.1	21.0	9.7 [b], 1.2 [e]	
22.6	(22.6)	22.7	22.7		
23.7 [d]	23.7	23.5	23.7	17.7 [b], 6.1 [e]	1.6
27 [c]	27		27–28		
30 [f]	30				
36 [f]					

[a] (1979WO04). See also Table 18.9 in (1983AJ01) and (1987JU07).
[b] $\sigma(\gamma, \text{n}) + 2\sigma(\gamma, 2\text{n})$.
[c] $T = 2$: see (1979WO04).
[d] $T = 1$: see (1979WO04).
[e] $\sigma(\gamma, \text{p})$.
[f] Weak and broad resonances: may indicate the presence of particle-hole
states at these high energies.

The cross sections for the (γ, p), (γ, n), $(\gamma, 2\text{n})$ and (γ, tot) [tot = total absorption] have been measured with monoenergetic photons to 42 MeV: observed resonances are displayed in Table 18.10. All three of the partial cross sections have substantial strength in the giant resonance region; the $(\gamma, 2\text{n})$ cross section is a significant fraction of $\sigma(\gamma, \text{tot})$ and is even larger than $\sigma(\gamma, \text{p})$.

Above the GDR the partial cross sections decrease but the integrated $\sigma(\gamma, \text{tot})$ between 29 and 42 MeV is about one-third of the value integrated from threshold to 42 MeV. The relative strengths of partial cross sections leads to the T assignments shown in Table 18.10. The $T_<$ and $T_>$ components of the ^{18}O photo absorption cross section are also derived (1979WO04). Structures in the (γ, α_0) cross section are reported at $E_\text{x} = 18.2, 20.9, 22.1$ and 24.2 MeV (1982BA03; $E_\text{brems.}$). The decay of the GDR to ^{14}C, ^{15}N, ^{16}O, ^{17}N and ^{17}O states has been studied: see (1983AJ01). Less than 20% of the decays of states with $14.5 < E_\text{x} < 20$ MeV goes via the n_0 channel (1987JU07). See (1978AJ03) for the earlier work, (1985SH1P), (1985PY01) and (1983KA28, 1984VA1G, 1985PY01, 1985VA1C; theor.).

21. ^{18}O$(\gamma, \gamma)^{18}$O

The Γ_{γ_0} of ^{18}O*(6.20) is 0.18 ± 0.03 eV, assuming $\Gamma_{\gamma_0}/\Gamma = 0.88$; $E_\text{x} = 6202.7 \pm 0.8$ keV: see (1978AJ03).

22. ^{18}O(e, e)^{18}O

The ^{18}O charge radius, $\langle r^2 \rangle^{1/2} = 2.784 \pm 0.020$ fm, based on studies of the elastic charge form factors for $E_\text{e} = 70$ to 370 MeV, the resulting determinations of the difference in the ^{18}O and ^{16}O radii, and the rms radius of ^{16}O: see (1983AJ01).

Inelastic scattering has been reported to many states of ^{18}O: see (1983AJ01) and Table 18.11 here (1982NO04, 1983BE36, 1986MA48). See also (1987DE43) and (1986GU05, 1986ST15, 1987MI1E; theor.).

Table 18.11: Some states of ^{18}O from ^{18}O(e, e′) [a]

E_x (MeV $\pm$ keV)	Γ (keV)	$J^\pi; T$	Mult.	Transition probability (in $e^2 \cdot \text{fm}^{2\lambda}$)
1.98 [b]		$2^+; 1$	C2	44.8 ± 1.3
3.55 [b]		$4^+; 1$	C4	$(9.04 \pm 0.90) \times 10^2$
3.92 [b]		$2^+; 1$	C2	22.2 ± 1.0
5.26 [b]		$2^+; 1$	C2	28.3 ± 1.5
7.12 [b]		$4^+; 1$	C4	$(1.31 \pm 0.06) \times 10^4$
9.36 ± 20 [c]	10 ± 7	$T = 1$		
11.65 ± 20 [c]	76 ± 8	$T = 1$		
12.06 ± 60 [c]	28 ± 6	$T = 1$		
16.210 ± 10 [d,e]		$1^{(-)}$		

Table 18.11: Some states of ^{18}O from ^{18}O(e, e') [a] (continued)

	Γ (keV)	$J^\pi; T$	Mult.	Transition probability (in $e^2 \cdot \text{fm}^{2\lambda}$)
16.315 ± 10 [d,e]		$(3, 2)^-$		
16.399 ± 5 [d,f]	< 20	$2^-; 2$ [g]	M2	$(64 \pm 8) \times 10^{-2}$
16.948 ± 10 [d,e]		$(3, 2)^-$		
17.025 ± 10 [d,e,f]	20 ± 6	$(> 2); 2$		
(17.35 ± 60) [f]	680 ± 250			
17.398 ± 10 [d,e]		$(2, 1, 3)^-$		
17.450 ± 10 [d,e]		$(2, 1, 3)^-$		
17.5 [d]	≈ 150			
17.502 ± 10 [d,e]		$(1, 2, 3)^-$		
17.635 ± 10 [d,e]				
18.049 ± 10 [d,e]		[d]		
18.2 [d]	≈ 150			
(18.48 ± 20) [f]	90 ± 34			
18.5 [d]	≈ 4300			
18.70 ± 20 [f]	< 20	$(4^-); 2$	M4	63 ± 8
18.871 ± 5 [d]		$1^+; 2$	M1	$(3.1 \pm 0.4) \times 10^{-2}$
18.927 [d,e]		$1; (2^+)$		
19.027 ± 10 [d,e]		$(1, 3)^-$		
19.150 ± 10 [d,e]		$1^-; (2^+, 3^-)$		
19.24 ± 20 [f]	< 20	$(> 2); 2$		
19.7 [d]	≈ 200			
20.2 [d]	≈ 180			
20.36 ± 20 [f]	< 20	$(4^-); 2$	M4	66 ± 6
21.0 [d]	≈ 150			
(21.43 ± 20) [f]	49 ± 37			
22.39 ± 40 [d,f]	74 ± 7	(4^-)	M4	400 ± 32
23.8 [d]	≈ 1300			

ᵃ Additional states have been excited: see reaction 28 in (1983AJ01). For ground state see text here.

ᵇ (1982NO04).

ᶜ Mark Manley, private communication.

ᵈ (1983BE36).

ᵉ Weakly excited.

ᶠ (1986MA48).

ᵍ See Fig. 4 (isobar diagram for $A = 18$) for missing $T = 2$ strength.

23. (a) $^{18}\text{O}(\pi^{\pm}, \pi^{\pm})^{18}\text{O}$

    (b) $^{18}\text{O}(\pi^{\pm}, \pi^{\pm}\text{p})^{17}\text{N}$ $Q_{\text{m}} = -15.942$

    (c) $^{18}\text{O}(\pi^{-}, \pi^{-}\text{n})^{17}\text{O}$ $Q_{\text{m}} = -8.0443$

Angular distributions for the scattering to $^{18}\text{O}*(0, 1.98, 5.10)$ have been reported at $E_{\pi\pm} = 29.2$ to 230 MeV [see (1983AJ01)] and at 50 MeV (1984TA1A; $^{18}\text{O}*(0, 1.98)$) at 140, 180 and 220 MeV (1984SE1A; $^{18}\text{O}*(1.98)$), at 164 MeV (1987CH14; $^{18}\text{O}*(0, 1.98, 4.46, 5.10)$) and at 180 MeV (1987MO07; $^{18}\text{O}*(1.98)$). $\langle r_{\text{n}}^2 \rangle^{1/2} = 2.81 \pm 0.03$ fm, $\langle r_{\text{n}}^2 \rangle^{1/2} - \langle r_{\text{p}}^2 \rangle^{1/2} = 0.03 \pm 0.03$ fm: see (1983AJ01). For a discussion of the proton matter distribution in ^{18}O see (1985BA27). For total reaction cross sections at $E_\pi = 50$ and 65 MeV see (1986ME1C; prelim.). At $E_\pi = 165$ MeV, the cross section for reaction (c) is larger for ^{18}O than for ^{16}O while reaction (b) has a lower cross section (1982PI06). For the $(\pi^+, 2\text{p})$, (π^+, pn) and (π^-, pn) reactions at $E_\pi = 165$ MeV see (1984AL20, 1986AL22). See also the "General" section here.

24. $^{18}\text{O}(\text{n}, \text{n})^{18}\text{O}$
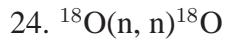
Angular distributions have been measured for $E_{\text{n}} = 2.9$ to 24 MeV [see (1972AJ02, 1983AJ01)] and at $E_{\text{n}} = 5.0$ to 7.5 MeV (1986KO10; n_0, n_1).

25. $^{18}\text{O}(\text{p}, \text{p})^{18}\text{O}$

Angular distributions have been measured for $E_{\text{p}} = 0.84$ to 135 MeV [see (1978AJ03, 1983AJ01)], at $E_{\text{p}} = 135$ MeV (1986KE05; p_1) and at $E_{\vec{\text{p}}} = 800$ MeV (1982GL08; p to $^{18}\text{O}*(0, 1.98, 7.12)$).

At $E_{\text{p}} = 24.5$ MeV (1974ES02) have studied the angular distributions of the proton groups to $^{18}\text{O}*(1.98, 3.55, 3.63, 3.92, 4.46, 5.10, 5.26, 5.53, 7.12)$: a modified DWBA analysis leads to $J^\pi = 2^+, 4^+, 0^+, 2^+, 1^-, 3^-, 2^+, 2^-$ and 4^+ for these states. A coupled-channels calculation suggests $\beta_2 = 0.37 \pm 0.03, 0.56 \pm 0.06$ and 0.18 ± 0.04 for $^{18}\text{O}*(1.98, 5.10, 7.12)$. Such calculations also support evidence for a rotational band involving $^{18}\text{O}*(0, 1.98, 7.12)$. The 3^- state at 5.10 MeV

is stongly excited and collective in nature: $B(E3) = 1120\ e^2 \cdot \text{fm}^6$. For ^{18}O*(1.98, 3.92, 5.26), $B(E2) = 45$, 8.3 and 24 $e^2 \cdot \text{fm}^4$ (1974ES02). The 800-MeV data indicates that ^{18}O*(7.12) can be described only if a large hexadecapole deformation is assumed (1982GL08). At $E_p = 201$ MeV forward angle $\sigma(\theta)$ have been measured to ^{18}O*(8.21, 8.82, 16.40): it is proposed that ^{18}O*(8.82) has $J^\pi = 1^+$ and that additional 1^+ strength is located in a group centered at $E_x \approx 10.1$ MeV as well as in the region $E_x = 12.4$ to 15 MeV. The $1^+; T = 2$ state ^{18}O*(18.87), reported in (e, e′), is not observed (1987DJ01).

^{18}O*(1.98) has $|g| = 0.287 \pm 0.015$ [$\tau_m = 2.99 \pm 0.12$ psec]. ^{18}O*(3.55) has $|g| = 0.62 \pm 0.10$ suggesting a mainly $(d_{5/2})^2$ configuration for this state: see (1983AJ01). See also ^{19}F, (1983CE1A) and (1982KU04, 1982NA13, 1984PH02, 1986DE1G, 1986PE1E; theor.).

26. ^{18}O($\overline{\text{p}}$, $\overline{\text{p}}$)^{18}O

Angular distributions are reported with 178.4 MeV antiprotons to ^{18}O*(0, 1.98) (1986BR04, 1986LE13). For atomic effects see (1986KO22). See also (1984PO1A), (1985LI16; theor.) and the "General" section here.

27. ^{18}O(d, d)^{18}O

Angular distributions have been reported at $E_d = 7.0$ to 15.0 MeV: see (1972AJ02, 1983AJ01). See also ^{20}F.

28. ^{18}O(t, t)^{18}O

See (1972AJ02).

29. ^{18}O(^{3}He, ^{3}He)^{18}O

The elastic scattering has been studied at $E(^3\text{He}) = 11.0$ to 41 MeV [see (1972AJ02, 1983AJ01)] and at 14 MeV (1982AB04), at 25 MeV (1982VE13) [the matter radius, $\langle r^2 \rangle_m^{1/2} = 2.59 \pm 0.12$ fm] and at $E(^3\text{He}) = 33$ MeV (1983LE03; also A_y; and also to ^{18}O*(1.98)). See also (1985HA11, 1987CO07; theor.).

30. ^{18}O(α, α)^{18}O

Angular distributions of many α-groups have been measured in the range $E_\alpha = 21$ to 40.5 MeV [see (1978AJ03)], at 23.5 MeV (1984SA28; to ^{18}O*(1.98, 3.56 + 3.63, 3.92, 4.45, 5.1 − 5.53)) and at 54.1 MeV (1987AB03; g.s.). The transitions to ^{18}O*(4.46, 5.10) are $L = 1$ and 3, respectively, fixing $J^\pi = 1^-$ and 3^- for these states. Measurements of α-groups near 180° for $E_\alpha = 20.0$ to 23.4 MeV confirm assignments of natural parity for ^{18}O*(1.98, 3.55, 3.63, 3.92, 4.46, 5.10, 5.26, 5.34, 6.20, 6.40, 7.12, 7.62, 7.86, 8.22, 8.29, 8.82, 8.96, 9.03, 9.10, 9.36, 9.41, 9.67, 9.72 ± 0.03, 9.88, 10.12, 10.30, 10.40, 11.62, 11.69). [See, however, Table 18.3.] Levels at $E_x = 5.38$, 8.48 and 8.64 MeV were not observed, and those at 5.53, 6.35 and 6.88 MeV were populated weakly indicating unnatural parity: $J^\pi = 3^+$ and 2^- respectively for ^{18}O*(5.38, 5.53).

Alpha-gamma correlation measurements involving ^{18}O states below $E_x = 6.4$ MeV [see Table 18.4] lead to $J^\pi = 1^-$ and 3^- for ^{18}O*(6.20, 6.40). Other J^π values agree with previous assignments. The transitions $3.92 \rightarrow 1.98$ and $5.26 \rightarrow 1.98$ are almost pure M1. For τ_m measurements see Table 18.4 in (1978AJ03). For references see (1983AJ01). See also (1983WI12, 1984BR1P, 1984LA01, 1987AS01; theor.).
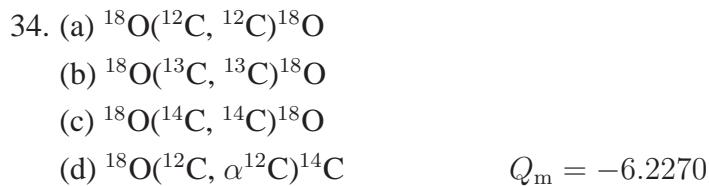
31. (a) ^{18}O(^{6}Li, ^{6}Li)^{18}O
    (b) ^{18}O(^{7}Li, ^{7}Li)^{18}O

See (1972AJ02, 1983AJ01).

32. ^{18}O(^{9}Be, ^{9}Be)^{18}O
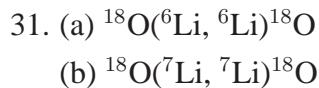
See (1972AJ02, 1983BI13, 1985BE1A) and (1984HA43; theor.).

33. (a) ^{18}O(^{10}B, ^{10}B)^{18}O
    (b) ^{18}O(^{11}B, ^{11}B)^{18}O
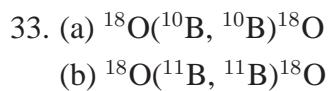
An elastic angular distribution has been reported at $E(^{11}$B$) = 115$ MeV: see (1983AJ01). For reaction (a) see (1974AJ01).

34. (a) ^{18}O(^{12}C, ^{12}C)^{18}O
    (b) ^{18}O(^{13}C, ^{13}C)^{18}O
    (c) ^{18}O(^{14}C, ^{14}C)^{18}O
    (d) ^{18}O(^{12}C, $\alpha\,^{12}$C)^{14}C $Q_m = -6.2270$

29

Elastic angular distributions have been studied at $E(^{18}O) = 32.3$ to 57.5 MeV for reaction (a) [as well as at $E(^{18}O) = 70$, 100 and 140 MeV (1982HE07)] and at $E(^{18}O) = 31$ MeV for reaction (b). Yields and fusion cross sections are reported by (1982BA49, 1982HE07, 1985BE40, 1985CA01, 1986GA13). See also (1983VO1B). For the earlier work see (1983AJ01). For reaction (c) see (1986STZY).

Angular correlations (reaction (d)) have been studied at $E(^{18}O) = 82$ MeV. $^{18}O^*(7.10, 7.62, 7.86, 8.04, 8.22, 10.30, 11.59, 12.55)$ are observed: the first seven of these have $J^\pi = 4^+$, 1^-, 5^-, 1^-, 2^+, 4^+, 5^- (1984BH01, 1984RA07). In addition $^{18}O^*(9.33, 9.65)$ are also populated [$\Gamma \approx 0.3$ MeV]: a possible interpretation of the data is that these two are 3^- states and that there is in addition a very wide (> 1 MeV) 2^+ state at ≈ 9.5 MeV (1984RA17). See also (1983CA1N), (1983BI13, 1984HA53) and (1982GI1C, 1982LO13, 1983CI08, 1983MA29, 1984FR1A, 1985CH1R, 1986HA13; theor.).

35. $^{18}O(^{15}N, ^{15}N)^{18}O$

See (1983DU13).

36. $^{18}O(^{16}O, ^{16}O)^{18}O$

Angular distributions have been measured at many energies for $E(^{16}O) = 24$ to 54.5 MeV and $E(^{18}O) = 25$ to 52 MeV, involving besides $^{18}O_{\text{g.s.}}$, $^{18}O^*(1.98, 3.55 + 3.63, 3.92, 4.46, 5.10, 7.12)$. At $E(^{18}O) = 126$ MeV $^{18}O^*(9.0)$ is relatively strongly populated. See (1983AJ01). For yields and fusion cross sections, including the effect of $^{18}O^*(1.98)$, see (1985TH03, 1985WU03, 1986GA13, 1986TH01). See also (1983DU13), (1986BA69) and (1983SH04, 1985MA1T, 1986DAZS, 1986VI08, 1987LO01; theor.).

37. (a) $^{18}O(^{17}O, ^{17}O)^{18}O$
(b) $^{18}O(^{18}O, ^{18}O)^{18}O$

Angular distributions involving $^{18}O^*(0, 1.98)$ are reported at $E(^{17}O) = 36$ MeV. Angular distributions [reaction (b)] have been studied at $E(^{18}O) = 20$ to 52 MeV. $^{18}O^*(3.55 + 3.63, 4.46, 5.10, 7.12)$ are also populated; see (1978AJ03, 1983AJ01). See also (1986GA13) and (1982CI1C, 1983DU13).

38. $^{18}O(^{19}F, ^{19}F)^{18}O$

The elastic scattering has been studied at $E(^{19}\text{F}) = 27$, 30 and 33 MeV: see (1983AJ01). See also (1986GA13) and (1982OH05; theor.).

39. (a) $^{18}\text{O}(^{24}\text{Mg}, {}^{24}\text{Mg})^{18}\text{O}$

(b) $^{18}\text{O}(^{26}\text{Mg}, {}^{26}\text{Mg})^{18}\text{O}$

Angular distributions are reported for reaction (a) at $E(^{18}\text{O}) = 29$ and 35 MeV to $^{18}\text{O}^*(0, 1.98)$. See (1983AJ01, 1983BI13) and (1982LO13, 1983CI08, 1984FR1A, 1985HU04, 1986HA13, 1986OS05; theor.).

40. $^{18}\text{O}(^{27}\text{Al}, {}^{27}\text{Al})^{18}\text{O}$

The elastic angular distribution has been studied at $E(^{18}\text{O}) = 100$ MeV (1981ME13). See also (1985DEZZ), (1983AJ01, 1983BI13) and (1982LO13, 1983CI08, 1984FR1A, 1985HU04; theor.).

41. $^{18}\text{O}(^{28}\text{Si}, {}^{28}\text{Si})^{18}\text{O}$

Elastic angular distributions are reported at $E(^{18}\text{O}) = 36$ to 56 MeV [see (1983AJ01)] and at 351.7 MeV (1984BUZX; also to $^{18}\text{O}^*(1.98)$). See also (1986BL08, 1986GA13), (1983BI13) and (1982LO13, 1983CI08, 1984FR1A, 1985HU04, 1986HOZF; theor.).

42. (a) $^{18}\text{O}(^{40}\text{Ca}, {}^{40}\text{Ca})^{18}\text{O}$

(b) $^{18}\text{O}(^{44}\text{Ca}, {}^{44}\text{Ca})^{18}\text{O}$

(c) $^{18}\text{O}(^{48}\text{Ca}, {}^{48}\text{Ca})^{18}\text{O}$

Angular distributions have been measured at $E(^{18}\text{O}) = 62.1$ MeV [reaction (a)] for the transitions to $^{18}\text{O}^*(0, 1.98, 5.10)$ (1982RE14). For fusion study [reaction (b)] see (1984DE38). See also (1985DE38, 1986OS05, 1986RO12; theor.).

43. $^{18}\text{F}(\beta^+)^{18}\text{O}$ $\qquad\qquad Q_m = 1.6554$

See ^{18}F.

Table 18.12: ^{18}O states from ^{19}F(t, $\alpha\gamma$) [a]

E_{x} (keV)	J^π	E_{x} (keV)	J^π
1982.16 ± 0.20		5530.5 ± 0.6	1, 2
3555.07 ± 0.45		6196.3 ± 1.2	1
3634.50 ± 0.40		6351.3 ± 0.6	1, 2
3920.6 ± 0.4		6404.4 ± 1.2	
4456.1 ± 0.5		6881.6 ± 1.2	0, (1)
5098.5 ± 1.2		7116.9 ± 1.2	
5260.4 ± 1.2		7.75	$1 \to 4$
5336.4 ± 0.6		7.98	$1 \to 5$
5377.8 ± 1.2		[b]	

[a] (1973OL02): see Table 18.4 for branching ratios and Table 18.3 for τ_{m}. See also Table 18.10 in (1983AJ01).
[b] Alpha groups are also reported to ^{18}O states with E_{x} = 7.60, 7.75, 7.84, 7.96, 8.02, 8.11, 8.19, 8.26, 8.39, 8.48, 8.64 MeV ($\pm$ 20 keV).

44. ^{19}F(γ, p)^{18}O $\qquad\qquad Q_{\mathrm{m}} = -7.9942$

(1985KE03) have measured the yields of proton groups to ^{18}O*(0, 1.98) [and to unresolved states] for E_{bs} in the GDR range. See also (1978AJ03) and ^{19}F.

45. ^{19}F(n, d)^{18}O
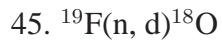
Angular distributions have been measured at E_{n} = 14 to 14.4 MeV: see (1972AJ02). See also (1978AJ03) and ^{20}F.

46. ^{19}F(d, ^{3}He)^{18}O $\qquad\qquad Q_{\mathrm{m}} = -2.5007$

Many states of ^{18}O ($E_{\mathrm{x}} < 14.6$ MeV) have been populated in this reaction: see Table 18.8 in (1978AJ03). [*Comment:* Note, however, density of states.] Analyzing powers for the ground-state transition are reported at $E_{\vec{\mathrm{d}}} = 12.4$ MeV (1983EN02). See also (1983KI13; theor.).

47. ^{19}F(t, α)^{18}O $\qquad\qquad\qquad\qquad$ $Q_m = 11.8198$

$\qquad$ See Table 18.12.

48. ^{22}Ne(d, ^{6}Li)^{18}O $\qquad\qquad\qquad\qquad$ $Q_m = -8.194$

$\qquad$ At $E_d = 80$ MeV angular distributions have been measured for the ^{6}Li groups to the ground state of ^{18}O and to excited states at 1.98, 3.57, 5.10, 6.30, 7.8, 9.4 [$\pm\,0.04$] MeV (1984OE02) [see also for S_{rel}]. For earlier work see (1983AJ01).

<center>

^{18}F

(Figs. 2 and 4)

</center>

GENERAL: (See also (1983AJ01).)

Shell model: (1978WI1B, 1982ZH01, 1983BR29, 1983KI13, 1984MI1H, 1984MI17, 1985LE1K, 1986YU1B).

Cluster, collective and deformed models: (1983ME12, 1984QU1A, 1985BA1A, 1987ER05).

Special states: (1978WI1B, 1982ZH01, 1983BI1C, 1983BR29, 1983ME12, 1983KI13, 1984AD1E, 1984HA14, 1984HO1H, 1984MI1H, 1984MI17, 1985AD1A, 1985HA18, 1985LE1K, 1985MI10, 1985SO12, 1985YU1B, 1986AN07, 1986CA27, 1986HA1E, 1986HA1Q, 1986SI1K, 1986TO1D, 1986WI1P, 1986YU1B, 1987ER05).

Electromagnetic transitions: (1982RI04, 1983BR29, 1983KI13, 1984BI10, 1984HA14, 1984MI1H, 1984QU1A, 1985AD1A, 1986CA27, 1986SI1K, 1987ER05, 1987KI03).

Astrophysical questions: (1982WI1B).

Applications: (1982HI1H, 1982YA1C, 1984HI1D, 1984NI1C, 1985HU02, 1986HI1B, 1987HI1B).

Complex reactions involving ^{18}F: (1983DE26, 1983JA05, 1983OL1A, 1983WI1A, 1984GR08, 1984HI1A, 1984HO23, 1985BE40, 1985CU1C, 1985DR07, 1985GR1K, 1985PO11, 1986AV07, 1986BA3G, 1986GR1A, 1986HA1B, 1986HO27, 1986PO06, 1986SC28, 1986SC29, 1986VA23, 1987RI03, 1987RO10).

Pion capture and reactions (See also reaction 32.): (1982LI15, 1983HO02, 1986GE06, 1986NA1K).

Hypernuclei: (1984AS1D).

Other topics: (1978WI1B, 1983AD1B, 1983AG1C, 1983AR1J, 1983BI1C, 1983BR29, 1983SH32, 1984BI10, 1984HO1H, 1984MI1H, 1985AD1A, 1985AN28, 1985MI10, 1985YU1B, 1986LA29, 1986NA1K, 1986TO1D, 1987KI03).

Ground and 1.12 MeV states of ^{18}F: (1978WI1B, 1983ANZQ, 1983AR1J, 1984HA14, 1985AN28, 1985HA18, 1986CA27).

<center>

$\mu_{1.12} = +2.86 \pm 0.03$ nm [see (1983AJ01)]

$Q_{1.12} = 0.13 \pm 0.03$ b [see (1983AJ01)].

</center>

1. ^{18}F$(\beta^+)^{18}$O $\qquad\qquad\qquad\qquad Q_\mathrm{m} = 1.6554$

The positron decay is entirely to the ground state of ^{18}O [$J^\pi = 0^+$, $T = 1$]; the half-life is 109.77 ± 0.05 min [see Table 18.11 in (1972AJ02)]; $\log ft = 3.554$. The fact that the β^+ transition to ^{18}O$_\mathrm{g.s.}$ is allowed indicates $J^\pi = 1^+$ for ^{18}F$_\mathrm{g.s.}$. The ratio $\epsilon_\mathrm{K}/\beta^+ = 0.030 \pm 0.002$:

<center>

34

</center>

see (1978AJ03). See also (1985BR29), (1982KA1C; applications), (1985AR1A, 1985KL1A, 1986HE1C, 1987GOZX; astrophyics) and (1983CA03; theor.) [see for discussions of weak magnetism form factor and of search for heavy neutrinos].

Table 18.13: Energy levels of ^{18}F ^{a}

E_{x} (MeV $\pm$ keV)	$J^{\pi}; T$	K^{π}	τ or $\Gamma_{\text{c.m.}}$ (keV)	Decay	Reactions
0	$1^{+}; 0$	0^{+}	$\tau_{1/2} = 109.77 \pm 0.05$ min	β^{+}	1, 4, 5, 6, 9, 10, 12, 13, 15, 21, 23, 24, 25, 29, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42
0.93720 ± 0.06	$3^{+}; 0$	0^{+}	$\tau_{\text{m}} = 67.6 \pm 2.5$ psec $g = +0.56 \pm 0.05$	γ	2, 6, 9, 10, 13, 21, 23, 25, 30, 34, 35, 37, 38, 39, 40, 42
1.04155 ± 0.08	$0^{+}; 1$		2.55 ± 0.45 fsec	γ	6, 9, 21, 25, 30, 33, 34, 36, 37, 38, 40, 41
1.08054 ± 0.12	$0^{-}; 0$	0^{-}	27.5 ± 1.9 fsec	γ	6, 9, 10, 21, 25, 34, 36, 37, 38, 39, 40, 42
1.12136 ± 0.15	$5^{+}; 0$	0^{+}	234 ± 10 nsec $\mu = +2.86 \pm 0.03$ nm $Q = 0.13 \pm 0.036$ b	γ	5, 6, 9, 10, 13, 14, 21, 22, 25, 30, 31, 34, 36, 38, 40, 42
1.70081 ± 0.18	$1^{+}; 0$	1^{+}	955 ± 27 fsec	γ	6, 10, 21, 25, 33, 34, 38, 40, 41, 42
2.10061 ± 0.10	$2^{-}; 0$	0^{-}	5.1 ± 0.5 psec	γ	6, 10, 13, 21, 23, 25, 34, 38, 40, 42
2.52335 ± 0.18	$2^{+}; 0$	1^{+}	590 ± 24 fsec	γ	6, 10, 21, 25, 30, 38, 40
3.06184 ± 0.18	$2^{+}; 1$		< 1.2 fsec	γ	6, 21, 25, 30, 34, 37, 38, 40, 41
3.13387 ± 0.15	$1^{-}; 0$	1^{-}	0.39 ± 0.02 psec	γ	6, 10, 21, 25, 34, 37, 38, 40
3.3582 ± 1.0	$3^{+}; 0$	1^{+}	0.44 ± 0.03 psec	γ	6, 10, 21, 34, 38, 40, 42
3.72419 ± 0.22	$1^{+}; 0$		$2.7^{+4.1}_{-2.7}$ fsec	γ	6, 10, 21, 23, 25, 33, 34, 38, 40, 42
3.79149 ± 0.22	$3^{-}; 0$	1^{-}	1.91 ± 0.13 psec	γ	5, 10, 21, 23, 25, 34, 38, 40, 42

Table 18.13: Energy levels of ^{18}F ^{a} (continued)

E_x (MeV $\pm$ keV)	$J^\pi; T$	K^π	τ or $\Gamma_{\text{c.m.}}$ (keV)	Decay	Reactions
3.83917 $\pm$ 0.22	2$^+$; 0		19.0 $\pm$ 2.7 fsec	γ	6, 10, 21, 23, 25, 30, 34, 38, 40, 42
4.11590 $\pm$ 0.25	3$^+$; 0		91 $\pm$ 22 fsec	γ	6, 10, 21, 23, 25, 30, 34, 38, 40, 42
4.2258 $\pm$ 0.7	2$^-$; 0	(1$^-$)	110 $\pm$ 15 fsec	γ	6, 10, 21, 23, 34, 38, 40, 42
4.36015 $\pm$ 0.26	1$^+$; 0		27 $\pm$ 10 fsec	γ	10, 21, 25, 33, 34, 38, 40, 42
4.3981 $\pm$ 0.7	4$^-$; 0	0$^-$	58 $\pm$ 12 fsec	γ	6, 10, 13, 14, 21, 34, 38, 40, 42
4.652 $\pm$ 2	4$^+$; 1		< 10 fsec	γ	6, 21, 24, 30, 34, 38, 40
4.753 $\pm$ 3	0$^+$; 1			γ	21, 34, 37, 38, 40, 42
4.8483 $\pm$ 0.5	5$^-$; 0	1$^-$	5.2 $\pm$ 0.9 psec	γ	5, 23
4.860 $\pm$ 2	1$^-$; 0		66 $\pm$ 18 fsec	γ, α	6, 21, 38, 40, 42
4.9636 $\pm$ 0.8	2$^+$; 1		< 4 fsec	γ	6, 21, 30, 38, 40
5.2976 $\pm$ 1.5	4$^+$; 0	1$^+$	30 $\pm$ 5 fsec	γ, α	6, 9, 10, 11, 21, 38, 40
5.502 $\pm$ 2	3$^{(-)}$; 0		63 $\pm$ 25 fsec	γ, α	6, 10, 21, 38, 40
5.60338 $\pm$ 0.27	1$^+$		15 $\pm$ 10 fsec	γ, α	6, 8, 25, 38, 40, 42
5.60486 $\pm$ 0.28	1$^-$; 0 + 1		Γ < 1.2 keV	γ, α	6, 8, 10, 21, 25, 38, 40, 42
5.673 $\pm$ 2	1$^-$; 0 + 1		< 0.8	γ, α	6, 8, 10, 21, 25, 38, 40, 42
5.786 $\pm$ 2.4	2$^-$; 0		τ_m = 15 $\pm$ 10 fsec	γ, α	6, 21, 38, 40, 42
6.0964 $\pm$ 1.1	4$^-$; 0	1$^-$	Γ = 0.24 $\pm$ 0.03	γ, p, α	6, 10, 21, 25, 29, 38, 40, 42
6.108 $\pm$ 3	(1$^+$); 0		0.034 $\pm$ 0.003	γ, p, α	6, 8, 21, 23, 29, 40, 42
6.13647 $\pm$ 0.33	0$^+$; 1		$\leq$ 1	γ, p	21, 25, 27, 40, 42
6.1632 $\pm$ 0.9	3$^+$; 1		14 $\pm$ 0.5	γ, p, α	21, 25, 27, 29, 42
6.2404 $\pm$ 0.8	3$^-$; 0 + 1		0.19 $\pm$ 0.03	γ, p, α	6, 21, 25, 27, 29, 40
6.242 $\pm$ 3	3$^-$; 0 + 1		0.18 $\pm$ 0.04	γ, p, α	6, 8, 21, 25, 29, 40
6.262 $\pm$ 2.5	1$^+$; 0		0.60 $\pm$ 0.12	γ, p, α	6, 8, 10, 21, 29, 33, 40

E_x (MeV $\pm$ keV)	$J^\pi; T$	K^π	τ or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
6.2832 ± 0.9	$2^+; 1$		10.0 ± 0.5	γ, p, α	21, 25, 27, 29
6.3105 ± 0.8	$3^+; 0$		0.95 ± 0.14	γ, p, α	6, 21, 25, 27, 29, 42
6.3855 ± 1.7	$2^+; 0+1$		0.49 ± 0.09	γ, p, α	6, 21, 25, 29, 40
6.4849 ± 1.5	$3^+; 0$		0.40 ± 0.10	γ, p, α	6, 21, 25, 29, 40, 42
6.5670 ± 1.5	$5^+; 0$	1^+	0.56 ± 0.13	γ, p, α	6, 8, 9, 10, 11, 21, 29, 40
6.633 ± 10	1		80 ± 2	p, α	29, 40
6.6437 ± 0.8	$2^-; 1$		0.60 ± 0.07	γ, p, α	6, 7, 21, 25, 29
6.647 ± 4	1^-		91 ± 4	p, α	8, 10, 29
6.777 ± 1.4	$4^+; 0$		9.2 ± 1.0	γ, p, α	21, 25, 27, 29, 40
6.8031 ± 1.5	$1^+, 2, 3^+; 0$		≤ 2	γ, p	10, 21, 25, 27, 40
6.809 ± 5	2^-		88 ± 2	p, α	7, 8, 29
6.811	(2^+)		3.0 ± 0.5	p, α	29
6.857 ± 10	(3^-)		5.0 ± 1.0	p, α	29, 40
6.8774 ± 1.7	$3, 4^-; 0$		≤ 2	γ, p, α	21, 25, 29
7.201 ± 2	$(4^+); 0$		6.5	p, α	8, 29, 40
7.247 ± 2	$(1^+); 0$		46.5	p, α	8, 29
7.291 ± 2	3^-		38	p, α	7, 8, 27, 29
7.315 ± 4	$(3^-; 0)$		52	p, α	29, 40
7.336 ± 2	$1^-; 1$		16 ± 2	γ, p	25, 27
7.406 ± 2	1^+		14.6 ± 1.4	p	27
7.447 ± 10			140	p, α	29
7.454 ± 2	1^-		6	p	27
7.478 ± 2	(2)		12 ± 3	γ, p, α	25, 27, 29
(7.485 ± 2)	(1^-)		32	p	27
7.506 ± 2	4^-		12 ± 2	p, α	27, 29
7.513 ± 2			< 4	γ, p	25
7.528 ± 2	$2^-; 1$		16.5 ± 3.0	γ, p, α	25, 27, 29
7.532 ± 5			75	p, α	27, 29
7.555 ± 2	(1^-)		30	p	27
7.584 ± 2			9 ± 2	γ, p, α	25, 27, 29
7.685 ± 2	$3^+, 4^+$		36 ± 4	p, α	27, 29
7.729 ± 4	≥ 1		66 ± 5	p, α	27, 29

Table 18.13: Energy levels of ^{18}F [a] (continued)

$E_{\rm x}$ (MeV $\pm$ keV)	$J^\pi; T$	K^π	τ or $\Gamma_{\rm c.m.}$ (keV)	Decay	Reactions
7.763 ± 4			70	p	27
7.878 ± 3	≥ 2		20	p, α	27, 29
7.899 ± 2	(2^-)		38	p, α	7, 8, 29
7.941 ± 12	(1^+)		112	p, α	7, 8, 29
8.064 ± 6	≥ 4		60	p, α	27, 29
8.115 ± 8			96	p	27
8.209 ± 2	2^-		52	p, α	27, 29
8.238 ± 2	4^+		20	p	27
9.207 ± 15 [b]	$3, 4^-; 0$			p, d, α	16, 17, 18
9.50	$2, 3^+; 0$			n, d, α	16, 18
9.58 ± 20 [c]	6^+	1^+		d, α	9, 10, 11, 22
10.58 ± 50					11
11.22 ± 30	7^+	1^+		d, α	9, 10, 11, 22
13.83	$4^-, 5^+$		60	d, α	18
14.02	$4^-, 5^+$		60	d, α	18
14.10	$4^-, 5^+$		60	d, α	18
14.18 ± 40	(8^+)	(1^+)		d, α	9, 10, 11
15.09	$4^-, 5^+$			d, α	18
15.34	$5^+, 6^-$			d, α	18
15.79 ± 100					11
16.07	$4^-, 5^+$		220	d, α	18
16.72	$4^-, 5^+$		60	d, α	18
17.43	$4^-, 5^+, 6^-$		70	d, α	18
18.62 ± 120					11
(19.00 ± 150)			(500 ± 150)	γ, ^{3}He	12
20.1 ± 200	$(2^-; 1)$		1600 ± 100	γ, ^{3}He	12
22.7 ± 200	$(2^-; 1)$		1200 ± 100	γ, ^{3}He	12
(24.1 ± 200)			(1400 ± 300)	γ, ^{3}He	12

^a See also Table 18.14 for radiative transitions and 18.15 for τ_m.

^b Uncertainty estimated by reviewer.

^c For other states with $E_\mathrm{x} < 9.6$ MeV see footnote (e) in Table 18.17 of (1978AJ03) and Table 18.16 here. For other states with $10.0 < E_\mathrm{x} < 19.6$ MeV see Table 18.16 here, and Tables 18.14 and 18.16 in (1978AJ03). These two tables in (1978AJ03) display the states deduced from the yields of the isospin-forbidden α_1 groups in $^{14}\mathrm{N} + \alpha$ and $^{16}\mathrm{O} + \mathrm{d}$, respectively. (1976CH24) reports 151 isospin mixed natural-parity states with $10.4 < E_\mathrm{x} < 17.5$ MeV [$^{14}\mathrm{N}(\alpha, \alpha_1)$] and (1973JO13) reports 138 such states with $9.2 < E_\mathrm{x} < 19.4$ MeV [$^{16}\mathrm{O}(\mathrm{d}, \alpha_1)$] of which 16 have $E_\mathrm{x} > 17.5$ MeV. In the region $10.4 < E_\mathrm{x} < 20.8$ MeV some 167 states with mixed isospin and natural parity have been reported. See also reaction 29.

2. (a) $^{10}\mathrm{B}(^9\mathrm{Be}, \mathrm{n})^{18}\mathrm{F}$ $Q_\mathrm{m} = 14.4539$

  (b) $^{11}\mathrm{B}(^9\mathrm{Be}, 2\mathrm{n})^{18}\mathrm{F}$ $Q_\mathrm{m} = 2.9998$

See (1986CU02) for production cross sections of 0.94 MeV γ-rays.

3. (a) $^{12}\mathrm{C}(^6\mathrm{Li}, \mathrm{d})^{16}\mathrm{O}$ $Q_\mathrm{m} = 5.6868$ $E_\mathrm{b} = 13.212$

  (b) $^{12}\mathrm{C}(^6\mathrm{Li}, \alpha)^{14}\mathrm{N}$ $Q_\mathrm{m} = 8.7972$

  (c) $^{12}\mathrm{C}(^6\mathrm{Li}, {}^6\mathrm{Li})^{12}\mathrm{C}$

Cross sections for these and other charged particle channels have been measured for $E(^6\mathrm{Li}) = 1.9$ to 36 MeV [see (1978AJ03, 1983AJ01)].

The cross section for the isospin-forbidden α_1 group [to $^{14}\mathrm{N}^*(2.31)$, 0^+, $T = 1$] is 1 to 2% of the cross section to the allowed α_0 and α_2 groups for $E(^6\mathrm{Li}) = 3.2$ to 6 MeV while for 9 to 14 MeV it varies from 0.4 to 1.8%. At 20 MeV, the α_1 yield is 0.02% of the allowed yield. Structures are reported at $E(^6\mathrm{Li}) = 11.0$ and 13.0 MeV in the α_0 yield, at 11.5 and (13.0) MeV in the α_1 yield and at ≈ 11.7 and 12.8 MeV in the α_2 yield. A resonance is also reported in the α_1 yield at $E(^6\mathrm{Li}) = 4.2$ MeV: $E_\mathrm{x} = 15.99 \pm 0.02$ MeV, $\Gamma_\mathrm{c.m.} = 290 \pm 30$ keV, $J^\pi = 2^+$ (one-level BW fit). It is suggested that this resonance is due to 2^+ states with $T = 0$ and $T = 1$ which are unresolved. Cross sections for populating $^{16}\mathrm{O}^*(8.87, 10.36, 11.08, 11.10)$ are reported by (1981GL02).

The excitation functions for the $^6\mathrm{Li}$ ions to $^{12}\mathrm{C}^*(0, 4.43)$ shows a single isolated structure at $E(^6\mathrm{Li}) = 22.8$ MeV, in the range 20–36 MeV, with $\Gamma \approx 0.8$ MeV. It is unlikely to be due to an isolated state in $^{18}\mathrm{F}$. At $E(^6\mathrm{Li}) = 20$ MeV analyzing power measurements are reported for many deuteron and α groups and for elastically scattered $^6\mathrm{Li}$ ions. VAP measurements for elastic scattering are also reported at $E_{\vec{\mathrm{d}}} = 9.0$ and 19.2 MeV (1983RU09) and at 150 MeV (1986TA1B, 1986KA1C).

Table 18.14: Radiative decays in ^{18}F [a]

E_i (MeV)	$J_i^\pi; T$	E_f (MeV)	Branch (%)	
0.94	$3^+; 0$	0	100	
1.04	$0^+; 1$	0	100	
1.08	$0^-; 0$	0	100	
1.12	$5^+; 0$	0.94	100	
1.70	$1^+; 0$	0	29.8 ± 1.3	
		1.04	70.2 ± 1.3	
2.10	$2^-; 0$	0	38 ± 1	$\Gamma_\gamma = (4.6 \pm 2.2) \times 10^{-5}$ eV
		0.94	31 ± 1	$\Gamma_\gamma = (4.0 \pm 1.9) \times 10^{-5}$ eV
		1.08	31 ± 1	
2.52	$2^+; 0$	0	74.9 ± 1.8	$\delta = 3.0 \pm 1.0$
		0.94	21.5 ± 1.2	$\delta = -(1.5 \pm 0.6)$
		1.70	3.9 ± 0.6	$\delta = 0.94 \pm 0.4$
3.06	$2^+; 1$	0	23.2 ± 0.8	
		0.94	76.7 ± 0.8	
		1.04	0.11 ± 0.03	
3.13	$1^-; 0$	0	39 ± 2	$\delta = +(0.07 \pm 0.05)$
				$\Gamma_\gamma = (5.7 \pm 2) \times 10^{-4}$ eV
		1.04	34 ± 2	$\Gamma_\gamma = (7.3 \pm 2.7) \times 10^{-4}$ eV
		1.08	25 ± 2	$\Gamma_\gamma = (4.8 \pm 1.8) \times 10^{-4}$ eV
		1.70	2.0 ± 0.5	$\delta = +(0.22 \pm 0.15)$
3.36	$3^+; 0$	0	45 ± 5	
		0.94	9 ± 3	
		1.70	40 ± 4	
		2.10	< 3	
		2.52	6 ± 3	$\delta = -0.4^{+0.3}_{-0.5}$
3.72	$1^+; 0$	0	5 ± 2	
		1.04	91 ± 2	$\Gamma_\gamma = (1.3 \pm 0.2) \times 10^{-3}$ eV [c]
		3.06	4 ± 2	
3.79	$3^-; 0$	2.10	68 ± 4	$\delta = -(0.22 \pm 0.06)$
		2.52	2.2 ± 1.1	
		3.06	30 ± 3	$\delta = -(0.09 \pm 0.09)$

Table 18.14: Radiative decays in ^{18}F [a] (continued)

E_i (MeV)	J_i^π; T	E_f (MeV)	Branch (%)	
3.84	2^+; 0	0	38 ± 2	$\delta = -(1.8 \pm 0.5)$
		0.94	8.9 ± 1.4	$\delta = -(0.3 \pm 0.3)$
		1.70	3.0 ± 1.0	
		3.06	50 ± 3	$\delta = -(0.1 \pm 0.3)$
4.12	3^+; 0	0	5 ± 3	
		3.06	95 ± 3	$\delta = +0.06 \pm 0.07$
4.23	2^-; 0	0	23 ± 2	$\delta = 0.15 \pm 0.15$
		0.94	49 ± 3	$\delta = 0.0 \pm 0.2$
		1.08	3.2 ± 1.0	
		1.70	9.3 ± 1.2	
		2.10	15 ± 5	
		3.13	0.9 ± 0.6	
4.36	1^+	3.06	100	
4.40	4^-; 0	0.94	13 ± 4	$\delta = -(0.2 \pm 0.3)$
		1.12	60 ± 6	$\delta = -(0.2 \pm 0.2)$
		2.10	27 ± 3	
4.65	4^+; 1	0.94	17 ± 3	
		1.12	83 ± 3	$\delta = 0.15 \pm 0.15$
4.75	0^+; 1	0	92 ± 4	
		1.70	8 ± 4	
4.85 [b]	5^-; 0	1.12	65 ± 4	
		3.79	35 ± 4	
4.86	1^-; 0	1.04	65 ± 11	
		1.08	8 ± 6	
		3.06	23 ± 7	$\delta = -(0.4 \pm 0.4)$
		3.13	4 ± 3	
4.96	2^+; 1	0	100	$\delta = 1.2 \pm 0.7$
5.30	4^+; 0	0.94	9 ± 2	$\delta = -(0.3 \pm 0.1)$
		1.12	7 ± 2	$\delta = -(1.1 \pm 0.5)$
		2.52	78 ± 3	$\Gamma_\gamma = 12 \pm 4\,\mathrm{meV}$ [c]
		3.36	5 ± 1	$\delta = 2.5 \pm 0.8$

Table 18.14: Radiative decays in ^{18}F [a] (continued)

E_i (MeV)	J_i^{π}; T	E_f (MeV)	Branch (%)	
		4.65	1.3 ± 0.3	
5.50	$3^{(-)}$; 0	3.06	100	$\Gamma_\gamma = 2.1 \pm 0.7$ meV [c]
5.603	1^+	0	16.7 ± 2.3	
		1.04	3.8 ± 1.2	
		3.06	79.5 ± 5.9	$\Gamma_\gamma = 0.48 \pm 0.05$ eV [c]
5.605	1^-; $0 + 1$	0	6.7 ± 1.2	
		1.04	4.2 ± 0.8	
		1.08	54.3 ± 3.1	$\Gamma_\gamma = 0.87 \pm 0.07$ eV [c]
		3.06	2.6 ± 1.4	
		3.13	32.2 ± 2.5	$\delta = -0.05 \pm 0.02$
5.67	1^-; $0 + 1$	0	6.2 ± 0.4	$\delta = -0.01 \pm 0.04$
		1.04	8.1 ± 0.7	
		1.08	52 ± 3	$\Gamma_\gamma = 0.46 \pm 0.06$ eV [c]
		1.70	0.8 ± 0.3	
		2.10	0.4 ± 0.2	
		3.06	4.0 ± 0.4	$\delta = 0.04 \pm 0.06$
		3.13	28.5 ± 2.0	$\delta = +0.10 \pm 0.03$
5.79	2^-; 0	0.94	40 ± 8	
		1.08	60 ± 8	
6.10	4^-; 0	0.94	4.9 ± 0.9	$\Gamma_\gamma = 51 \pm 10$ meV [c]
		1.12	55 ± 3	
		2.10	27 ± 2	
		3.79	1.4 ± 0.3	
		4.12	1.8 ± 0.3	
		4.40	0.7 ± 0.3	
		4.65	8.7 ± 0.7	
6.10	(1^+); 0	0	24 ± 3	
		0.94	11 ± 3	
		2.10	20 ± 6	
		3.06	45 ± 5	
6.14	0^+; 1	0	50 ± 3	$\Gamma_\gamma > 1.6$ eV

Table 18.14: Radiative decays in ^{18}F [a] (continued)

E_i (MeV)	J_i^π; T	E_f (MeV)	Branch (%)	
		1.70	12 ± 2	
		3.72	36 ± 3	
		4.36	2.1 ± 0.4	
		5.603	0.19 ± 0.02	
6.16	3^+; 1	0	0.2 ± 0.2	$\Gamma_\gamma = 0.96 \pm 0.26$ eV [c]
		0.94	51 ± 3	
		1.12	1.0 ± 0.1	
		2.52	5.5 ± 0.4	
		3.06	1.3 ± 0.3	
		3.79	11.6 ± 1.3	
		3.84	25.0 ± 1.6	
		4.12	1.5 ± 0.3	
		4.23	0.9 ± 0.3	
		4.40	2.0 ± 0.2	
6.242	3^-; $0+1$	0.94	4.6 ± 0.3	
		2.10	71.5 ± 3.0	$\Gamma_\gamma = 0.80 \pm 0.11$ eV [c]
		3.36	1.1 ± 0.4	
		3.79	10.6 ± 0.5	
		3.84	1.0 ± 0.2	
		4.12	0.5 ± 0.2	
		4.23	7.8 ± 0.4	
		4.40	2.9 ± 0.3	
6.241	3^-; $0+1$	0.94	4.1 ± 0.3	
		2.10	71.2 ± 3.0	$\Gamma_\gamma = 0.73 \pm 0.11$ eV [c]
		3.36	0.8 ± 0.3	
		3.79	11.6 ± 0.6	
		3.84	0.9 ± 0.2	
		4.12	1.1 ± 0.4	
		4.23	8.2 ± 0.4	
		4.40	2.1 ± 0.3	
6.26	1^+; 0	0	(100)	

Table 18.14: Radiative decays in ^{18}F [a] (continued)

E_i (MeV)	$J_i^\pi; T$	E_f (MeV)	Branch (%)	
6.28	$2^+; 1$	0	0.3 ± 0.1	$\Gamma_\gamma = 1.8 \pm 0.5$ eV [c]
		0.94	67 ± 3	
		1.04	1.3 ± 0.1	
		1.70	5.7 ± 0.6	
		2.10	1.2 ± 0.3	
		2.52	0.3 ± 0.2	
		3.13	0.7 ± 0.3	
		3.36	2.3 ± 0.3	
		3.72	1.4 ± 0.5	
		3.84	15.8 ± 1.4	
		4.12	3.9 ± 0.2	
		4.36	0.5 ± 0.4	
6.31	$3^+; 0$	0	4.0 ± 0.7	$\Gamma_\gamma = 0.17 \pm 0.04$ eV [c]
		0.94	10.6 ± 1.0	
		1.70	3.0 ± 0.8	
		2.52	4.0 ± 0.5	
		3.06	57 ± 3	$\delta = -(0.03 \pm 0.10)$
		3.72	1.4 ± 0.7	
		3.84	4.6 ± 1.0	
		4.12	2.4 ± 1.7	
		4.96	13.0 ± 1.5	$\delta = -(0.01 \pm 0.14)$
6.39	$2^+; 0+1$	0	1.5 ± 0.5	$\Gamma_\gamma = 0.44 \pm 0.18$ eV [c]
		0.94	75 ± 3	$\delta = -(0.25 \pm 0.10)$
		1.70	6.8 ± 1.7	
		3.84	14.1 ± 1.6	$\delta = 0.1 \pm 0.2$
		4.12	2.3 ± 0.5	
6.48	$3^+; 0$	0	13 ± 2	$\Gamma_\gamma = 74 \pm 21$ meV [c]
		0.94	33 ± 2	
		1.12	10 ± 2	
		1.70	4 ± 2	
		2.52	4 ± 2	

Table 18.14: Radiative decays in ^{18}F [a] (continued)

E_i (MeV)	$J_\mathrm{i}^\pi; T$	E_f (MeV)	Branch (%)	
		3.06	21 ± 3	
		3.79	4 ± 2	
		3.84	9 ± 2	
		4.96	2 ± 2	
6.57	$5^+; 0$	0.94	15.2 ± 1.6	
		3.36	83 ± 3	$\Gamma_\gamma = 26 \pm 5$ meV [c,d]
		5.30	2.3 ± 0.6	
6.64	$2^-; 1$	0.94	8.9 ± 0.6	$\Gamma_\gamma = 1.4 \pm 0.4$ eV [c]
		2.10	58 ± 3	
		3.13	22.0 ± 1.3	
		3.72	0.9 ± 0.2	
		3.79	2.4 ± 0.2	
		4.12	1.0 ± 0.3	
		4.86	2.6 ± 0.2	
		5.50	4.0 ± 0.3	
6.78	$4^+; 0$	0.94	12.6 ± 0.9	$\Gamma_\gamma = 0.31 \pm 0.08$ eV [c]
				$\delta = -(0.35 \pm 0.18)$
		1.12	25.2 ± 1.3	$\delta = -(1.4 \pm 1.1)$
		4.65	62 ± 2	$\delta = 0.13 \pm 0.13$
6.80	$1^+, 2, 3^+; (0)$	0	20 ± 2	
		0.94	20 ± 2	
		3.06	50 ± 3	
		3.84	3.0 ± 1.6	
		4.96	7.0 ± 1.7	
6.88	$3, 4^-; 0$	2.10	9 ± 2	
		4.65	91 ± 2	
7.34	$1^-; 1$	0	4 ± 0.5	
		1.08	54 ± 2	
		2.10	18 ± 1	
		3.06	1 ± 0.5	
		3.13	8 ± 0.5	

Table 18.14: Radiative decays in ^{18}F ^{a} (continued)

E_i (MeV)	$J_i^\pi; T$	E_f (MeV)	Branch (%)	
		4.23	15 ± 0.6	
7.48	(2)	0.94	100	
7.52		0.94	5 ± 4	
		2.10	7 ± 5	
		3.79	33 ± 5	
		4.40	55 ± 7	
7.53	2^-	0	10 ± 3	
		0.94	14 ± 6	
		2.10	50 ± 9	
		3.79	26 ± 7	
7.59		0	18 ± 7	
		0.94	14 ± 12	
		1.12	9 ± 7	
		4.65	59 ± 16	

^{a} For earlier references see Tables 18.11 in (1978AJ03) and 18.12 in (1983AJ01). See these tables also for upper limits for transitions to other states.

^{b} (1982FR15): see reactions 6 and 23.

^{c} Γ_γ = total radiative width for this state.

^{d} $\Gamma_\alpha = \Gamma \approx 560$ eV, $\Gamma_p < 4.5$ eV.

For fusion studies see (1982DE30, 1987PA12). For references to earlier work and for additional comments see (1978AJ03, 1983AJ01). See also (1980KR1F), (1984MU1D; theor.) and ^{12}C in (1985AJ01), ^{14}N in (1986AJ01) and ^{16}O in (1986AJ04).

4. ^{12}C(^{9}Be, t)^{18}F $\qquad\qquad Q_m = -4.4754$

Angular distributions are reported at $E(^9$Be$) = 12$ to 27 MeV to ^{18}F$_{g.s.}$ and to the unresolved states at 1 MeV: see (1983AJ01). For excitation functions see (1982HU06, 1983JA09).

5. ^{12}C(^{11}B, αn)^{18}F $\qquad\qquad Q_m = -2.7015$

Table 18.15: Lifetime measurements of some ^{18}F states

^{18}F* (MeV)	J^π; T	τ_m	Refs.
0.94	3^+; 0	67.6 ± 2.5 psec	mean [a]
1.04	0^+; 1	2.7 ± 0.4 fsec	[b]
		$\underline{2.2 \pm 0.6}$ fsec	(1983CA21)
		2.55 ± 0.45 fsec	see (1983CA21) [c]
1.08	0^-; 0	27.5 ± 1.9 psec	mean [a]
1.12	5^+; 0	234 ± 10 nsec	mean [b]
1.70	1^+; 0	0.971 ± 0.30 psec	(1982BA40)
		$\underline{0.897 \pm 0.057}$ psec	(1983MO16) [d]
		0.955 ± 0.027 psec	mean
2.10	2^-; 0	5.12 ± 0.56 psec	(1982BA40)
		$\underline{4.93 \pm 0.78}$ psec	(1983MO16)
		5.06 ± 0.46 psec	mean
2.52	2^+; 0	0.605 ± 0.029 psec	(1982BA40)
		$\underline{0.554 \pm 0.045}$ psec	(1983MO16)
		0.590 ± 0.024 psec	mean
3.06	2^+; 1	< 1.2 fsec	(1982BA40) [a,e]
3.13	1^-; 0	0.403 ± 0.018 psec	(1982BA40)
		$\underline{0.343 \pm 0.022}$ psec	(1983MO16)
		0.39 ± 0.02 psec [A]	
3.36	3^+; 0	0.435 ± 0.041 psec	(1982BA40)
		$\underline{0.451 \pm 0.034}$ psec	(1983MO16)
		0.44 ± 0.03 psec [A]	
3.72	1^+; 0	4 ± 2 fsec	(1973RO04)
		$2.7^{+4.1}_{-2.7}$ fsec [A]	(1982BA40) [e]
3.79	3^-; 0	1.91 ± 0.17 psec	(1982BA40)
		$\underline{1.90 \pm 0.20}$ psec	(1983MO16)
		1.91 ± 0.13 psec	mean
3.84	2^+; 0	17.4 ± 3.6 fsec	(1982BA40)
		$\underline{21 \pm 4}$ fsec	(1983MO16)
		19.0 ± 2.7 fsec	mean
4.12	3^+; 0	91 ± 22 fsec	(1973RO06)

Table 18.15: Lifetime measurements of some ^{18}F states (continued)

^{18}F* (MeV)	$J^\pi; T$	τ_m	Refs.
4.23	$2^-; 0$	110 ± 15 fsec	(1973RO06)
4.36	$1^+; 0$	27 ± 10 fsec	(1973RO06)
4.40	$4^-; 0$	58 ± 12 fsec	(1973RO06)
4.65	$4^+; 1$	< 10 fsec	(1973RO06)
4.85	$5^-; 0$	5.2 ± 0.9 psec	(1982KO24)
4.86	$1^-; 0$	66 ± 18 fsec	(1973RO06)
4.96	$2^+; 1$	< 4 fsec	(1973RO06)
5.30	$4^+; 0$	30 ± 5 fsec	(1973RO05)
5.50	$3^{(-)}; 0$	63 ± 25 fsec	(1973RO06)
5.79	$2^-; 0$	15 ± 10 fsec	(1973RO06)

A = adopted.
[a] See Table 18.12 in (1978AJ03).
[b] See Table 18.13 in (1983AJ01).
[c] See also (1985KE1C).
[d] See also (1982MO09).
[e] See also (1983MO16).

$\tau_m = 5.2 \pm 0.9$ psec for ^{18}F*(4.85) [$5^-; T = 0$]. The E1 strength is $(3.4 \pm 0.6) \times 10^{-6}$ W.u. for the transition to ^{18}F*(1.12) [$5^+; T = 0$] and the E2 strength is 14.8 ± 2.6 W.u. for that to ^{18}F*(3.79) [$3^-; 0$]. The latter strength, which is that of a highly collective transition, corresponds to a quadrupole moment $Q_0 = 395 \pm 35$ mb and suggests that ^{18}F*(4.85) is the 5^- state of a (strongly decoupled) $K^\pi = 1^-$ band (1982KO24). See also Tables 18.14 and 18.15.

6. ^{14}N$(\alpha, \gamma)^{18}$F $Q_m = 4.4152$

The non-resonant S-factor for this reaction, $S \approx 0.7$ MeV $\cdot$ b: see (1978AJ03). A number of resonances have been observed for $E_\alpha < 3$ MeV: see Table 18.16. Studies of these, principally by the Toronto and Queen's groups [see references in (1978AJ03, 1983AJ01)] in conjunction with work on ^{14}N(α, α), ^{16}O$(^3$He, p), ^{17}O(p, γ) and ^{17}O(p, α) [see Tables 18.18, 18.19, 18.20] have led to the determination of branching ratios, mixing ratios and widths (Table 18.14), lifetimes (Table 18.15) and the E_x, J^π and K^π assignments for ^{18}F states with $E_x < 6.9$ MeV. The reader is referred to the series of papers by the Toronto group for the most complete and definitive arguments on the parameters of the low-lying states of ^{18}F.

Table 18.16: Resonances in $^{14}\text{N} + \alpha$ below $E_\alpha = 5$ MeV [a]

E_α (MeV $\pm$ keV)	Particles out	$\Gamma_{\text{c.m.}}$ (keV)	$(2J+1)\Gamma_\gamma\Gamma_\alpha/\Gamma$ (eV)	$J^\pi; T$	E_{x} (MeV)
			$< 2 \times 10^{-5}$		4.657
0.559	γ		$(2.8 \pm 0.5) \times 10^{-4}$	$1; 0$	4.850
0.698			$< 0.5 \times 10^{-4}$	$2^+; 1$	4.958
1.136 ± 3	γ		0.084 ± 0.004	$4^+; 0$	5.299
1.398 ± 3	γ		0.022 ± 0.003	$3^{(-)}; 0$	5.502
1.527	γ, α_0		1.44 ± 0.14	1^+	5.603 [e]
1.529 ± 2	γ, α_0	< 1.2	2.60 ± 0.21	$1^-; 0+1$	5.604 [f]
1.618 ± 2	γ, α_0	< 0.8	1.4 ± 0.2 [b]	$1^-; 0+1$	5.673 [g]
1.765 ± 4	γ		0.047 ± 0.018	$2^-; 0$	5.788
2.160 ± 4	γ		0.20 ± 0.04	$4^-; 0$	6.095
2.166 ± 7	γ, α_0		0.08 ± 0.03	$1, 2, 3^{(-)}; 0$	6.100
			c		
2.348 ± 3	γ, α_0	< 0.8		$3^-; 0+1$	6.241 [h]
2.372 ± 3	γ, α_0	< 3		$1^+; (0)$	6.260 [i]
			d		
2.438 ± 4	γ		0.52 ± 0.12	$3^+; 0$	6.311
2.532 ± 4	γ		1.6 ± 0.4	$2^+; 0+1$	6.384
	γ		0.16 ± 0.06	$3^+; (0)$	6.480
2.767 ± 4	γ, α_0	(< 0.8)	0.29 ± 0.06	$5^+; 0$	6.567
2.870 ± 4	γ, p_0	< 1.6	2.7 ± 0.5	$2^-; 1$	6.647
2.870 ± 6	α_0	93 ± 5	$\Gamma_\alpha/\Gamma = 0.85$	1^-	6.647
			0.12 ± 0.07	$4^+; 0$	6.78
			< 0.2	$1^+, 2, 3^+; (0)$	6.803
3.080 ± 6	p_0, α_0	101 ± 5		2^-	6.810
3.576 ± 4	α_0	< 4		(4^+)	7.196
3.67	α_0	45 ± 10		(1^+)	7.27
3.72	p_0, α_0	53 ± 6		(3^-)	7.31
4.00	p_0, α_0	35		(3^-)	7.53
4.05	p_0, α_0	60			7.57
4.11	p_0, α_0	40			7.61

Table 18.16: Resonances in ^{14}N $+ \alpha$ below $E_\alpha = 5$ MeV [a] (continued)

E_α (MeV $\pm$ keV)	Particles out	$\Gamma_{\text{c.m.}}$ (keV)	$(2J+1)\Gamma_\gamma\Gamma_\alpha/\Gamma$ (eV)	$J^\pi; T$	E_x (MeV)
4.28	p_0, α_0	120			7.74
4.50	p_0, α_0	30		(2^-)	7.92
4.55	p_0, α_0	70		(1^+)	7.95

[a] References are displayed in Tables 18.13 of (1972AJ02, 1978AJ03). Higher resonances observed in ^{14}N(α, α_1) are listed in Table 18.14 of (1978AJ03).

[b] $\omega\gamma = 0.45 \pm 0.02$ (1982BE29).

[c] ≤ 0.07 for ^{18}F*(6.11, 6.16) (1973RO03).

[d] ≤ 0.03 for ^{18}F*(6.28) (1973RO03).

[e] $\Gamma_\alpha = 42.8 \pm 1.6$ eV, $\Gamma_\gamma = 0.485 \pm 0.046$ eV, $l_\alpha = 0$ (1980MA26). See also Table 18.19.

[f] $\Gamma_\alpha = 32.0 \pm 2.1$ eV, $\Gamma_\gamma = 0.891 \pm 0.074$ eV, $l_\alpha = 1$. ΔE_x for ^{18}F*(5.603, 5.605) is 1.84 ± 0.04 keV (1980MA26). See also Table 18.19.

[g] $\Gamma_\alpha = 130 \pm 5$ eV, $\Gamma_\gamma = 1.4 \pm 0.3$ eV, $l_\alpha = 1$ (1980MA26).

[h] This resonance corresponds to two states at $E_x = 6240$ and 6242 keV. The lower member of the doublet (both of which have $J^\pi = 3^-$ and mixed isospin) has $\Gamma_\alpha = 133 \pm 4$ eV, $\Gamma_\gamma = 0.80 \pm 0.11$ eV; the higher has $\Gamma_\alpha = 137 \pm 4$ eV, $\Gamma_\gamma = 0.73 \pm 0.11$ eV (1979KI12).

[i] $\Gamma_\alpha = 580 \pm 12$ eV, $\Gamma_p = 25^{+35}_{-25}$ eV (1979KI12).

No evidence is seen for the excitation of the (forbidden) state at $E_x = 4.753$ MeV [$J^\pi = 0^+$; $T = 1$] (1981LE1A, 1983LE08). See also (1985GO27; applications) and (1982BA1D, 1985AR1A, 1985KL1A, 1985MA1A, 1986HE1C, 1987GOZX; astrophysics).

7. ^{14}N$(\alpha, p)^{17}$O $\qquad\qquad Q_m = -1.1914 \qquad\qquad E_b = 4.4152$

Observed resonances are displayed in Table 18.16. See also ^{17}O in (1986AJ04).

8. (a) ^{14}N$(\alpha, \alpha)^{14}$N $\qquad\qquad\qquad\qquad\qquad\qquad\qquad E_b = 4.4152$

(b) ^{14}N$(\alpha, 2\alpha)^{10}$B $\qquad\qquad Q_m = -11.6123$

(c) ^{14}N$(\alpha, ^6$Li$)^{12}$C $\qquad\qquad Q_m = -8.7972$

Observed anomalies in the elastic scattering [reaction (a)] are exhibited in Table 18.16. Resonances in the α_1 isospin-forbidden yield are displayed in Table 18.14 of (1978AJ03). In the α_1 study, carried out for $E_\alpha = 7.6 \to 16.9$ MeV, a partial-wave analysis involving a method of removing ambiguities and parametrizing S-matrix elements gives the level parameters of 151 isospin

mixed, natural-parity states in ^{18}F with $10.4 < E_x < 17.5$ MeV. Many of these states have also been reported in the ^{16}O(d, α_1) reaction [Table 18.16 of (1978AJ03)]. The argeement is best for low-lying 2^+ or 4^+ states, and is quite good for 3^- and 5^- states, while for high-J states the greater centrifugal barrier for ^{16}O + d at the same E_x relatively suppresses high-J states in the ^{16}O + d work. A study of the energy dependence of averaged intensities of the partial waves shows some indication that the lower partial waves reconserve isospin as E_x increases.

The total cross sections for formation of ^{10}B and ^{6}Li have been studied for $E_\alpha = 21$ to 42 MeV [see (1978AJ03)], as has the cross section for production of 1.64 and 2.31 MeV γ-rays from threshold to $E_\alpha = 26$ MeV [(1985DY05)]: see for astrophysical implications.] See also (1984RE14, 1986CO11) and (1986ALZZ; theor.).

9. (a) ^{14}N(^{6}Li, d)^{18}F $Q_m = 2.940$
   (b) ^{14}N(^{6}Li, dα)^{14}N $Q_m = -1.4751$

At $E(^6\text{Li}) = 36$ MeV angular distributions have been measured for the deuteron groups to ^{18}F*(5.34 [4^+], 6.56 [5^+], 9.58, 11.2, 14.1). Angular correlations lead to $J^\pi = 6^+$ and 8^+ for ^{18}F*(9.58, 14.1) and the data are consistent with $J^\pi = 7^+$ for ^{18}F*(11.2) (1983ET02). For the earlier work see (1978AJ03).

10. ^{14}N(^{7}Li, t)^{18}F $Q_m = 1.947$

At $E(^7\text{Li}) = 36$ MeV the $K^\pi = 1^+$ band appears to be selectively populated. States at $E_x = 9.58 \pm 0.02$, 11.22 ± 0.03 and 14.18 ± 0.04 MeV are stongly populated. It is suggested that the first two are the 6^+ and 7^+ members of that band: see reaction 8. [Angular distributions are reported for ^{18}F*(1.70, 2.10, 2.52, 3.36, 4.40, 5.30, 6.57, 9.58, 11.22, 14.18).] See (1978AJ03) for the earlier work, and (1986NE1A; $E(^{14}\text{N}) = 150$ MeV). See also (1986CO11; theor.).

11. (a) ^{14}N(^{11}B, ^{7}Li)^{18}F $Q_m = -4.249$
    (b) ^{14}N(^{13}C, ^{9}Be)^{18}F $Q_m = -6.2324$

These reactions have been studied at $E(^{11}\text{B}) = 115$ MeV and $E(^{13}\text{C}) = 105$ MeV. Differential cross sections at three angles are reported for the transitions to ^{18}F*(9.58, 10.57 ± 0.07, 11.2) in reaction (a) and to ^{18}F*(5.30, 6.57, 9.58, 10.60 ± 0.08, 11.2) in reaction (b). In addition to these states ^{18}F*(14.18) is strongly excited in both reactions, and transitions to ^{18}F*(15.79 ± 0.10, 18.62 ± 0.12) are also reported: see (1983AJ01).

12. (a) ^{15}N(^{3}He, γ)^{18}F $\qquad\qquad Q_m = 14.1596$

(b) ^{15}N(^{3}He, α)^{14}N $\qquad\qquad Q_m = 9.7445 \qquad\qquad\qquad\qquad E_b = 14.1596$

Excitation functions have been measured for $E(^3\text{He}) = 2.5$ to 16 MeV for the γ_0 and $\gamma_{1\to4}$ yields. Resonances are observed corresponding to $E_x = (19.00 \pm 0.15)$ [$\gamma_{1\to4}$], 20.1 ± 0.2 [γ_0, $\gamma_{1\to4}$], 22.7 ± 0.2 [γ_0, $\gamma_{1\to4}$] and (24.1 ± 0.2) MeV [$\gamma_{1\to4}$], with $\Gamma_{\text{c.m.}} = 0.5 \pm 0.15$, 1.6 ± 0.1, 1.2 ± 0.1 and 1.4 ± 0.3 MeV, respectively. The γ_0 yield is dominated by ^{18}F*(20.1) (1983WA05) [see for $(2J + 1)\Gamma_{^3\text{He}}\Gamma_\gamma$ values]. It is suggested that the structures decaying by γ_0 have $J^\pi = 2^-$ (and possibly $T = 1$) (1983WA05). For analyzing power measurements at $E(^3\vec{\text{He}}) = 33$ MeV see (1986DR03).

13. ^{15}N(^{6}Li, t)^{18}F $\qquad\qquad\qquad Q_m = -1.636$

At $E(^6\text{Li}) = 30$ MeV preferential excitation of odd-parity states of ^{18}F below $E_x = 5$ MeV is reported. Angular distributions of the tritons to ^{18}F*(0, 0.94, 2.10, 4.40) [$J^\pi = 1^+, 3^+, 2^-, 4^-$] are all strongly forward peaked: see (1978AJ03).

14. (a) ^{15}N(^{11}B, ^{8}Li)^{18}F $\qquad\qquad Q_m = -13.049$

(b) ^{15}N(^{12}C, ^{9}Be)^{18}F $\qquad\qquad Q_m = -12.1194$

These reactions have been studied with $E(^{11}\text{B}) = E(^{12}\text{C}) = 115$ MeV. Reaction (a) is dominated by the transitions to ^{18}F*(1.12) [presumably the $J^\pi = 5^+$ state, although the group is unresolved] and to ^{18}F*(7.15, 9.45) [$J^\pi = (7^-)$ and (6^-)]. In reaction (b) no single state is strongly preferentially populated. Differential cross sections for ^{18}F*(4.40, 6.10, 7.15, 9.45) [$J^\pi = 4^-$, (5^-), (7^-), (6^-)], are fitted by FRDWBA: see (1983AJ01).

15. ^{16}O(d, γ)^{18}F $\qquad\qquad\qquad Q_m = 7.5256$

The capture cross section rises from 0.1 μb at $E_d = 0.4$ MeV to 25 μb at 3.5 MeV: Γ_γ over this range is ≈ 2 eV: see (1972AJ02).

16. (a) ^{16}O(d, n)^{17}F $\qquad\qquad\qquad Q_m = -1.6241 \qquad\qquad\qquad E_b = 7.5256$

(b) ^{16}O(d, p)^{17}O $\qquad\qquad\qquad Q_m = 1.9191$

Excitation functions and polarization studies have been carried out to $E_d = 17$ MeV [see (1978AJ03, 1983AJ01)] and at $E_d \approx 5.6$ to 8.3 MeV (1985GR1B; p$_0$, p$_3$, p$_4$). Structures attributed to states in ^{18}F are displyed in Table 18.17. See also ^{17}O and ^{17}F in (1986AJ04), (1985JOZZ, 1986SE1B) and (1983DA31; applications).

Table 18.17: Maxima in the yields of ^{16}O + d [a]

E_d (MeV $\pm$ keV)	Particles out	$\Gamma_{\text{c.m.}}$ (keV)	$J^\pi; T$	E_x (MeV)
0.895	p_1, α_0	210 ± 25		(8.320)
1.048	p_1, d_0, α_0	88 ± 10	1^+	8.456
1.199	α_0	230 ± 30		(8.590)
1.298	p_1, d_0, α_0	13 ± 3		(8.678)
1.325	d_0, α_0			(8.702)
1.482	α_0	40 ± 5		(8.842)
1.563	d_0, α_0	121 ± 15		(8.914)
1.616	α_0	19 ± 15		(8.961)
1.765	d_0, α_0	141 ± 10		(9.093)
1.885	p_0, p_1, d_0, α_0	108 ± 12	$3, 4^-; 0$	9.200
2.22	n_0, α_0		$2, 3^+; 0$	9.50
2.28	α_0		$2, 3^+; 0$	(9.55)
2.34	n_0, p_1			(9.60)
2.55	p_1			(9.79)
2.92	n, p_0, p_1			10.12
3.05	α_0		$3, 4^-; 0$	10.24
3.13	$n, p_1, \alpha_0, \alpha_1$		$\geq 2; 0$	10.31
3.37	n_0, p_0, p_1, α_1			10.52
3.47	α_0		$4, 5^+; 0$	10.61
3.68	n, p_0, p_1, α_1		2^+	10.79
3.80	p_0, α_0		$\geq 2^+; 0$	10.90
3.94	n, p_1, α_1			11.03
3.95	p_1, α_0	≈ 35	$3, 4^-; 0$	11.03
4.07	n, p_1			11.14
4.38	p_1, α_0		$4, 5^+; 0$	11.42
4.57	α_0		$5, 6^-; 0$	11.58
4.80	d_0, α_0		$\geq 3; 0$	11.79
4.93	α_0		$5, 6^-; 0$	11.90
5.05 ± 15	α_4	40		12.01
5.11	$\alpha_0, \alpha_2, \alpha_4$	60	$4, 5^+; 0$	12.06
5.17	α_0	55	$T = 0$	12.12

Table 18.17: Maxima in the yields of ^{16}O + d ^{a} (continued)

E_d (MeV $\pm$ keV)	Particles out	$\Gamma_{c.m.}$ (keV)	J^π; T	E_x (MeV)
5.32	α_0	70		12.25
5.34	α_0, α_2	170		12.27
5.40	α_0, α_4	130		12.32
5.47	α_4	80		12.38
5.49	$\alpha_2, \alpha_3, \alpha_4$	120		12.40
5.59	α_0, α_2	120		12.49
5.65	α_0, α_2	140		12.54
5.77	α_0	180	2^+	12.65
5.80	$\alpha_0, \alpha_2, \alpha_4$	160		12.68
5.81	α_3, α_4	80	5^-	12.69
5.91	α_2	160		12.77
6.00	α_0	120		12.85
6.11	α_0, α_4	120		12.95
6.19	α_2, α_3	200	$\geq 4; 0$	13.02
6.25	α_0, α_4	150	$T = 0$	13.08
6.30	α_0, α_2	160		13.12
6.34	α_0, α_3	160	$5, 6^-; 0$	13.16
6.38	α_0, α_3	145	$T = 0$	13.19
6.43	α_0, α_2	120		13.24
6.46	α_0, α_4	100		13.26
6.54	α_0, α_2	135		13.33
6.61	$\alpha_2, \alpha_3, \alpha_4$	120		13.40
6.64	α_0, α_2	200		13.42
6.66	α_0	100		13.44
6.72	α_2	100		13.79
6.73	α_2	100		13.50
6.80	α_2, α_3	140		13.56
6.84	$\alpha_0, \alpha_2, \alpha_4$	150		13.60
6.94	α_0, α_3	90		13.69
7.10	α_3, α_4	60	$4^-, 5^+$	13.83
7.27	α_3	150		13.98

Table 18.17: Maxima in the yields of $^{16}O + d$ [a] (continued)

E_d (MeV $\pm$ keV)	Particles out	$\Gamma_{\text{c.m.}}$ (keV)	$J^\pi; T$	E_x (MeV)
7.31	α_2	60	$4^-, 5^+$	14.18
7.34	$\alpha_0, \alpha_3, \alpha_4$	200		14.04
7.38	α_0, α_3	210		14.08
7.41	α_3	60	$4^-, 5^+$	14.02
7.49	α_0	220		14.18
7.58	α_0	200	$\geq 4; 0$	14.26
7.62	α_4	85		14.29
7.66	$\alpha_0, \alpha_2, \alpha_4$	130	$T = 0$	14.33
7.67	$\alpha_0, \alpha_2, \alpha_3, \alpha_4$	250	$T = 0$	14.34
7.74	α_3	200	$3^+. 4^-$	14.40
7.80	α_0, α_4	70		14.45
7.82	α_0, α_2	225		14.47
7.99	α_4	200		14.62
8.02	α_0	150		14.65
8.03	α_3	310		14.66
8.07	α_0	120		14.69
8.08	α_3, α_4	310		14.70
8.21	α_2	250		14.82
8.25	α_4	380		14.85
8.30	$\alpha_0, \alpha_2, \alpha_3$	210		14.90
8.34	α_4	115		14.93
8.37	α_0	130		14.96
8.37	α_0, α_3	250		14.96
8.40	α_0	310		14.99
8.43	α_4	120		15.01
8.52	α_3, α_4	160	$4^-, 5^+$	15.09
8.52	α_2	150		15.09
8.56	α_2	220		15.13
8.58	α_4	180		15.15
8.61	α_0, α_3	200		15.17
8.65	α_0, α_2	135		15.21

Table 18.17: Maxima in the yields of ^{16}O + d [a] (continued)

E_d (MeV $\pm$ keV)	Particles out	$\Gamma_{c.m.}$ (keV)	$J^\pi; T$	E_x (MeV)
8.72	α_2, α_4	120		15.27
8.76	α_2	160		15.30
8.79	α_0	200		15.33
8.80	$\alpha_0, \alpha_3, \alpha_4$	200	$5^+, 6^-$	15.34
8.89	α_3	110		15.42
8.93	α_3, α_4	190		15.46
8.97	α_2, α_4	210		15.49
9.00	α_0, α_2	190		15.52
9.62	α_3	220	$4^-, 5^+$	16.07
10.35	α_3	60	$4^-, 5^+$	16.72
11.15	α_3	70	$4^-, 5^+, 6^-$	17.43

[a] For references see Table 18.15 in (1978AJ03). This table does not include the structures in α_1 leading to mixed isospin states in ^{18}F: for the latter see Table 18.16 in (1978AJ03).

17. ^{16}O(d, d)^{16}O $\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad E_b = 7.5256$

The yield of elastically scattered deuterons and elastic polarization measurements have been reported for $E_d = 0.65$ to 56 MeV: see (1978AJ03, 1983AJ01). More recent measurements are those by (1985GR1B) [excitation functions for $E_d \approx 5.6$ to 8.3 MeV] and the polarization studies at $E_{\vec{d}} = 20.5$ MeV (1984FR14; TAP), 56 MeV (1986MA32; VAP, TAP) and 200, 400 and 700 MeV (1987NG01; VAP, TAP). See also (1982AO06, 1983AO03, 1986NG1B, 1986YA1R, 1987MA09; theor.) and ^{16}O in (1986AJ04).

18. ^{16}O(d, α)^{14}N $\qquad\qquad\qquad Q_m = 3.1104 \qquad\qquad\qquad\qquad E_b = 7.5256$
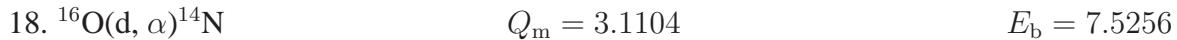
The yields of various groups of α-particles have been measured for $E_d \leq 20$ MeV: see (1978AJ03, 1983AJ01). The yield curves have been fitted in terms of a large number of states in ^{18}F: see Tables 18.17 here, and 18.16 in (1978AJ03).

A detailed study by (1973JO13) of the isospin-forbidden α_1 yield, analyzed by S-matrix theory, identifies a large number of isospin mixed states in ^{18}F, possibly as many as 138 with $9.2 < E_x < 19.4$ MeV. The reaction mechanism appears to be almost entirely compound nuclear. The isospin

impurity, averaged over 1 MeV intervals, is $3-10\%$ for the above E_x range. The average coherence width increases from ≈ 100 keV at $E_\mathrm{x} = 14$ MeV to ≈ 500 keV at $E_\mathrm{x} = 20$ MeV. The level densities appear to be consistent with predictions of the Fermi-gas model (1973JO13). See also (1985JOZZ). [For mixed isospin states observed in ^{14}N(α, α_1) see Table 18.14 in (1978AJ03).] Polarization measurements are reported for $E_\mathrm{d} = 6.8$ to 16 MeV: see (1978AJ03, 1983AJ01).

19. ^{16}O(d, ^{6}Li)^{12}C $\qquad\qquad Q_\mathrm{m} = -5.6868$ $\qquad\qquad\qquad E_\mathrm{b} = 7.5256$
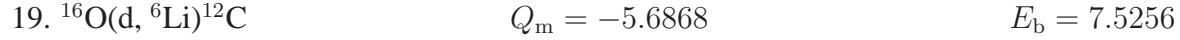
Polarization measurements for the transitions to ^{12}C*(0, 4.4) are reported at $E_{\vec{\mathrm{d}}} = 18$ and 22 MeV (1987TA07; VAP, TAP) and 51.7 MeV (1986YA12; VAP; also to ^{12}C*(14.1)).

20. ^{16}O(t, n)^{18}F $\qquad\qquad Q_\mathrm{m} = 1.2690$

See (1987BO16; applied) and (1983AJ01).

21. ^{16}O(^{3}He, p)^{18}F $\qquad\qquad Q_\mathrm{m} = 0.321$

Excitation energies derived from measurements of γ-rays are displayed in Table 18.18 together with l-assignments obtained from distorted-wave analyses, and J^π; T and K^π assignments from branching ratios, radiative widths, linear polarization, γ-ray angular distributions and τ_m measurements [see also Tables 18.14 and 18.15]. Studies of this reaction, together with the work on ^{14}N(α, γ) and ^{17}O(p, γ), have defined the low-lying states of ^{18}F.

The g-factor of ^{18}F*(0.94) [$J^\pi = 3^+$] is $+(0.56 \pm 0.05)$: see (1983AJ01). The circular polarization of the 1.08 MeV $\to$ g.s. γ-ray, $P_\gamma = (-10 \pm 18) \times 10^{-4}$ (1982AH07), $(2.7 \pm 5.7) \times 10^{-4}$ (1985BI03), $(1.6 \pm 5.6) \times 10^{-4}$ (1985EV03), $(1.7 \pm 5.8) \times 10^{-4}$ (1987PA07). The weak pion-nucleon coupling constant deduced from the weighted average of all recent P_γ measurements $[(1.2 \pm 3.9) \times 10^{-4}]$ is $(0.3^{+1.0}_{-0.3}) \times 10^{-7}$. Together with PNC matrix elements in other experiments this suggests that the isovector weak NN interaction may be strongly suppressed compared with the isoscalar weak NN interaction (1985EV03, 1987PA07). For a measurement of the ICC of the 0.94, 1.02, 1.04 and 1.08 MeV γ-rays see (1986KR04). See also (1978AJ03, 1983AJ01), (1984BE1A; applications), (1987ER05; theor.) and ^{19}Ne.

22. ^{16}O(α, d)^{18}F $\qquad\qquad Q_\mathrm{m} = -16.3211$

Table 18.18: States in ^{18}F from ^{16}O(^{3}He, pγ)^{18}F [a]

E_x (keV) [b]	l [a]	$J^\pi; T$ [c]	K^π [c]
0	0	$1^+; 0$	0^+
937.1 ± 0.4	2	$3^+; 0$	0^+
1040.9 ± 0.5	0	$0^+; 1$	
1080.1 ± 0.5		$0^-; 0$	0^-
1119.0 ± 0.6	4	$5^+; 0$	0^+
1701.4 ± 0.7	0	$1^+; 0$	1^+
2099.9 ± 0.6		$2^-; 0$	0^-
2523.4 ± 0.7	2	$2^+; 0$	1^+
3061.2 ± 0.5	2	$2^+; 1$	
3132.8 ± 0.6		$1^-; 0$	1^-
3358.2 ± 1.0		$3^+; 0$	1^+
3725.4 ± 0.8		$1^+; 0$	
3790.6 ± 0.9		$3^-; 0$	1^-
3838.4 ± 0.7	2	$2^+; 0$	
4114.5 ± 0.9		$3^+; 0$	
4225.8 ± 0.7		$2^{(-)}; 0$	(1^-)
4361.0 ± 0.7		$1^{(+)}$	
4398.1 ± 0.7		$3^-, 4^-; 0$ [d]	(0^-)
4652 ± 2	4	$4^+; 1$	
4753 ± 3		$(0^+; 1)$	
4860 ± 2		$1^{(-)}; 0$	
4963.6 ± 0.8		$2^+; 1$	
5297.6 ± 1.5		4^+	1^+
5502 ± 2		$3^{(-)}; 0$	
5603 ± 2		$1^-; 0+1$	
5669 ± 2		$1^-; 0+1$	
5785 ± 3		$2^-; 0$	
6097.4 ± 1.4		$4^-; 0$	1^-
6108 ± 3		$1, 2, 3^{(-)}; 0$	
6138.3 ± 1.0		$0^+; 1$	
6164.0 ± 1.0		$3^+; 1$	

Table 18.18: States in ^{18}F from ^{16}O(^{3}He, pγ)^{18}F ^{a} (continued)

E_x (keV) ^{b}	l ^{a}	$J^\pi; T$ ^{c}	K^{π} ^{c}
6241.2 ± 1.0		$3^-; 1$	
6263 ± 3		1^+	
6284.0 ± 1.0		$2^+; 0+1$	
6310.5 ± 0.8		$3^+; 0$	
6383 ± 3		$2^+; 0+1$	
6480 ± 2		$3^+; (0)$	
6567.0 ± 1.5		5^+	1^+
6643.0 ± 1.5		$2^-; 1$	
6777 ± 2 ^{c}		4^+	
6803.0 ± 1.5		$1^+, 2, 3^+; (0)$	
6878 ± 2 ^{c}		$3^{(-)}, 4^-; (0)$	

^{a} For earlier results derived from measurements of proton spectra and of γ-rays, see Table 18.18 in (1972AJ02). See also Tables 18.14 and 18.15 here.

^{b} (1973RO03): γ-ray measurements.

^{c} See Table 18.17 in (1978AJ03).

^{d} See p. 179 of (1979KI12).

Angular distributions of the deuteron groups to ^{18}F*(1.12) [$J^\pi = 5^+$] have been studied at $E_\alpha = 28.0$ to 33.6 MeV: see (1983AJ01). At $E_\alpha = 65.3$ MeV a number of angular distributions are reported to ^{18}F states with $E_x \leq 11.4$ MeV: ^{18}F*(9.49, 10.54) are suggested to have $J^\pi = 6^-$ and 7^+ respectively (1986KA36). See, however, reactions 9 and 10.

23. ^{16}O(^{6}Li, α)^{18}F $Q_m = 6.050$

Angular distributions have been measured at $E(^6$Li$) = 5.5$ to 34 MeV [see (1983AJ01)] and at $E(^6$Li$) = 48$ MeV (1984CO05; α_0, α_1, α_4). (1982FR15) report the excitation of a state at $E_x = 4848.3 \pm 0.5$ keV which decays (35 ± 4)% to ^{18}F*(3.79) [$E_\gamma = 1056.8 \pm 0.4$ keV] and (65 ± 4)% to ^{18}F*(1.12). Alpha-γ angular correlations are consistent with $J^\pi = 5^-$, and $T = 0$ (1982FR15). See also (1986GL02) and (1986IC01; theor.).

24. (a) ^{16}O(^{11}B, ^{9}Be)^{18}F $Q_m = -8.290$

    (b) ^{16}O(^{13}C, ^{11}B)^{18}F $Q_m = -11.153$

    (c) ^{16}O(^{14}N, ^{12}C)^{18}F $Q_m = -2.7468$

Table 18.19: Excited states of ^{18}F from ^{17}O(p, γ)^{18}F [a]

E_x (keV)	E_x (keV)
937.18 ± 0.06	3724.19 ± 0.22
1041.55 ± 0.08	3791.49 ± 0.22
1080.54 ± 0.12	3839.17 ± 0.22
1121.36 ± 0.15	4115.90 ± 0.25
1700.81 ± 0.18	4360.15 ± 0.26
2100.61 ± 0.10	5603.38 ± 0.27
2523.35 ± 0.18	5604.86 ± 0.28
3061.84 ± 0.18	5668 ± 2
3133.87 ± 0.15	6136.47 ± 0.33

[a] See also Table 18.20 here, and Table 18.17 in (1983AJ01).

See (1983AJ01).

25. ^{17}O(p, γ)^{18}F $\qquad\qquad\qquad Q_m = 5.6065$
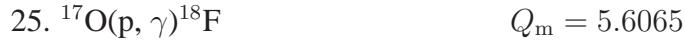
Gamma-ray measurements lead to the very accurate E_x determinations for ^{18}F states below 6.2 MeV: see Table 18.19. Observed resonances are displayed in Table 18.20; branching ratios, radiative widths and multipole mixing ratios are shown in Table 18.14; and τ_m in Table 18.15.

The direct capture cross section has been studied for $E_p = 0.3$ to 1.9 MeV: ^{18}F*(5.603, 5.605, 5.668, 5.786) have $J^\pi = 1^+$, 1^-, 1^- and 2^-. The 1^- states have mixed isospin. For astrophysical considerations see (1978AJ03, 1983AJ01) and (1982RO1A).

26. ^{17}O(p, n)^{17}F $\qquad\qquad Q_m = -3.5432 \qquad\qquad E_b = 5.6065$
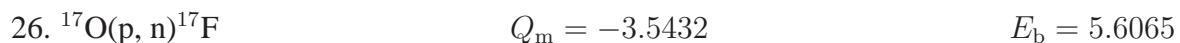
Observed resonances are displayed in Table 18.20. Analyzing power measurements are reported at $E_{\vec{p}} = 135$ MeV (1983PUZZ; n$_0$).

27. ^{17}O(p, p)^{17}O $\qquad\qquad\qquad\qquad\qquad\qquad E_b = 5.6065$

Table 18.20: Resonances in $^{17}O + p$ [a]

E_p (keV)	Yield of	$\Gamma_{c.m.}$ (keV)	$(2J+1)\Gamma_\gamma\Gamma_p/\Gamma$ (eV)	$J^\pi; T$	E_x (MeV $\pm$ keV)
517.0 ± 1.0	γ, α_0	0.24 ± 0.03	0.26 ± 0.05	$4^-; 0$	6.095
525	α_0	0.034 ± 0.003		(1^+)	6.102
561.2 ± 1.0	γ	≤ 1	2.2 ± 0.6	$0^+; 1$	6.136
587.1 ± 1.0	γ, p_0, α_0	14 ± 0.5	6.7 ± 1.8	$3^+; 1$	6.161
670.5 ± 1.0	γ, p_0, α_0	0.19 ± 0.03	(c)	$3^-; 0+1$	6.239
673.0	γ, α_0	0.18 ± 0.04	(c)	$3^-; 0+1$	6.242
690 ± 4	α_0	0.60 ± 0.12	≤ 0.02	$1^+; 0$	6.258
714.2 ± 1.0	γ, p_0, α_0	10.0 ± 0.5	9.1 ± 2.3	$2^+; 1$	6.281
741 ± 2	γ, p_0, α_0	0.95 ± 0.14	0.64 ± 0.17	$3^+; 0$	6.306
826 ± 2	γ, α_0	0.40 ± 0.09	0.60 ± 0.18	$2^+; 0+1$	6.386
926 ± 2	γ, α_0	0.40 ± 0.10	0.36 ± 0.15	$3^+; 0$	6.481
1015	α_0	0.56 ± 0.13	≤ 0.0023	$5^+; 0$	6.565
1090	α_0	80 ± 2		1	6.635
1098.9 ± 0.4	γ, α	0.60 ± 0.07	4.3 ± 1.2	$2^-; 1$	6.6439
1101 ± 4	α_0	89 ± 5			6.646
1240 ± 2 [b]	γ, p_0, α_0	9.2 ± 1.0	2.8 ± 0.7	$4^+; 0$	6.777
1270	γ, p_0	≤ 2	0.54 ± 0.20	$1^+, 2, 3^+; 0$	6.8031 ± 1.5
1274 ± 5	α_0	88 ± 2		2^-	6.809
1276	α_0	3.0 ± 0.5		(2^+)	6.811
1338	α_0	5.0 ± 1.0		(3^-)	6.870
1345 ± 3	γ, α_0	≤ 2	1.0 ± 0.4	$3, 4^-; 0$	6.876
1687.5 ± 1	α_0	6.5	3.9	$(4^+); 0$	7.199
1738 ± 2	α_0	46.5	8.8	$(1^+); 0$	7.247
1784 ± 2	p_0, α_0	38	47	3^-	7.291
1810 ± 4	α_0	52	8.5	$(3^-; 0)$	7.315
1832.5 ± 1	γ, p_0, p_1	16 ± 2	[d]	$1^-; 1$	7.336
1906 ± 2	p_0, p_1	14.6 ± 1.4		1^+	7.406
1950 ± 10	α_0	140	5.6		7.447
1957 ± 2	p_0	6		1^-	7.454
1983 ± 2	γ, p_1, α_0	12 ± 3	1.5	(2)	7.478
(1990 ± 2)	p_0	32		(1^-)	(7.485)
2012 ± 2	p_0, α_0	12 ± 2	7.2	4^-	7.506
2020 ± 2	γ	< 4			7.513

Table 18.20: Resonances in ^{17}O + p ^{a} (continued)

E_p (keV)	Yield of	$\Gamma_{c.m.}$ (keV)	$(2J+1)\Gamma_\gamma\Gamma_p/\Gamma$ (eV)	$J^\pi; T$	E_x (MeV $\pm$ keV)
2036 ± 2	$\gamma, p_0, p_1, \alpha_0$	16.5 ± 3.0	5.5 ^{e}	$2^-; 1$	7.528
2040 ± 5	p_1, α_0	75			7.532
2064 ± 2	p_0	30		(1^-)	7.555
2095 ± 2	$\gamma, p_0, p_1, \alpha_0$	9 ± 2	3.7 ^{f}	^{g}	7.584
2202 ± 2	p_0, p_1, α_0	36 ± 4	25.1	$3^+, 4^+$ ^{g}	7.685
2248 ± 4	p_1, α_0	66 ± 5	28.2	≥ 1	7.729
2284 ± 4	p_1	70			7.763
2406 ± 3	p_1, α_0	20	24.4	≥ 2	7.878
2429 ± 2	α_0	38	42	(2^-)	7.899
2473 ± 12	α_0	112	80	(1^+)	7.941
2603 ± 6	p_1, α_0	60	11	≥ 4	8.064
2657 ± 2	p_1	96			8.115
2757 ± 8	p_0, α_0	52	63	2^-	8.209
2788 ± 2	p_0	20		4^+	8.238
2928	α_0	≈ 50			8.370
3915 ± 20	n	95			9.302
(4163 ± 20)	n	19			(9.536)
4235 ± 10	n	33			9.604
4330 ± 10	n	33			9.694
4490 ± 20	n	≈ 100			9.845
(4790 ± 10)	n	28			(10.128)
4900 ± 20	n	≈ 140			10.232

^{a} For references see Tables 18.18 in (1978AJ03, 1983AJ01).

^{b} See footnote ^{d} in Table 18.18 (1978AJ03).

^{c} This corresponds to a doublet of 3^-, mixed isospin states, separated by 2.09 ± 0.04 keV. $\omega\gamma_{p,\gamma} = 2.04 \pm 0.45$ eV for the lower resonance and 1.16 ± 0.26 eV for the higher one.

^{d} $\Gamma_\gamma = 3.5 \pm 1.0$ eV.

^{e} $\Gamma_\gamma = 0.44 \pm 0.10$ eV.

^{f} $\Gamma_\gamma = 0.11 \pm 0.03$ eV.

^{g} Assumed to be unresolved.

The elastic scattering has been studied for $E_p = 0.5$ to 13 MeV [see (1978AJ03, 1983AJ01)]: observed anomalies are displayed in Table 18.20. Analyzing powers have been measured at $E_{\vec{p}} = 89.7$ MeV (1985VO12; p_0).

28. ^{17}O(p, t)^{15}O $\qquad\qquad Q_m = -11.3257 \qquad\qquad E_b = 5.6065$
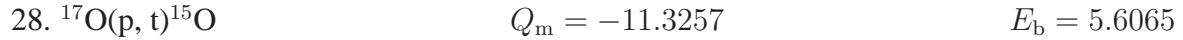
Analyzing powers have been reported at $E_{\vec{p}} = 89.7$ MeV for the triton groups to a number of ^{15}O states (1985VO12).

29. ^{17}O(p, α)^{14}N $\qquad\qquad Q_m = 1.1914 \qquad\qquad E_b = 5.6065$
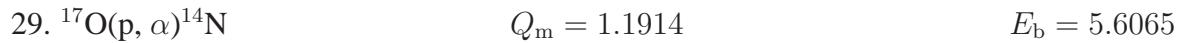
The yield of α_0 shows a number of resonances for $E_p = 0.49$ to 3.0 MeV: see Table 18.20. The R-matrix fit of (1979KI13), obtained from data from $E_p = 400$ to 1400 keV, confirms the earlier result [see, e.g., reaction 31 in (1978AJ03)] that a significant quantity of ^{17}O is burned up in the (p, γ) rather than in the (p, α) reaction for a wide range of stellar temperatures (1979KI13). See also (1982RO1A, 1987RO25) and (1986BA89; theor.).

30. ^{17}O(^{3}He, d)^{18}F $\qquad\qquad Q_m = 0.1130$

At $E(^3$He$) = 15$ MeV DWBA analysis of angular distributions of deuteron groups corresponding to states of ^{18}F with $E_x < 5$ MeV have led to J^π values and spectroscopic information: see (1972AJ02). See also (1987ER05; theor.).

31. ^{17}O(^{12}C, ^{11}B)^{18}F $\qquad\qquad Q_m = -10.351$

See (1983AJ01).

32. ^{18}O(π^+, π^0)^{18}F $\qquad\qquad Q_m = 2.949$

See (1983AS01, 1984AS05).

33. ^{18}O(p, n)^{18}F $\qquad\qquad Q_m = -2.4387$
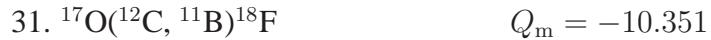
(1983AN05) have studied the distribution of Gamow-Teller (GT) strength. At $E_p = 135$ MeV angular distributions have been studied to the 0^+ state at 1.04 MeV and to the 1^+ states ^{18}F*(0, 1.70, 3.72, 4.36, 6.26) as well as to possible 1^+; $T = 1$ groups at $E_x = 9.9$ 10.9 and 11.9 MeV. 82% of the observed strength lies in the ground state group and 5.5% in the ($T = 1$) states. The observed GT strength is $\approx \frac{2}{3}$ of that expected from the simple sum rule (1983AN05). See also (1985TAZY), (1985WA24), (1986MA1P, 1987HI1B; applied) and the earlier work in (1978AJ03).

Table 18.21: Branching in ^{18}Ne$(\beta^+)^{18}$F [a]

Decay to ^{18}F* (MeV)	$J^\pi; T$	E_{γ_0} (keV)	Branch (%) [b]	$\log f_0 t$ [c]
0	$1^+; 0$		92.11 ± 0.21	3.096 ± 0.004
1.04 [d]	$0^+; 1$	1041.5 ± 0.3	7.70 ± 0.21	3.473 ± 0.013
1.08 [d]	$0^-; 0$	1080.76 ± 0.13 [b]	$(2.07 \pm 0.28) \times 10^{-3}$	7.012 ± 0.059
1.70	$1^+; 0$	1699.9 ± 0.3 [e]	0.188 ± 0.006	4.477 ± 0.015

[a] For the earlier work see Tables 18.19 in (1983AJ01) and 18.20 in (1978AJ03).

[b] (1983AD03). See also (1982HE04).

[c] Based on $\tau_{1/2} = 1672 \pm 8$ msec: see (1983AD03).

[d] The splitting of the 0^+ and 0^- states is 39.20 ± 0.11 keV (1983AD03).

[e] And 659.2 ± 0.3 keV for the γ-ray to ^{18}F*(1.04) (1982HE04).
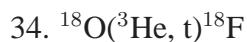
34. ^{18}O$(^3$He, t)^{18}F $Q_m = -1.675$

At $E(^3$He$) = 16$ MeV, the triton spectrum is dominated by strong groups to ^{18}F*(0, 0.94) and to the 0^+ and 2^+, $T = 1$ states ^{18}F*(1.04, 3.06). Angular distributions have been studied to these and many other states at this energy and at $E(^3$He$) = 17.3$ MeV. At $E(^3\vec{\text{He}}) = 33$ MeV A_y measurements for t_0 have been reported. See (1983AJ01) for references.

35. ^{18}O$(^6$Li, ^{6}He)^{18}F $Q_m = -5.162$

See (1978AJ03).

36. ^{18}Ne$(\beta^+)^{18}$F $Q_m = 4.446$

The half-life of ^{18}Ne is 1672 ± 8 msec [see ^{18}Ne]. The decay is to ^{18}F*(0, 1.04, 1.08, 1.70): see Table 18.21.

37. ^{19}F$(\gamma,$ n)^{18}F $Q_m = -10.4320$

Cross sections have been reported to 30 MeV for the transitions to ^{18}F*(0.94, 1.04, 1.08, 3.06, 3.13, 4.75): see (1983AJ01).

38. ^{19}F(p, d)^{18}F $\qquad\qquad\qquad\qquad$ $Q_m = -8.2074$

Angular distributions have been reported to many states of ^{18}F with $E_x \overset{<}{\sim} 6$ MeV: see Table 18.20 in (1983AJ01). See also (1986VAZV [$E_p = 18.6$ MeV; d$_0$, d$_2$]), (1983BEYY) and (1981CL05, 1983KI13; theor.).

39. ^{19}F(d, t)^{18}F $\qquad\qquad\qquad\qquad$ $Q_m = -4.1747$

See (1972AJ02, 1978AJ03).

40. ^{19}F(^{3}He, α)^{18}F $\qquad\qquad\qquad\qquad$ $Q_m = 10.1458$

See (1978AJ03).

41. ^{20}Ne(p, ^{3}He)^{18}F $\qquad\qquad\qquad\qquad$ $Q_m = -15.562$

See (1978AJ03).

42. ^{20}Ne(d, α)^{18}F $\qquad\qquad\qquad\qquad$ $Q_m = 2.7915$

At $E_d = 11$ MeV α-groups are observed to many states of ^{18}F with $E_x < 7$ MeV. Weak or absent (each $\leq 0.3\%$ of the total yield at $30°$) are the groups corresponding to ^{18}F*(1.04, 3.06, 4.66, 4.74, 4.96): $T = 1$. Measurements of the TAP for $E_{\vec{d}} = 10.25$ to 12.0 MeV leads to assignments of 2^-, 1^+, 0^+, 1^-, 1^+, 3^+, 3^+ to ^{18}F*(4.23, 4.36, 4.75, 4.86, 5.603, 6.16, 6.48). See (1972AJ02, 1978AJ03, 1983AJ01) for references and for other results and (1987HI1B; applications).

43. ^{21}Ne(p, α)^{18}F $\qquad\qquad\qquad\qquad$ $Q_m = -1.744$

See (1987GOZX).

44. ^{23}Na(d, ^{7}Li)^{18}F $\qquad\qquad\qquad\qquad$ $Q_m = -12.176$

See (1984NE1A).

^{18}Ne
(Figs. 3 and 4)

GENERAL: (See also (1983AJ01).)

Model calculations: (1982ZH01, 1983BR29, 1984SA37, 1985RO1G).

Special states: (1982ZH01, 1983BI1C, 1983BR29, 1984SA37, 1985RO1G, 1986AN10, 1986AN07).

Electromagnetic transitions: (1982BR24, 1982RI04, 1983BR29, 1985AL21, 1986AN10).

Astrophysical questions: (1982WI1B, 1987WI11).

Complex reactions involving ^{18}*Ne:* (1986HA1B).

Pion capture and reactions (See also reaction 4.): (1982AS1B, 1983HO02, 1983JO06, 1983LI08, 1983LI1U, 1983OS1E, 1984JO01, 1984KA26, 1985GM01, 1986BA1C, 1986FO06, 1986GE06).

Other topics: (1983BI1C, 1983BR29, 1983BR1E, 1985AL21, 1985AN28, 1986ST15).

Ground state of ^{18}*Ne:* (1983ANZQ, 1985AN28).

For B(E2) of ^{18}Ne*(1.89) and other parameters see (1987RA01) and Table 2 in the Introduction here.

1. ^{18}Ne$(\beta^+)^{18}$F $\qquad\qquad Q_m = 4.446$

The half-life of ^{18}Ne is 1672 ± 8 msec: see (1978AJ03) and (1983AD03). The decay is primarily to ^{18}F*(0, 1.04, 1.70). In addition there is an extremely weak branch $[(2.07 \pm 0.28) \times 10^{-3}\%]$ to ^{18}F*(1.08) $[J^\pi = 0^-; T = 0]$ (1983AD03): see Table 18.21 for the parameters of the decay. The parity mixing in the ^{18}F*(1.04, 1.08) $0^+ - 0^-$ doublet has been studied by (1983AD03). See also (1982HE04). For the earlier work see, in particular, (1981AD01, 1981HA06). See also (1983AD1C, 1983AD1B, 1983AD1D, 1984AD1E, 1985AD1A, 1985BR29) and (1984HA58, 1986BR1X, 1986HA1Q, 1986TO1D, 1987KI03; theor.).

2. ^{16}O(^{3}He, n)^{18}Ne $\qquad\qquad Q_m = -3.196$

See Table 18.24. See also (1983AJ01).

3. ^{16}O(^{10}B, ^{8}Li)^{18}Ne $\qquad\qquad Q_m = -18.951$
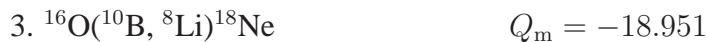
Table 18.22: Energy levels of ^{18}Ne [a]

$E_{\rm x}$ (MeV $\pm$ keV)	J^π; T	τ or $\Gamma_{\rm c.m.}$ (keV)	Decay	Reactions
0	0^+; 1	$\tau_{1/2} = 1672 \pm 8$ msec	β^+	1, 2, 4, 5
1.8873 ± 0.2	2^+	$\tau_{\rm m} = 0.67 \pm 0.06$ psec	γ	2, 4, 5
3.3762 ± 0.4	4^+	4.4 ± 0.6 psec	γ	2, 3, 5
3.5763 ± 2.0	0^+	4 ± 2 psec	γ	2, 5
3.6164 ± 0.6	2^+	63^{+30}_{-20} fsec	γ	2, 5
4.519 ± 8	1^-	$\Gamma \leq 20$	(p)	2, 5
4.590 ± 8	0^+	≤ 20	(p)	2, 5
5.090 ± 8	$(2^+, 3^-)$	40 ± 20	(p)	2, 5
5.146 ± 7	$(2^+, 3^-)$	25 ± 15		2, 5
5.453 ± 10		≤ 50		5
6.297 ± 10	(4^+)	≤ 60		2, 5
6.353 ± 10		≤ 60		5
7.059 ± 10	$(1^-, 2^+)$	180 ± 50		2
7.713 ± 10		≤ 50		2, 5
7.910 ± 10	$(1^-, 2^+)$	≤ 50		2
7.950 ± 10		≤ 60		5
8.086 ± 10		≤ 50		2
8.500 ± 30		≤ 120		2
9.201 ± 9		≤ 50		5

[a] See also Table 18.23.

At $E(^{10}$B$) = 100$ MeV the angular distribution to ^{18}Ne*(3.38) $[(d_{5/2})^2_{4+}$ state] which is preferentially populated has been studied. ^{18}Ne*(1.89) is also observed. See (1983AJ01). See also (1983OS07; theor.).

4. ^{18}O$(\pi^+, \pi^-)^{18}$Ne $\qquad\qquad\qquad Q_{\rm m} = -6.101$

Angular distributions have been studied at $E_{\pi^+} = 164$ and 292 MeV [see (1983AJ01)] and at 48.3 MeV (1985AL15; to ^{18}Ne$_{\rm g.s.}$) and 100 to 292 MeV (1985SE08; to ^{18}Ne$_{\rm g.s.}$). The excitation functions for production of ^{18}Ne*(0, 1.89) have been measured for $E_{\pi^+} = 80$ to 292 MeV: see (1983AJ01, 1985SE08). See also (1984BA1B, 1985GIZX, 1986ANZY), (1985GI01; theor.) and the "General" section here.

Table 18.23: Branching ratios and lifetimes of ^{18}Ne states [a]

E_i (MeV)	J_i^π	E_f (MeV)	Branch (%)	τ_m (psec)
1.89	2^+	0	100	0.67 ± 0.06
3.38	4^+	1.89	100 [b]	4.4 ± 0.6
3.58	0^+	1.89	100 [c]	4 ± 2
3.62	2^+	0	9 ± 2	
		1.89	91 ± 2 [d]	$0.063^{+0.030}_{-0.020}$

[a] For references see Table 18.24 in (1978AJ03).

[b] Ground state decay is $< 1\%$.

[c] Ground state decay is $< 5\%$.

[d] The mixing ratio, δ, is consistent with 0.

5. ^{20}Ne(p, t)^{18}Ne $Q_m = -20.026$

Observed triton groups are displayed in Table 18.24 as are J^π derived from DWBA analysis of angular distributions: The 0_3^+ state, identified at $E_x = 4.59$ MeV, appears to have largely $s_{1/2}^2$ configuration based on its large downward shift with respect to the analog state in ^{18}O (1981NE09).

^{18}Na
(not observed)

^{18}Na has not been observed; its atomic mass excess has been estimated to be 25.32 MeV; it is then unbound with respect to proton emission by 1.6 MeV: see (1978AJ03). See also (1986AN07) and (1983ANZQ; theor.).

^{18}Mg, etc.
(not observed)

See (1986AN07) and (1983ANZQ; theor.).

Table 18.24: States in ^{18}Ne from ^{16}O(^{3}He, n) and ^{20}Ne(p, t) [a]

E_x (MeV ± keV)		$\Gamma_{c.m.}$ (keV) [b]	J^π [a,b]
A	B		
0			0^+
1.8873 ± 0.2	1.886 ± 10		2^+
3.3762 ± 0.4	3.375 ± 10		4^+
3.5763 ± 2.0	3.580 ± 10		0^+
3.6164 ± 0.6	3.612 ± 10		2^+
4.513 ± 13	4.522 ± 10	≤ 20	1^-
4.587 ± 13	4.592 ± 10	≤ 20	0^+
5.075 ± 13	5.099 ± 10	40 ± 20	$(2^+, 3^-)$
5.141 ± 10	5.151 ± 10	25 ± 15	$(2^+, 3^-)$
	5.453 ± 10	≤ 50	
6.291 ± 30 [c]	6.297 ± 10	≤ 60	(4^+)
	6.353 ± 10	≤ 60	
7.062 ± 12 [a]		180 ± 50	$(1^-, 2^+)$
7.712 ± 20	7.713 ± 10	≤ 50	
7.915 ± 12 [a]		≤ 50	$(1^-, 2^+)$
	7.949 ± 10	≤ 60	
8.100 ± 14 [a]		≤ 50	
8.50 ± 30		≤ 120	
	9.198 ± 10	≤ 50	

A: ^{16}O(^{3}He, n)^{18}Ne: for references see Table 18.23 (1978AJ03) and (1981NE09).

B: ^{20}Ne(p, t)^{18}Ne: (1981NE09).

[a] See also Table 18.23 in (1978AJ03).

[b] (1981NE09).

[c] $\Gamma = 180 \pm 60$ keV.

References

(Closed 01 June 1987)

1972AJ02   F. Ajzenberg-Selove, Nucl. Phys. A190 (1972) 1

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

1973OL02   J.W. Olness, E.K. Warburton and J.A. Becker, Phys. Rev. C7 (1973) 2239

1973RO03   C. Rolfs, A.M. Charlesworth and R.E. Azuma, Nucl. Phys. A199 (1973) 257

1973RO04   C. Rolfs, W.E. Kieser, R.E. Azuma and A.E. Litherland, Nucl. Phys. A199 (1973) 274

1973RO05   C. Rolfs, H.P. Trautvetter, R.E. Azuma and A.E. Litherland, Nucl. Phys. A199 (1973) 289

1973RO06   C. Rolfs, I. Berka and R.E. Azuma, Nucl. Phys. A199 (1973) 306

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

1974ES02   J.L. Escudie, R. Lombard, M. Pignanelli, F. Resmini and A. Tarrats, Phys. Rev. C10 (1974) 1645; Erratum Phys. Rev. C11 (1975) 639

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

1976LA13   R.D. Lawson, F.J.D. Serduke and H.T. Fortune, Phys. Rev. C14 (1976) 1245

1978AJ03   F. Ajzenberg-Selove, Nucl. Phys. A300 (1978) 1

1978FO29   H.T. Fortune, L.R. Medsker and J.N. Bishop, Nucl. Phys. A309 (1978) 221

1978WI1B   B.H. Wildenthal, Nukelonika 23 (1978) 459

1979FE06   M.P. Fewell, A.M. Baxter, D.C. Kean, R.H. Spear and T.H. Zabel, Nucl. Phys. A321 (1979) 457

1979KI12   W.E. Kieser, R.E. Azuma, I. Berka, K.P. Jackson, A.B. McDonald, H.B. Mak, and W. McLatchie, Nucl. Phys. A327 (1979) 172

1979KI13   W.E. Kieser, R.E. Azuma and K.P. Jackson, Nucl. Phys. A331 (1979) 155

1979WO04   J.G. Woodworth, K.G. McNeill, J.W. Jury, R.A. Alvarez, B.L. Berman, D.D. Paul and P. Meyer, Phys. Rev. C19 (1979) 1667

1980KR1F   Kraus and Linck, Proc. Int. Conf. on Nucl. Phys., Berkeley (1980) 555

1980MA26   H.-B. Mak, G.T. Ewan, H.C. Evans, J.D. MacArthur, W. McLatchie and R.E. Azuma, Nucl. Phys. A343 (1980) 79

1980NA14   F. Naulin, C. Detraz, M. Bernas, D. Guillemaud, E. Kashy, M. Langevin, F. Pougheon, P. Roussel and M. Roy-Stephan, J. Phys. Lett. 41 (1980) L79

1981AD01   E.G. Adelberger, C.D. Hoyle, H.E. Swanson and R.D. von Lintig, Phys. Rev. Lett. 46 (1981) 695

1981CL05   C.F. Clement and S.M. Perez, J. Phys. (London) G7 (1981) L293

1981CO13   M.E. Cobern, L.C. Bland, H.T. Fortune, G.E. Moore, S. Mordechai and R. Middleton, Phys. Rev. C23 (1981) 2387

1981CU07   A. Cunsolo, A. Foti, G. Imme, G. Pappalardo, G. Raciti and N. Saunier, Phys. Rev. C24 (1981) 476

1981GL02   C.W. Glover and K.W. Kemper, Nucl. Phys. A366 (1981) 469

1981HA06   W.C. Haxton, Phys. Rev. Lett. 46 (1981) 698

1981IC02   A. Ichimura and M. Ichimura, Prog. Theor. Phys. 66 (1981) 913

1981LE1A   F. Leccia, P. Mennrath, A. Morales, J. Morales, R. Nunez-Lagos and M. Plo, An. Fis. A77 (1981) 114

1981ME13   M.C. Mermaz, J. Barrette and H.E. Wegner, Phys. Rev. C24 (1981) 2148

1981NAZQ   F. Naulin, C. Detraz, M. Roy-Stephan, M. Bernas, J. de Boer, D. Guillemaud, M. Langevin, F. Pougheon, P. Roussel, 4th Int. Conf. on Nucl. Far from Stability, Helsingon, Denmark (1981) 376; CERN Rept. 81-09 (1981)

1981NE09   A.V. Nero, E.G. Adelberger and F.S. Dietrich, Phys. Rev. C24 (1981) 1864

1981SEZR   K.K. Seth, 4th Int. Conf. on Nucl. Far from Stability, Helsingon, Denmark (1981) 655; CERN Rept. 81-09 (1981)

1981WA1Q   R.K. Wallace and S.E. Woosley, Astrophys. J. Suppl. 45 (1981) 389

1982AB04   M.S. Abdel-Wahab, L. Potvin, R. Roy, P. Bricault, R. Larue, D. Pouliot, C. Rioux and R.J. Slobodrian, Can. J. Phys. 60 (1982) 1595

1982AH07   G. Ahrens, W. Harfst, J.R. Kass, E.V. Mason, H. Schober, G. Steffens, H. Waeffler, P. Bock and K. Grotz, Nucl. Phys. A390 (1982) 486

1982AL30   Y. Alhassid, M. Gai and G.F. Bertsch, Phys. Rev. Lett. 49 (1982) 1482

1982AN12   M.S. ANTONY, J. Phys. G8 (1982) 1659

1982AO06   K. Aoki and H. Horiuchi, Prog. Theor. Phys. 68 (1982) 2028

1982AS1B   E. Aslanides, T. Bressani, M. Caria, E. Chiavassa, S. Costa, G. Dellacasa, P. Fassnacht, M. Gallio, F. Hibou, B. Minetti et al., Proc. Int. Conf. on Nucleus-Nucleus Collisions, 26 Sept.-1 Oct. 1982, East Lansing, MI, USA (1982) 2

1982AV1A   I.K. Averyanov, A.I. Golubev, A.A. Sadovoi, Yad. Fiz. 35 (1982) 833; Sov. J. Nucl. Phys. 35 (1982) 484

1982BA03   K. Bangert, U.E.P. Berg, G. Junghans, R. Stock and K. Wienhard, Nucl. Phys. A376 (1982) 15

1982BA06   G.C. Ball, T.K. Alexander, W.G. Davies, J.S. Forster and I.V. Mitchell, Nucl. Phys. A377 (1982) 268

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

1982BA40 G.C. Ball, T.K. Alexander, W.G. Davies, J.S. Forster, I.V. Mitchell, J. Keinonen and H. B. Mak, Nucl. Phys. A386 (1982) 333

1982BA49 Z. Basrak, R. Caplar, C. Beck, R.M. Freeman and F. Haas, Phys. Rev. C26 (1982) 1774

1982BA62 F.C. Barker, Aust. J. Phys. 35 (1982) 377

1982BE1Z J.J. Bevelacqua, Rev. Mex. Fis. 28 (1982) 573

1982BE29 H.W. Becker, W.E. Kieser, C. Rolfs, H.P. Trautvetter and M. Wiescher, Z. Phys. A305 (1982) 319

1982BI08 B.L. Birbrair and Yu.A. Kalashnikov, J. Phys. (London) G8 (1982) 1531

1982BR24 B.A. Brown, B.H. Wildenthal, W. Chung, S.E. Massen, M. Bernas, A.M. Bernstein, R. Miskimen, V.R. Brown and V. A.Madsen, Phys. Rev. C26 (1982) 2247

1982BU1A Burbidge and Burbidge, Essays in Nucl. Astrophys. (1982) 11

1982CA12 E. Caurier and A. Poves, Nucl. Phys. A385 (1982) 407

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

1982CI1C N. Cindro, Nukleonika 27 (1982) 137

1982CU01 A. Cunsolo, A. Foti, G. Imme, G. Pappalardo, G. Raciti and N. Saunier, Phys. Lett. B112 (1982) 121

1982DE30 L.C. Dennis, K.M. Abdo, A.D. Frawley and K.W. Kemper, Phys. Rev. C26 (1982) 981

1982FI10 L.K. Fifield, J.L. Durell, M.A.C. Hotchkis, J.R. Leigh, T.R. Ophel and D.C. Weisser, Nucl. Phys. A385 (1982) 505

1982FR15 R.M. Freeman, P.A. DeYoung, L.J. Satkowiak, M.A. Xapsos and J.J. Kolata, Nucl. Phys. A385 (1982) 516

1982GI1C R. Giordano, F. Porto, S. Sambataro and A. Scalia, in MSU (1982) 101

1982GL08 C. Glashausser, R. de Swiniarski, K. Jones, S. Nanda, F.T. Baker, M. Grimm, V. Penumetcha, A. Scott, G. Adams, G. Igo et al., Phys. Lett. B116 (1982) 215

1982HE04 A.M. Hernandez and W.W. Daehnick, Phys. Rev. C25 (1982) 2957

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

1982HU06 M. Hugi, J. Lang, R. Muller, J. Sromicki, E. Ungricht, K. Bodek, L. Jarczyk, B. Kamys, A. Strzalkowski and H. Witala, Phys. Rev. C25 (1982) 2403

1982KA1C K. Kakihara, Y. Kasida and T. Ido, Radioisotopes 31 (1982) 357

1982KO24 J.J. Kolata, E.G. Funk and J.D. Hinnefeld, Phys. Rev. C26 (1982) 1750

1982KU04   P.D. Kunz, J.S. Vaagen, J.M. Bang and B.S. Nilsson, Phys. Lett. B112 (1982) 5

1982LI15   B.J. Lieb, H.S. Plendl, C.E. Stronach, H.O. Funsten and V.G. Lind, Phys. Rev. C26 (1982) 2084

1982LI1M   B. Liu and H.-C. Chiang, Phys. Energ. Fortis Phys. Nucl. 6 (1982) 595

1982LI1N   B. Liu and H.-C. Chiang, Phys. Energ. Fortis Phys. Nucl. 6 (1982) 743

1982LO13   M. Lozano, J.I. Escudero and G. Madurga, J. Phys. (London) G8 (1982) 1259

1982MA1Q   B. Maurel, G. Amsel and J.P. Nadai, Nucl. Instrum. Meth. Phys. Res. 197 (1982) 1

1982MO09   R. Moro, A. Brondi, A. D'Onofrio, V. Roca, M. Romano, F. Terrasi and B. Delaunay, Lett. Nuovo Cim. 33 (1982) 407

1982MO1K   C.B.O. Mohr, Aust. J. Phys. 35 (1982) 1

1982NA13   S. Nanda and C. Glashausser, Phys. Rev. C26 (1982) 758

1982NO04   B.E. Norum, M.V. Hynes, H. Miska, W. Bertozzi, J. Kelly, S. Kowalski, F.N. Rad, C.P. Sargent, T. Sasanuma, W. Turchinetz et al., Phys. Rev. C25 (1982) 1778

1982OH05   S. Ohkubo, Phys. Rev. C25 (1982) 2498

1982OL01   J.W. Olness, E.K. Warburton, D.E. Alburger, C.J. Lister and D.J. Millener, Nucl. Phys. A373 (1982) 13

1982PI06   E. Piasetzky, A. Altman, J. Lichtenstadt, A.I. Yavin, D. Ashery, W. Bertl, L. Felawka, H.K. Walter, F.W. Schleputz, R.J. Powers et al., Phys. Rev. C26 (1982) 2702

1982PI1H   G. Pinto, Bull. Amer. Phys. Soc. 27 (1982) 792

1982RE14   K.E. Rehm, W. Henning, J.R. Erskine and D.G. Kovar, Phys. Rev. C26 (1982) 1010

1982RI04   L. Ricken, D. Bohle, G. Domogala, K. Glasner and E. Kuhlmann, Z. Phys. A306 (1982) 67

1982RO1A   Rodney and Rolfs, Essay in Nucl. Astrophys. (1982) 171

1982SA1Q   G.R. Satchler, Lecture Notes in Phys. 168 (1982) 25

1982VE02   J.J.M. Verbaarschot, G.A. Timmer and P.J. Brussaard, Nucl. Phys. A378 (1982) 280

1982VE13   J. Vernotte, G. Berrier-Ronsin, J. Kalifa and R. Tamisier, Nucl. Phys. A390 (1982) 285

1982WI1B   M. Wiescher and K.-U. Kettner, Astrophys. J. 263 (1982) 891

1982WO1A   Woosley and Weaver, Essays in Nucl. Astrophys. (1982) 377

1982YA1C   T. Yamada, Bull. Amer. Phys. Soc. 27 (1982) 813

1982ZH01   M.V. Zhukov, J.M.G. Gomez and J. Bang, Phys. Scr. 25 (1982) 522

1983AD03   E.G. Adelberger, M.M. Hindi, C.D. Doyle, H.E. Swanson, R.D. von Lintig and W.C. Haxton, Phys. Rev. C27 (1983) 2833

1983AD1B E.G. Adelberger, Proc. NATO Advanced Study Institute on Symmetries in Nuclear Structure, 16-28 Aug. 1982, Dronten, Netherlands; Eds., Abrahams, Allaart and Dieperink (1983) 55

1983AD1C E.G. Adelberger, Comments Nucl. Part. Phys. 11 (1983) 189

1983AD1D Adelberger, Proc. Int. Conf. on Nucl. Phys., August-Spet. 1983; Eds., P. Blasi and R.A. Ricci (1983) 499

1983AG1C Agalarov, Kerimov and Safin, in Moscow (1983) 494

1983AJ01 F. Ajzenberg-Selove, Nucl. Phys. A392 (1983) 1; Erratum Nucl. Phys. A413 (1984) 168

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

1983AM1C P. Amaudrez, Th.S. Bauer, J. Domingo, C.H.Q. Ingram, G. Kyle, D. Renker, G. Smith and R. Stamminger, SIN Newsl. 15 (1983) 48

1983AM1D G. Amsel and B. Maurel, Nucl. Instrum. Meth. Phys. Res. 218 (1983) 183

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)

1983AO03 K. Aoki and H. Horiuchi, Prog. Theor. Phys. (Kyoto) 69 (1983) 857

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

1983AR1J Arima et al., in Florence (1983) 207

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

1983BE1W A.M. Bernstein, V.R. Brown and V.A. Madsen, Comments Nucl. Part. Phys. 11 (1983) 1 or 203

1983BE36 D. Bender, A. Richter, E. Spamer, E.J. Ansaldo, C. Rangacharyulu and W. Knupfer, Nucl. Phys. A406 (1983) 504

1983BEYY R.B. Begzhanov, G.S. Valiev, I. Borbely, I.R. Gulamov, T. Iskhakov, A.M. Mukhamedzhanov, G.K. Ni, E.A. Romanovsky, A.V. Tsupin and R. Yarmukhamedov, in Moscow (1983) 282

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

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

1983BR1E Bromley, Proc. Int. Conf. on Nucl. Phys., Aug.-Sept. 1983, Florence; Eds., P. Blasi and R.A. Ricci; Vol. 2 (1983) 3

1983BR29 B.A. Brown and B.H. Wildenthal, Phys. Rev. C28 (1983) 2397

1983CA03   F.P. Calaprice and D.J. Millener, Phys. Rev. C27 (1983) 1175

1983CA1N   Carlin et al., in Florence (1983) 590

1983CA21   W.N. Catford, E.F. Garman, D.M. Pringle and L.K. Fifield, Nucl. Phys. A407 (1983) 255

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

1983CI08   O. Civitarese, B.V. Carlson, M.S. Hussein and A. Szanto de Toledo, Phys. Lett. B125 (1983) 22

1983CL1B   Clement et al., in Florence (1983) 126

1983CO1K   J.J. Cowan, A.G.W. Cameron and J.W. Truran, Astrophys. J. 265 (1983) 429

1983CU03   A. Cunsolo, A. Foti, G. Imme, G. Pappalardo, G. Raciti and N. Saunier, Lett. Nuovo Cim. 37 (1983)193

1983DA31   J.A. Davies, T.E. Jackman, H. Plattner and I. Bubb, Nucl. Instrum. Meth. Phys. Res. 218 (1983) 141

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

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

1983EN02   F. Entezami, J.D. Brown, K.S. Dhuga, O. Karban, J.M. Nelson and S. Roman, Nucl. Phys. A405 (1983) 69

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

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

1983GA02   M. Gai, M. Ruscev, A.C. Hayes, J.F. Ennis, R. Keddy, E.C. Schloemer, S.M. Sterbenz and D.A. Bromley, Phys. Rev. Lett. 50 (1983) 239

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

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

1983GR10   E.E. Gross, J.R. Beene, K.A. Erb, M.P. Fewell, D. Shapira, M.J. Rhoades-Brown, G.R. Satchler and C.E. Thorn, Nucl. Phys. A401 (1983) 362

1983GR11   A. Green, W. Stepien-Rudzka and S. Wycech, Nucl. Phys. A399 (1983) 307

1983GR1L   Grootes, Nature 303 (1983) 753

1983GR28   E.E. Gross and M.P. Fewell, Nucl. Phys. A411 (1983) 329

1983HO02   P. Hoodbhoy, R.A. Freedman, G.A. Miller and E.M. Henley, Phys. Rev. C27 (1983) 277

1983IS1F   Ishkhanov and Kapitonov, in Florence (1983) 203

1983JA05   U. Jahnke, G. Ingold, H. Homeyer, M. Burgel, Ch. Egelhaaf, H. Fuchs and D. Hilscher, Phys. Rev. Lett. 50 (1983) 1246

1983JA09   L. Jarczyk, B. Kamys, Z. Rudy, A. Strzalkowski, H. Witala, M. Hugi, J. Lang, R. Muller, J. Sromicki and H.H. Wolter. Phys. Rev. C28 (1983) 700

1983JO06   M.B. Johnson and E.R. Siciliano, Phys. Rev. C27 (1983) 1647

1983JO1C   M.B. Johnson and E.R. Siciliano, Phys. Rev. C27 (1983) 730

1983KA28   I.M. Kapitonov, Yad. Fiz. 38 (1983) 612; Sov. J. Nucl. Phys. 38 (1983) 364

1983KI13   M.M. King Yen, S.T. Hsieh and D.S. Chuu, J. Phys. G9 (1983) 1347

1983KI1D   J.S. Killingley, Nature 301 (1983) 594

1983KU1C   Kutschera, Radiocarbon 25 (1983) 677

1983LE03   P.M. Lewis, A.K. Basak, J.D. Brown, P.V. Drumm, O. Karban, E.C. Pollacco and S. Roman, Nucl. Phys. A395 (1983) 204

1983LE08   F. Leccia, Ph. Hubert, P. Mennrath, A. Morales, J. Morales, R. Nunez-Lagos and M. Plo, Nuovo Cim. A74 (1983) 28

1983LI08   L.C. Liu, Phys. Rev. C27 (1983) 1611

1983LI10   J.S. Lilley, B.R. Fulton, D. Banes, T.M. Cormier, I.J. Thompson, S. Landowne and H.H. Wolter, Phys. Lett. B128 (1983) 153

1983LI1T   C.-D. Lien, L. Wielunski and M.-A. Nicolet, Nucl. Instrum. Meth. Phys. Res. 213 (1983) 463

1983LI1U   X.-H. Liu and Y.-G. Li, Phys. Energ. Fortis Phys. Nucl. 7 (1983) 197

1983MA16   C.J. Martoff, J.A. Bistirlich, C.W. Clawson, K.M. Crowe, M. Koike, J.P. Miller, S.S. Rosenblum, W.A. Zajc, H.W. Baer, A.H. Wapstra et al., Phys. Rev. C27 (1983) 1621

1983MA1V   Mahalanabis and Sinha Rey, in Florence (1983) 406

1983MA29   N. Marquardt, Phys. Rev. C28 (1983) 202

1983MA35   F.J. Margetan and J.P. Vary, Phys. Rev. C28 (1983) 907

1983ME12   A.C. Merchant, J. Phys. G9 (1983) 1169

1983ME1H   Metsch, Klingenbeck and Huber, in Florence (1983) 378

1983MO16   R. Moro, A. Brondi, A. D'Onofrio, V. Roca, M. Romano, F. Terrasi, B. Delaunay and H. Dumont, Lett. Nuovo Cim. 38 (1983) 7

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

1983OS07   A. Osman and S.S. Abdel-Aziz, Acta Phys. Hung. 54 (1983) 9

1983OS1E   E. Oset, D. Strottman, M.J. Vicente-Vacas and W.-H. Ma, Nucl. Phys. A408 (1983) 461

1983PU01   G.D. Putt, L.K. Fifield, M.A.C. Hotchkis, T.R. Ophel and D.C. Weisser, Nucl. Phys. A399 (1983) 190

1983PUZZ   B. Pugh, W. Bertozzi, T.N. Buti, J.M. Finn, C. Hyde, J.J. Kelly, M.A. Kovash, B. Murdock, B.D. Anderson, A.R. Baldwin, A. Fazely, C. Lebo, R. Madey, J.W. Watson and C.C. Foster, Bull. Amer. Phys. Soc. 28 (1983) 690, DG6

1983RO07   R.M. Rockmore, Phys. Rev. C27 (1983) 2150

1983RU09   K. Rusek, Z. Moroz, R. Caplar, P. Egelhof, K.-H. Mobius, E. Steffens, I. Koenig, A. Weller and D. Fick, Nucl. Phys. A407 (1983) 208

1983SA06   M. Sato, M. Sasagase, Y. Nagashima, J. Schimizu, T. Nakagawa, Y. Fukuchi and T. Mikumo, Phys. Rev. C27 (1983) 2621

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

1983SH04   V. Shkolnik and Y.C. Tang, Nucl. Phys. A397 (1983) 132

1983SH32   J. Shurpin, T.T.S. Kuo and D. Strottman, Nucl. Phys. A408 (1983) 310

1983SH44   R.K. Sheline, Aust. J. Phys. 36 (1983) 825

1983SN03   K.A. Snover, E.G. Adelberger, P.G. Ikossi and B.A. Brown, Phys. Rev. C27 (1983) 1837

1983TA1P   D.S. Tannhauser, J.A. Kilner and B.C.H. Steele, Nucl. Instrum. Meth. Phys. Res. 218 (1983) 504

1983TO21   F.M. Toyama, Prog. Theor. Phys. 70 (1983) 1299

1983UE01   K. Ueta, H. Miyake and A. Mizukami, Phys. Rev. C27 (1983) 389

1983VA23   J. van der Plicht, H.C. Britt, M.M. Fowler, Z. Fraenkel, A. Gavron, J.B. Wilhelmy, F. Plasil, T.C. Awes and G.R. Young, Phys. Rev. C28 (1983) 2022

1983VO1A   G. Vourvopoulos, IEEE Trans. Nucl. Sci. 30 (1983) 1119

1983VO1B   G. Vourvopoulos et al., in Florence (1983) 639

1983WA05   C.E. Waltham, S.H. Chew, J. Lowe, J.M. Nelson and A.R. Barnett, Nucl. Phys. A395 (1983) 119

1983WA17   M. Waroquier, G. Wenes and K. Heyde, Nucl. Phys. A404 (1983) 298

1983WI12   D. Wintgen, H. Friedrich and K. Langanke, Nucl. Phys. A408 (1983) 239

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

1983ZE1C   B. Zeidman and D.F. Geesaman, Nucl. Phys. A396 (1983) 419

1984AB1A   Abe and Park, RIFP-508 (1984)

1984AD1E   E.G. Adelberger, AIP Conf. Proc. 123 (1984) 300

1984AL20   A. Altman, D. Ashery, E. Piasetzky, J. Lichtenstadt, A.I. Yavin, W. Bertl, L. Felawka, H.K. Walter, R.J. Powers, R.G. Winter et al., Phys. Lett. B144 (1984) 337

1984ANZW   G.S. Anagnostatos, H.S. Kosmas, S.E. Massen and C.N. Panos, Bull. Amer. Phys. Soc. 29 (1984) 1029, AC10

1984AS04   H.J. Assenbaum, K. Langanke and A. Weiguny, Z. Phys. A318 (1984) 35

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

1984BA1B   Bauer et al., 10th Int. Conf. on Paricles and Nuclei, 30 July-3 Aug. 1984, Heidelberg (1984) F21

1984BA24   F.C. Barker, Aust J. Phys. 37 (1984) 17

1984BA55   D. Baye and P. Descouvemont, Phys. Lett. B146 (1984) 285

1984BE1A   K. Bethge, Bull. Amer. Phys. Soc. 29 (1984) 1080

1984BH01   R.K. Bhowmik, W.D.M. Rae and B.R. Fulton, Phys. Lett. B136 (1984) 149

1984BI10   M. Bini, P.G. Bizzeti and P. Sona, Lett. Nuovo Cim. 41 (1984) 191

1984BL17   C.L. Blilie, D. Dehnhard, M.A. Franey, D.H. Gay, D.B. Holtkamp, S.J. Seestrom-Morris, P.J. Ellis, C.L. Morris and D.J. Millener, Phys. Rev. C30 (1984) 1989

1984BL1J   J.H. Black and P.L. Smith, Astrophys. J. 277 (1984) 562

1984BR1L   D.A. Bromley, Nuovo Cim. A81 (1984) 360

1984BR1P   H.P. Brall, R. Stademann, K. Langanke and A. Weiguny, Fizika 16 (1984) 7

1984BUZX   B.L. Burks, D.J. Horen, R.L. Auble, F.E. Bertrand, J.L. Blankenship, J.L.C. Ford, Jr., E.E. Gross, D.C. Hensley, R.O. Sayer, D. Shapira et al., Bull. Amer. Phys. Soc. 29 (1984) 1026, AB6

1984CH1V   W.H. Chung and J.H. Lee, New Phys. (Korea) 24 (1984) 267

1984CO05   J. Cook, L.C. Dennis, K.W. Kemper, T.R. Ophel, A.F. Zeller, C.F. Maguire and Z. Kui, Nucl. Phys. A415 (1984) 114

1984DE38   D.M. De Castro Rizzo, E. Bozek, S. Cavallaro, B. Delaunay, J. Delaunay, H. Dumont, M.G. Saint-Laurent and F. Terrasi, Nucl. Phys. A427 (1984) 151

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

1984FO15   H.T. Fortune, Phys. Rev. C30 (1984) 848

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

1984FR14   R. Frick, H. Clement, G. Graw, P. Schiemenz, N. Seichert and T.-H Sun, Z. Phys. A319 (1984) 133

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

1984GA1T   M. Gai, Proc. Int. Symp. on In-Beam Nucl. Spectrosc., 14-18 May 1984, Debrecen, Hungary (1984) 331

1984GE1A   D.F. Geesaman, AIP Conf. Proc. 123 (1984) 150

1984GI10   R. Gilman, H.T. Fortune, L.C. Bland, R.R. Kiziah, C.F. Moore, P.A. Seidl, C.L. Morris and W.B. Cottingame, Phys. Rev. C30 (1984) 962

1984GI11   W.R. Gibbs and W.B. Kaufmann, Phys. Lett. B145 (1984) 1

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

1984GR27   S.J. Greene, C.J. Harvey, P.A. Seidl, R. Gilman, E.R. Siciliano and M.B. Johnson, Phys. Rev. C30 (1984) 2003

1984HA14   P. Halse, J.P. Elliott and J.A. Evans, Nucl. Phys. A417 (1984) 301

1984HA1R   M.J. Harris and D.L. Lambert, Astrophys. J. 281 (1984) 739

1984HA1Z   M.J. Harris and D.L. Lambert, Astrophys. J. 285 (1984) 674

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

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

1984HA58   J.C. Hardy and I.S. Towner, J. Phys. (Paris) 45 (1984) C4-417

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

1984HI1D   R.D. Hichwa, Bull. Amer. Phys. Soc. 29 (1984) 1072

1984HO1H   B.R. Holstein, AIP Conf. Proc. 123 (1984) 1110

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

1984HU1C   Hupke et al., in Panic (1984) I50

1984JO01   M.B. Johnson, E.R. Siciliano, H. Toki and A. Wirzba, Phys. Rev. Lett. 52 (1984) 593

1984KA26   T. Karapiperis, M. Kobayashi and M. Hirata, Phys. Lett. B144 (1984) 23

1984KL06   H.V. Klapdor, J. Metzinger and T. Oda, At. Data Nucl. Data Tables 31 (1984) 81

1984LA01   K. Langanke, R. Stademann and D. Frekers, Phys. Rev. C29 (1984) 40

1984LA1J   W.D. Langer, T.E. Graedel, M.A. Frerking and P.B. Armentrout, Astrophys. J. 277 (1984) 581

1984LE1G   Lecolle, C. R. Acad. Sci. Ser. II-Mec. Phys. 298 (1984) 211

1984MI17   H. Miyake, A. Mizukami and K. Ueta, Nuovo Cim. A84 (1984) 225

1984MI1H   Millener, Drexel Univ. Symp., Unpublished (1984)

1984MO1N Motoba, Bando, Ikeda and Yamamoto, in Panic (1984) M8

1984MU1D D. Mukhopadhyay and G. Grawert, J. Phys. (Paris) 45 (1984) C6-435

1984MU27 J.A. Musser and J.D. Stevenson, Phys. Rev. Lett. 53 (1984) 847

1984NA1D S. Nagamiya, J. Randrup and T.J.M. Symons, Ann. Rev. Nucl. Part. Sci. 34 (1984) 155

1984NE1A Nemets, Rudchik and Chuvilski, in Alma Ata (1984) 334

1984NI1C   R.J. Nickles, Bull. Amer. Phys. Soc. 29 (1984) 1072

1984OE02   W. Oelert, G. Palla, B. Rubio, M.G. Betigeri, C. Mayer-Boricke, P. Turek and H.T. Fortune, Phys. Rev. C30 (1984) 1378

1984PH02   D.L. Pham and R. de Swiniarski, Nuovo Cim. A83 (1984) 294

1984PO1A Poth et al., 10th Int. Conf. on Particles and Nuclei, 30 July-3 Aug. 1984, Heidelberg (1984) L1

1984QU1A Quader and Erikson, Bull. Amer. Phys. Soc. 29 (1984) 630

1984RA07   W.D.M. Rae and R.K. Bhowmik, Nucl. Phys. A420 (1984) 320

1984RA17   W.D.M. Rae and R.K. Bhowmik, Nucl. Phys. A427 (1984) 142

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

1984RU1A Ruscev, Ph. D. Thesis, Yale Univ. (1984)

1984SA28   V.S. Sadkovsky, G.A. Feofilov, A.E. Denisov, R.P. Kolalis and L. Peres Tamaio, Izv. Akad. Nauk. SSSR Ser. Fiz. 48 (1984) 995; Bull. Acad. Sci. USSR Phys. Ser. 48 (1984) 158

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

1984SC09   I. Schwanner, G. Backenstoss, W. Kowald, L. Tauscher, H.-J. Weyer, D. Gottaand H. Ullrich, Nucl. Phys. A412 (1984) 253

1984SE1A Seestrom-Morris et al., 10th Int. Conf. on Particles and Nuclei, 30 July-3 Aug. 1984, Heidelberg (1984) F1

1984SH2A N.J. Shackleton, J. Backman, H. Zimmerman, D.V. Kent, M.A. Hall, D.G. Roberts, D. Schnitker, J.G. Baldauf, A. Desprairies, R. Homrighausen et al., Nature 307 (1984) 620

1984ST02   M.R. Strayer, R.Y. Cusson, A.S. Umar, P.-G. Reinhard, D.A. Bromley and W. Greiner, Phys. Lett. B135 (1984) 261

1984ST1E   Stone, Moszkowski, Mathews and Bloom, Bull. Amer. Phys. Soc. 29 (1984) 630

1984SU07   T. Suzuki and H. Narumi, Nucl. Phys. A426 (1984) 413

1984TA1A Tacik et al., 10th Int. Conf. on Paricles and Nuclei, 30 July-3 Aug. 1984, Heidelberg (1984) F13

1984TR15   M.A. Troitsky, A.V. Tsybulnikov and N.I. Chekunaev, Izv. Akad. Nauk. SSSR Ser. Fiz. 48 (1984) 370; Bull. Acad. Sci. USSR Phys. Ser. 48 (1984) 149

1984VA1G   V.V. Varlamov, B.S. Ishkhanov, Yu.P. Pyt'ev, A.P. Chernyaev and D.V. Yudin, Moscow Univ. Phys. Bull. 39 (1984) 62

1984WE04   E. Wesolowski, J. Phys. (London) G10 (1984) 321

1984WI17   B.H. Wildenthal, Prog. Part. Nucl. Phys. 11 (1984) 5

1985AD1A   E.G. Adelberger and W.C. Haxton, Ann. Rev. Nucl. Part. Sci. 35 (1985) 501

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

1985AL15   A. Altman, R.R. Johnson, U. Wienands, N. Hessey, B.M. Barnett, B.M. Forster, N. Grion, D. Mills, F.M. Rozon, G.R. Smith et al., Phys. Rev. Lett. 55 (1985) 1273

1985AL21   T.K. Alexander, B. Castel and I.S. Towner, Nucl. Phys. A445 (1985) 189

1985AN17   M.S. Antony, J. Britz, J.B. Bueb and V.B. Ndocko-Ndongue, Nuovo Cim. A88 (1985) 265

1985AN1B   Anne et al., in Visby (1985) 31

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

1985AR1A   W.D. Arnett and F.-K. Thielemann, Astrophys. J. 295 (1985) 589

1985BA1A   J.M. Bang, F.G. Gareev, W.T. Pinkston and J.S. Vaagen, Phys. Rept. 125 (1985) 253

1985BA27   B.M. Barnett, W. Gyles, R.R. Johnson, R. Tacik, K.L. Erdman, H.W. Roser, D.R. Gill, E.W. Blackmore, S. Martin, C.A. Wiedner et al., Phys. Lett. B156 (1985) 172

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

1985BE40   C. Beck, F. Haas, R.M. Freeman, B. Heusch, J.P. Coffin, G. Guillaume, F. Rami and P. Wagner, Nucl. Phys. A442 (1985) 320

1985BI01   B.L. Birbrair, V.N. Fomenko, A.B. Gridnev and Yu.A. Kalashnikov, J. Phys. (London) G11 (1985) 471

1985BI03   M. Bini, T.F. Fazzini, G. Poggi and N. Taccetti, Phys. Rev. Lett. 55 (1985) 795

1985BR20   V.R. Brown, A.M. Bernstein and V.A. Madsen, Phys. Lett. B164 (1985) 217

1985BR29   B.A. Brown and B.H. Wildenthal, At. Data Nucl. Data Tables 33 (1985) 347

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

1985CA1Q   J.A. Carr, F. Petrovich and J.J. Kelly, AIP Conf. Proc. 124 (1985) 230

1985CH1R   Cha and Park, Bull. Amer. Phys. Soc. 30 (1985) 1769

1985CH23   H.-C. Chiang and M.B. Johnson, Phys. Rev. C32 (1985) 531

1985CU1C J.B. Cumming, Phys. Rev. C32 (1985) 1445

1985DE24 P. Descouvemont and D. Baye, Phys. Rev. C31 (1985) 2274

1985DE38 D.M. de Castro Rizzo and N. Alamanos, Nucl. Phys. A443 (1985) 525

1985DE60 C. Detraz, J. Phys. Soc. Jpn. Suppl. 54 (1985) 27

1985DEZZ P. DeYoung, R. McGrath, J. Alexander, M. Gordon, R. Lefferts, D.M. De Castro-Rizzo, L. Vaz and X. Lu, Bull. Amer. Phys. Soc. 30 (1985) 708, AH10

1985DR07 B.J. Dropesky, G.W. Butler, G.C. Giesler, C.J. Orth and R.A. Williams, Phys. Rev. C32 (1985) 1305

1985DU05 O. Dumbrajs, Phys. Scr. 31 (1985) 485

1985DY05 P. Dyer, D. Bodansky, D.D. Leach, E.B. Norman and A.G. Seamster, Phys. Rev. C32 (1985) 1873

1985EV03 H.C. Evans, G.T. Ewan, S.-P. Kwan, J.R. Leslie, J.D. MacArthur, H.-B. Mak, W. McLatchie, S.A. Page, P. Skensved, S.-S. Wang et al., Phys. Rev. Lett. 55 (1985) 791

1985FO11 H.T. Fortune, L.C. Bland and W.D.M. Rae, J. Phys. (London) G11 (1985) 1175

1985GA1J M. Gai, J. Phys. Soc. Jpn. Suppl. 54 (1985) 470

1985GAZT S.B. Gazes, C.R. Albiston, Y. Chan, H.R. Schmidt, R.G. Stokstad and R. Kamermans, Bull. Amer. Phys. Soc. 30 (1985) 1280, EB8

1985GI01 R. Gilman, L.C. Bland, P.A. Seidl, C.F. Moore, C.L. Morris, S.J. Greene and H.T. Fortune, Nucl. Phys. A432 (1985) 610

1985GIZX R. Gilman, H.T. Fortune, K.S. Dhuga, J.D. Zumbro, C.L. Morris, S.J. Greene, J.A. Faucett, W.B. Cottingame, G.R. Burleson, P.A. Seidl et al., Bull. Amer. Phys. Soc. 30 (1985) 783, GH4

1985GM01 M. Gmitro, J. Kvasil and R. Mach, Phys. Rev. C31 (1985) 1349

1985GO27 C.R. Gossett, Nucl. Instrum. Meth. Phys. Res. B10-11 (1985) 722

1985GR1B C. Grama, N. Grama and Gh. Voiculescu, Rev. Roum. Phys. 30 (1985) 23

1985GR1K E.O. Grigoryan, A.G. Khudaverdyan, A.P. Bezverkhaya and N.A. Demekhina, Izv. Akad. Nauk. Arm. SSR Fiz. 20 (1985) 69; Sov. J. Contemp. Phys. 20 (1985) 12

1985HA11 J.S. Hanspal, R.J. Griffiths and N.M. Clarke, Phys. Rev. C31 (1985) 1138

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

1985HA1R M.J. Harris, D.L. Lambert and V.V. Smith, Astrophys. J. 299 (1985) 375

1985HA1Z M.J. Harris, D.L. Lambert and V.V. Smith, Astrophys. J. 292 (1985) 620

1985HO05 J.J. Hogan, J. Asher and D.J. Parker, Phys. Rev. C31 (1985) 477

1985HU02 I. Huszar and R. Weinreich, J. Radioanal. Nucl. Chem. Lett. 93 (1985) 349

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

1985JOZZ P.L. Jolivette, M.J. Honkanen, M. Young and E. Moser, Bull. Amer. Phys. Soc. 30 (1985) 1248, AC7

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

1985KE03 E. Kerkhove, R. van de Vyver, H. Ferdinande, D. Ryckbosch, P. van Otten, P. Berkvens and E. Van Camp, Phys. Rev. C32 (1985) 368

1985KE1A Kelly, PP 85-202, Unpublished (1985)

1985KE1C J. Keinonen, AIP Conf. Proc. 125 (1985) 557

1985KL1A H.V. Klapdor, Fortschr. Phys. 33 (1985) 1

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

1985KO1B Kozyr, in Leningrad (1985) 411

1985LA03 M. Langevin, E. Quiniou, M. Bernas, J. Galin, J.C. Jacmart, F. Naulin, F. Pougheon, R. Anne, C. Detraz, D. Guerreau et al., Phys. Lett. B150 (1985) 71

1985LE1K J.H. Lee and W.-H. Chang, New Phys. (Korean Phys. Soc.) 25 (1985) 101

1985LE1L J.H. Lee and W.-H. Chang, New Phys. (Korean Phys. Soc.) 25 (1985) 381

1985LI16 J. Lichtenstadt, A.I. Yavin, S. Janouin, P. Birien, G. Bruge, A. Chaumeaux, D. Drake, D. Garreta, D. Legrand, M.C. Lemaire et al., Phys. Rev. C32 (1985) 1096

1985MA1A G.J. Mathews and R.A. Ward, Rept. Prog. Phys. 48 (1985) 1371

1985MA1Q S. Marsh and W.D.M. Rae, Phys. Lett. B153 (1985) 21

1985MA1R V.A. Madsen and V.R. Brown, AIP Conf. Proc. 124 (1985) 171

1985MA1T Maglione, Vitturi and Pollaroio, in Visby (1985) 44

1985MA56 E. Maglione, G. Pollarolo, A. Vitturi, R.A. Broglia and A. Winther, Phys. Lett. B162 (1985) 59

1985MI10 R.E. Mischke, Nucl. Phys. A434 (1985) 505c

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

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

1985PY01 R.E. Pywell, B.L. Berman, J.G. Woodworth, J.W. Jury, K.G. McNeill and M.N. Thompson, Phys. Rev. C32 (1985) 384

1985RO1G D.J. Rowe, Rept. Prog. Phys. 48 (1985) 1419

1985SA29 H. Sagawa, B.A. Brown and O. Scholten, Phys. Lett. B159 (1985) 228

1985SE08 P.A. Seidl, C.F. Moore, S. Mordechai, R. Gilman, K.S. Dhuga, H.T. Fortune, J.D. Zumbro, C.L. Morris, J.A. Faucett and G.R. Burleson, Phys. Lett. B154 (1985) 255

1985SE21 R. Seki, Prog. Theor. Phys. 74 (1985) 511

1985SH1P N.K. Sherman, W.F. Davidson, S. Raman, W. Delbianco and G. Kajrys, AIP Conf. Proc. 125 (1985) 221

1985SO12 H.Q. Song, Z.X. Wang, Y.H. Cai and W.Z. Huang, Chin. J. Nucl. Phys. 7 (1985) 320

1985SU10 Y. Suzuki, A. Yamamoto and K. Ikeda, Nucl. Phys. A444 (1985) 365

1985TAZY T.N. Taddeucci, C.D. Goodman, C.C. Foster, R.C. Byrd, C. Gaarde, J.S. Larsen, D.J. Horen, J. Rapaport and E. Sugarbaker, Bull. Amer. Phys. Soc. 30 (1985) 1255, BB4

1985TH03 J. Thomas, Y.T. Chen, S. Hinds, K. Langanke, D. Meredith, M. Olson and C.A. Barnes, Phys. Rev. C31 (1985) 1980

1985VA1C Varlamov et al., in Leningrad (1985) 339

1985VO12 K.F. von Reden, W.W. Daehnick, S.A. Dytman, R.D. Rosa, J.D. Brown, C.C. Foster, W.W. Jacobs and J.R. Comfort, Phys. Rev. C32 (1985) 1465

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

1985WA1R M. Wahlen and T. Yoshinari, Nature 313 (1985) 780

1985WA24 J.W. Watson, W. Pairsuwan, B.D. Anderson, A.R. Baldwin, B.S. Flanders, R. Madey, R.J. McCarthy, B.A. Brown, B.H. Wildenthal and C.C. Foster, Phys. Rev. Lett. 55 (1985) 1369

1985WI17 B.H. Wildenthal, B.A. Brown and I. Sick, Phys. Rev. C32 (1985) 2185

1985WU03 J.Q. Wu, G. Bertsch and A.B. Balantekin, Phys. Rev. C32 (1985) 1432

1985YA1C T. Yamada, T. Motoba, K. Ikeda and H. Bando, Prog. Theor. Phys. Suppl. 81 (1985) 104

1985YO1B T. Yosshinari and M. Wahlen, Nature 317 (1985) 349

1985YU1B Z.-S. Yuan, Y.-P. Shen, Y.-S. Wang, Z.-H. Qiu and T.T.S. Kuo, Phys. Energ. Fortis Phys. Nucl. 9 (1985) 586

1985ZA1A R. Zahn, B. Markussen and J. Thiede, Nature 314 (1985) 433

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

1986AJ04 F. Ajzenberg-Selove, Nucl. Phys. A460 (1986) 1

1986AL22 A. Altman, D. Ashery, E. Piasetzky, J. Lichtenstadt, A.I. Yavin, W. Bertl, L. Felawka, H.K. Walter, R.J. Powers, R.G. Winter et al., Phys. Rev. C34 (1986) 1757

1986ALZZ M.M. Alam and F.B. Malik, Bull. Amer. Phys. Soc. 31 (1986) 770, AG11

1986AN07 M.S. Antony, J. Britz and A. Pape, At. Data Nucl. Data Tables 34 (1986) 279

1986AN10 M.S. Antony, J. Britz and J.B. Bueb, Nuovo Cim. A91 (1986) 283

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

1986ANZY   T. Anderl, A. Altman, R.R. Johnson, B.M. Barnett, R. Rui, F.M. Rozon, G.R. Smith, M. Sevior, R.P. Trelle, U. Wienands et al., Bull. Amer. Phys. Soc. 31 (1986) 856, HI5

1986AV07   A.R. Avakyan, G.A. Vartapetyan, E.O. Grigoryan and N.A. Demekhina, Yad. Fiz. 44 (1986) 566; Sov. J. Nucl. Phys. 44 (1986) 187

1986AV1B   Avdeichikov, in Dubna (1986) 122

1986BA1C   H.W. Baer and G.A. Miller, Comments Nucl. Part. Phys. 15 (1986) 269

1986BA3G   V.P. Bamblevskij, Kernenergie 29 (1986) 64

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

1986BA89   G. Baur, Phys. Lett. B178 (1986) 135

1986BI1A   R. Bimbot, S. Della-Negra, M. Manasijevic, P. Aguer, G. Bastin, R. Anne, H. Delagrange, Y. Schutz, F. Hubert, Y. Gono et al., J. Phys. (Paris) 47 (1986) C4-241

1986BL08   K. Blatt, K. Becker, B. Heck, H. Jansch, H. Leucker, D. Fick, R. Caplar, R. Butsch, D. Kramer, K.-H. Mobius et al., Phys. Rev. Lett. 57 (1986) 819

1986BR04   G. Bruge, A. Chaumeaux, P. Birien, D.M. Drake, D. Garreta, S. Janouin, D. Legrand, M.C. Lemaire, B. Mayer, J. Pain et al., Phys. Lett. B169 (1986) 14

1986BR1X   Brown, in Harrogate (1986) 119

1986CA1T   F. Catara, M. Sambataro, A. Insolia and A. Vitturi, Phys. Lett. B180 (1986) 1

1986CA27   M. Carchidi, B.H. Wildenthal and B.A. Brown, Phys. Rev. C34 (1986) 2280

1986CO11   S.G. Cooper, J. Phys. (London) G12 (1986) 869

1986CO2B   D.D. Cohen, A. Katsaros and D. Garton, Nucl. Instrum. Meth. Phys. Res. B15 (1986) 555

1986CO2C   E.R. Comben, J.M. Brown, T.C. Steimle, K.R. Leopold and K.M. Evenson, Astrophys. J. 305 (1986) 513

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

1986DAZS   C.H. Dasso and A. Vitturi, in Harrogate (1986) 221

1986DE1G   R. de Swiniarski and D.L. Pham, J. Phys. Soc. Jpn. Suppl. 55 (1986) 932

1986DO1L   J.F. Dominy, G. Wallerstein and N.B. Suntzeff, Astrophys. J. 300 (1986) 325

1986DR03   P.V. Drumm, O. Karban, A.K. Basak, P.M. Lewis, S. Roman and G.C. Morrison, Nucl. Phys. A448 (1986) 93

1986DR1E   Druffel and Benavides, Nature 321 (1986) 58

1986DU10   O. Dumbrajs, H. Heiselberg, A.S. Jensen, A. Miranda, G.C. Oades and J.M. Richard, Nucl. Phys. A457 (1986) 491

1986DU1Q J.-C. Duplessy, M. Arnold, P. Maurice, E. Bard, J. Duprat and J. Moyes, Nature 320 (1986) 350

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

1986ER1A R.A. Eramzhyan, B.S. Ishkhanov, I.M. Kapitonov and V.G. Neudatchin, Phys. Rept. 136 (1986) 229

1986FO06 H.T. Fortune and R. Gilman, Phys. Rev. C33 (1986) 2171

1986FR10 E. Friedman and J. Lichtenstadt, Nucl. Phys. A455 (1986) 573

1986GA13 E.N. Gazis, C.T. Papadopoulos, R. Vlastou and A.C. Xenoulis, Phys. Rev. C34 (1986) 872

1986GE06 W.J. Gerace, W.J. Leonard and D.A. Sparrow, Phys. Rev. C34 (1986) 353

1986GL02 K. Glasner, L. Ricken and E. Kuhlmann, Nucl. Phys. A452 (1986) 150

1986GM01 M. Gmitro and A.I. Steshenko, Yad. Fiz. 43 (1986) 333; Sov. J. Nucl. Phys. 43 (1986) 213

1986GR1A C. Gregoire and B. Tamain, Ann. Phys. (France) 11 (1986) 323

1986GU05 I.S. Gulkarov and R.Kh. Vakil, Yad. Fiz. 43 (1986) 809; Sov. J. Nucl. Phys. 43 (1986) 515

1986GU1A Gulkarov and Pinkus, in Kharkov (1986) 172

1986GU1D D. Guerreau, J. Phys. (Paris) 47 (1986) C4-207

1986HA13 Q. Haider and F.B. Malik, J. Phys. (London) G12 (1986) 537

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

1986HA1E H.L. Harney, A. Richter and H.A. Weidenmuller, Rev. Mod. Phys. 58 (1986) 607

1986HA1Q Haxton, Proc. Int. Nucl. Phys. Conf., Harrogate, U.K., No. 68, Vol. 2 (1986) 415

1986HA2D M. Hashimoto, K. Nomoto, K. Arai and K. Kaminisi, Astrophys. J. 307 (1986) 687

1986HAZY A.C. Hayes, D.A. Bromley and D.J. Millener, Bull. Amer. Phys. Soc. 31 (1986) 815, EI3

1986HE1C R.B.C. Henry, Publ. Astron. Soc. Soc. Pac. 98 (1986) 1044

1986HI1B Hichwa, Bull. Amer. Phys. Soc. 31 (1986) 1335

1986HO1L N. Horvatincic, I. Krajcar-Bronic, J. Pezdic, D. Srdoc and B. Obelic, Nucl. Instrum. Meth. Phys. Res. B17 (1986) 550

1986HO1Q S.E. Hoffman, M. Wilson and D.S. Stakes, Nature 321 (1986) 55

1986HO27 D.J. Horen, B.L. Burks, M.A.G. Fernandes, R.L. Auble, F.E. Bertrand, J.L. Blankenship, J.L.C. Ford, Jr., E.E. Gross, D.C. Hensley, R.O. Sayer et al., Phys. Lett. B181 (1986) 38

1986HOZF   D.J. Horen, M.A.G. Fernandes, B.L. Burks and G.R. Satchler, in Harrogate (1986) 399

1986IC01   H. Ichihara and H. Yoshida, Nucl. Phys. A448 (1993) 546

1986IR01   M. Iriondo, D. Jerrestam and R.J. Liotta, Nucl. Phys. A454 (1986) 252

1986KA1C   M. Kamimura, Y. Sakuragi, M. Yahiro and M. Tanifuji, J. Phys. Soc. Jpn. Suppl. 55 (1986) 205

1986KA1D   Karban, in Dubna (1986) 83

1986KA36   Y. Kadota, K. Ogino, K. Obori, Y. Taniguchi, T. Tanabe, M. Yasue and J. Schimizu, Nucl. Phys. A458 (1986) 523

1986KE05   J. Kelly, W. Bertozzi, T.N. Buti, J.M. Finn, F.W. Hersman, M.V. Hynes, C. Hyde-Wright, B.E. Norum, A.D. Bacher, G.T. Emery et al., Phys. Lett. B169 (1986) 157

1986KO10   P.E. Koehler, H.D. Knox, D.A. Resler, R.O. Lane and G.F. Auchampaugh, Nucl. Phys. A453 (1986) 429

1986KO22   Th. Kohler, P. Blum, G. Buche, A.D. Hancock, H. Koch, A. Kreissl, H. Poth, U. Raich, D. Rohmann, G. Backenstoss et al., Phys. Lett. B176 (1986) 327

1986KR04   A. Krasznahorkay, T. Kibedi and Zs. Dombradi, Z. Phys. A323 (1986) 125

1986LA1C   D.L. Lambert, B. Gustafsson, K. Eriksson and K.H. Hinkle, Astrophys. J. Suppl. 62 (1986) 373

1986LA29   J. Lang, Th. Maier, R. Muller, F. Nessi-Tedaldi, Th. Roser, M. Simonius, J. Sromicki and W. Haeberli, Phys. Rev. C34 (1986) 1545

1986LE13   M.-C. Lemaire, P. Birien, G. Bruge, D.M. Drake, D. Garreta, S. Janouin, D. Legrand, B. Mayer, J. Pain, J.C. Peng et al., Nucl. Phys. A456 (1986) 557

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

1986MA1P   Martin et al., Bull. Amer. Phys. Soc. 31 (1986) 1304

1986MA32   N. Matsuoka, H. Sakai, T. Saito, K. Hosono, M. Kondo, H. Ito, K. Hatanaka, T. Ichihara, A. Okihana, K. Imai et al., Nucl. Phys. A455 (1986) 413

1986MA48   D.M. Manley, B.L. Berman, W. Bertozzi, J.M. Finn, F.W. Hersman, C.E. Hyde-Wright, M.V. Hynes, J.J. Kelly, M.A. Kovash, S. Kowalski et al., Phys. Rev. C34 (1986) 1214

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

1986ME1C   O. Meirav, A. Altman, E. Friedman, D.R. Gill and R.R. Johnson, in Harrogate (1986) A2

1986ME1F   D.F. Measday, Czech. J. Phys. 36 (1986) 395

1986MO1A   T. Motoba, Czech. J. Phys. B36 (1986) 435

1986MO1Q T. Motoba, Nucl. Phys. A450 (1986) 209c

1986NA1K G. Nardulli, J. Phys. Soc. Jpn. Suppl. 55 (1986) 1000

1986NE1A Nemets et al., in Kharkov (1986) 372

1986NG1B Nguyen and Ye, in Harrogate (1986) C168

1986NI1C D. Nitz, D. Ciampa, T. Hemmick, D. Elmore, P.W. Kubik, S.L. Olsen, T. Gentile, H. Kagan, P. Haas and P.F. Smith, AIP Conf. Proc. 150 (1986) 1143

1986OS05 A. Osman and S.S. Abdel-AzizIndian, J. Pure Appl. Phys. 24 (1986) 65

1986PE1E F. Petrovich, J.A. Carr and H. McManus, Ann. Rev. Nucl. Part. Sci. 36 (1986) 29

1986PI09 C. Pillai, L.W. Swenson, D.J. Vieira, G.W. Butler, J.M. Wouters, S.H. Rokni, K. Vaziri and L.P. Remsberg, Radiat. Eff. 96 (1986) 41

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

1986PO13 F. Pougheon, D. Guillemaud-Mueller, E. Quiniou, M.G. Saint Laurent, R. Anne, D. Bazin, M. Bernas, D. Guerreau, J.C. Jacmart, S.D. Hoath et al., Europhys. Lett. 2 (1986) 505

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

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

1986RO23 D. Rohmann, H. Barth, A.D. Hancock, H. Koch, Th. Kohler, A. Kreissl, H. Poth, U. Raich, A. Wolf, L. Tauscher et al., Z. Phys. A325 (1986) 261

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

1986SC28 C.J.S. Scholz, L. Ricken and E. Kuhlmann, Z. Phys. A325 (1986) 203

1986SC29 H.R. Schmidt, S.B. Gazes, Y. Chan, R. Kamermans and R.G. Stokstad, Phys. Lett. B180 (1986) 9

1986SCZX R.A. Schumacher, P. Amaudruz, Q. Ingram, U. Sennhauser, H. Breuer, N.S. Chant, A. Feldman, B.S. Flanders, F. Khazaie, D.J. Mack et al., Bull. Amer. Phys. Soc. 31 (1986) 1220, CC1

1986SE1B N. Seichert, W. Assmann, H. Clement, G. Graw, C. Hategan, H. Kader, F. Merz and P. Schiemenz, J. Phys. Soc. Jpn. Suppl. 55 (1986) 646

1986SI11 E.R. Siciliano, M.D. Cooper, M.B. Johnson and M.J. Leitch, Phys. Rev. C34 (1986) 267

1986SI1K Simonius, J. Phys. Soc. Jpn. Suppl. 55 (1986) 523

1986SM01 M.J. Smithson, D.L. Watson and H.T. Fortune, Phys. Rev. C33 (1986) 509

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

1986ST15 A.I. Steshenko, Izv. Akad. Nauk. SSSR Ser. Fiz. 50 (1986) 953; Bull. Acad. Sci USSR Phys. Ser. 50 (1986) 121

1986STZY S.M. Sterbenz, M. Gai, J.F. Shriner, Jr., P.D. Cottle, D.A. Bromley, M. Morando and R.A. Ricci, Bull. Amer. Phys. Soc. 31 (1986) 839, GJ1

1986TA1B Tanaka et al., J. Phys. Soc. Jpn. Suppl. 55 (1986) 764

1986TH01 J. Thomas, Y.T. Chen, S. Hinds, D. Meredith and M. Olson, Phys. Rev. C33 (1986) 1679

1986TO1D I.S. Towner, Ann. Rev. Nucl. Part. Sci. 36 (1986) 115

1986VA23 C.P.M. van Engelen, E.A. Bakkum, R.J. Meijer and R. Kamermans, Nucl. Phys. A457 (1986) 375

1986VAZV G.S. Valiev, I.R. Gulamov, Yu.I. Denisov, T. Iskhakov, A.M. Mukhamedzhanov, G.K. Ni, E.A. Romanovsky, V.A. Stepanenko and R. Yarmukhamedov, in Kharkov (1986) 292

1986VAZZ S.P. Van Verst, J.A. Carr and K.W. Kemper, Bull. Amer. Phys. Soc. 31 (1986) 64, HD3

1986VI08 A. Vitturi and C.H. Dasso, Nucl. Phys. A458 (1986) 157

1986WI1L T.L. Wilson, E. Serabyn, C. Henkel and C.M. Walmsley, Astron. Astrophys. 158 (1986) L1

1986WI1P D. Wilkinson, J. Phys. Soc. Jpn. Suppl. 55 (1986) 347

1986XU1C D.-Y. Xu, Z. Yan, Q.-W. Zhang, Z.-D. Shen, Y.-Y. Sun and L.-F. Ye, Nature 321 (1986) 854

1986YA12 T. Yamaya, J.I. Hirota, K. Takimoto, S. Shimoura, A. Sakaguchi, S. Kubono, M. Sugitani, S. Kato, T. Suehiro and M. Fukada, Phys. Rev. C34 (1986) 2369

1986YA1R T. Yamaya et al., J. Phys. Soc. Jpn. Suppl. 55 (1986) 730, 732

1986YU1B Z.-S. Yuan, Y.-P. Sheng, Y.-S. Wang, Z.-H. Qui and T.T.S. Kuo, Chin. Phys. 6 (1986) 611

1987AB03 H. Abele, H.J. Hauser, A. Korber, W. Leitner, R. Neu, H. Plappert, T. Rohwer, G. Staudt, M. Strasser, S. Welte et al., Z. Phys. A326 (1987) 373

1987AS01 H.J. Assenbaum, K. Langanke and A. Weiguny, Phys. Rev. C35 (1987) 755

1987BA18 C.J. Batty, Phys. Lett. B189 (1987) 393

1987BO16 N. Bordes, G. Blondiaux, C.J. Maggiore, M. Valladon, J.L. Debrun, R. Coquille and M. Gauneau, Nucl. Instrum. Meth. Phys. Res. B24-25 (1987) 722

1987CH14 S. Chakravarti, D. Dehnhard, M.A. Franey, S.J. Seestrom-Morris, D.B. Holtkamp, C.L. Blilie, A.C. Hayes, C.L. Morris and D.J. Millener, Phys. Rev. C35 (1987) 2197

1987CO07 J. Cook, Nucl. Phys. A465 (1987) 207

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

1987DJ01　C. Djalali, G.M. Crawley, B.A. Brown, V. Rotberg, G. Caskey, A. Galonsky, N. Marty, M. Morlet and A. Willis, Phys. Rev. C35 (1987) 1201

1987ER05　T. Erikson, K.F. Quader, G.E. Brown and H.T. Fortune, Nucl. Phys. A465 (1987) 123

1987GA15　M. Gai, R. Keddy, D.A. Bromley, J.W. Olness and E.K. Warburton, Phys. Rev. C36 (1987) 1256

1987GOZX　J. Gorres, M. Wiescher, U. Giesen, H.W. Becker, C. Rolfs and H.P. Trautvetter, Bull. Amer. Phys. Soc. 32 (1987) 1062, EG9

1987HA1C　Harris, Lambert and Goldman, Mon. Notic. Roy. Astron. Soc. 224 (1987) 237

1987HA1D　Harris et al., Astrophys. J. 316 (1987) 294

1987HI1B　R.D. Hichwa, E.A. Hugel, J.J. Moskwa and R.R. Raylman, Nucl. Instrum. Meth. Phys. Res. B24-25 (1987) 932

1987JU07　J.W. Jury, P.C.-K. Kuo, K.G. McNeill, C.K. Ross, H.R. Weller and S. Raman, Phys. Rev. C36 (1987) 1243

1987KI03　M. Kirchbach, J. Phys. (London) G13 (1987) 135

1987LI04　J.S. Lilley, M.A. Nagarajan, D.W. Banes, B.R. Fulton and I.J. Thompson, Nucl. Phys. A463 (1987) 710

1987LO01　M. Lozano and A. Vitturi, Phys. Rev. C35 (1987) 367

1987MA09　Q. Ma and N. Austern, Nucl. Phys. A463 (1987) 620

1987MI1E　Millener, Private Communication (1987)

1987MO07　C.L. Morris, S.J. Seestrom-Morris, D. Dehnhard, C.L. Blilie, R. Gilman, G.P. Gilfoyle, J.D. Zumbro, M.G. Burlein, S. Mordechai, H.T. Fortune et al., Phys. Rev. C35 (1987) 1388

1987MU1J　Mueller, GANIL (1987) 87-06; XXV Int. Winter Meeting on Nucl. Phys., Bormio, Italy (1987)

1987NG01　Nguyen Van Sen, Ye Yanlin, J. Arvieux, G. Gaillard, B. Bonin, A. Boudard, G. Bruge, J.C. Lugol, T. Hasegawa, F. Soga et al., Nucl. Phys. A464 (1987) 717

1987PA07　S.A. Page, H.C. Evans, G.T. Ewan, S.-P. Kwan, J.R. Leslie, J.D. MacArthur, W. McLatchie, P. Skensved, S.-S. Wang, H.-B. Mak et al., Phys. Rev. C35 (1987) 1119

1987PA12　S.J. Padalino, K. Sartor, L.C. Dennis and K.W. Kemper, Phys. Rev. C35 (1987) 1692

1987PR1A　N. Prantzos, M. Arnould and J.-P. Arcoragi, Astrophys. J. 315 (1987) 209

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

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

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

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

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

1987SP05   D.A. Sparrow, Phys. Rev. C35 (1987) 1410

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

1987TA07   Y. Tagishi, Y. Aoki, M. Kurokawa, T. Murayama, T. Sakai, M. Takei, M. Tomizawa and K. Yagi, Phys. Rev. C35 (1987) 1153

1987TE01   A. Tellez-Arenas, R.J. Lombard and J.P. Maillet, J. Phys. (London) G13 (1987) 311

1987WA1H   M. Waroquier, J. Ryckebusch, J. Moreau, K. Heyde, N. Blasi, S.Y. van der Werf and G. Wenes, Phys. Rept. 148 (1987) 249

1987WI11   M. Wiescher, V. Harms, J. Gorres, F.-K. Theilemann and L.J. Rybarcyk, Astrophys. J. 316 (1987) 162

1987YA03   B.-J. Yang and Z. Hwang, Phys. Rev. C35 (1987) 851

1988UM1A   K. Umezawa, T. Kurio, J. Yamane, F. Shoji, K. Oura, T. Hanawa and S. Yano, Nucl. Instrum. Meth. Phys. Res. B33 (1988) 634