A = 17 Theoretical

Because much of the theoretical work reported in the literature for $A = 17$ is relevant to more than one of the $A = 17$ nuclides, the following general theoretical discussion for this mass system is provided here. Some of this work is also referenced in later sections of this compilation.

Ground-state properties of ^{17}O and ^{17}F are calculated by (89FU05) with the use of self-consistent relativistic mean field models of baryon-meson dynamics, including contributions from ρ, ω, and σ mesons. They calculate binding energies, rms radii, magnetic and quadrupole moments, and elastic magnetic scattering form factors and compare to experimental data. Work reported in (90LO11) revisits previous calculations based on the density functional method. Binding energies of ^{17}O and ^{17}F as well as proton and neutron radii are calculated and compared to experimental data. Calculations of Coulomb excitation of the first excited state of ^{17}O due to virtual E1 transitions through intermediate states are reported in (89BA60). They use shell-model wavefunctions including single-particle harmonic oscillator and higher configurations. The work in (86PO06, 87RI03, 89VO1F) deals with $A = 17$ nuclei as reaction products in heavy ion reactions. (89WA06) reports shell model calculations which use a modification of the Millener-Kurath interaction (MK3), including energy spectra and wavefunctions of ^{17}C and ^{17}N. The half-life and decay modes of both the allowed and first-forbidden β-decays of ^{17}C are predicted, as are the spectroscopic factors and electromagnetic transition rates of ^{17}N. They find generally good agreement with experimental results.

Analog correspondences and structure of states in ^{17}N and ^{17}O are covered in Table 17.3. A relativistic Hartree calculation was performed by (91ZH06). The effect of tensor coupling of the pion is found to be important in calculating the magnetic moments. Results are presented for binding energies, quadrupole moments, magnetic moments, and single particle energies. (88BR11) analyze ground-state binding energies and excited-state energies using several two-body interactions. They develop a semi-empirical "best fit" based on a 14-parameter density-dependent two-body potential. (88MI1J) discuss features of an effective interaction used to calculate cross-shell matrix elements. They apply shell-model transition densities to the $1\hbar\omega$ excitation of non-normal-parity states in electron, nucleon, and pion scattering. (86YA1B) obtain an effective shell-model interaction by starting with a bare hamiltonian of kinetic energy and the Reid soft-core pair potential, and folding this with pair correlation operators not represented by configuration mixing in a given shell model space. In (87BR30), calculations based on the full-basis sd-shell wave function are used to analyze M1 transition data and magnetic moment data. The parameters of an effective M1 operator are obtained.

Differences in effective operators are used to evaluate the importance of meson exchange currents, Δ-isobar effects and other mesonic exchange currents. The authors of (86ED03) apply the particle-hole model to the study of E1 states below the GDR using the WMBH residual interaction and compare the results to experimental data. The elastic magnetic form factor is calculated with the inclusion of both the $2\hbar\omega$ particle-hole excitations and the Zuker-type multi-particle-multi-hole configuration mixing, the latter of which helps explain the M3 suppression, but produces magnetic moments which are too small (92ZH07). The low-energy spectra were investigated by (90LI1Q), who included 2h-1p multiple scattering and PH TDA self-screening in their Paris-potential-based Green's function calculation. Two- and three-fragment clustering of 1p-shell nuclei is studied in the framework of the intermediate-coupling shell model (92KW01). (91SK02) use matrix inversion techniques to determine effective matrix elements for E2 and M1 transitions for $A = 17$ nuclei. A compilation of calculated mass excesses and binding energies of members of $T \leq 6$ isospin multiplets for $9 \leq A \leq 60$ is presented in (86AN07). The production of nuclei far from stability via multinucleon transfer reactions is reviewed in (89VO1F).

^{17}He, ^{17}Li

(Not illustrated)

Not observed: see (86AJ04, 88PO1E).

^{17}Be

(Not illustrated)

This nucleus has not been observed. Its atomic mass excess is calculated to be 70.67 MeV: see (77AJ02). It is then unstable with respect to breakup into ^{16}Be + n and ^{15}Be + 2n by 3.38 and 3.35 MeV, respectively. See also (83ANZQ).

^{17}B

(Not illustrated)

^{17}B was observed in the 4.8 GeV proton bombardment of uranium: it is particle stable and its ground state probably has $J^\pi = \frac{3}{2}^-$ (74BO05, 86AJ04) in agreement with the shell model (92WA22). It has been observed in several heavy ion reactions (87GI05, 88DU09, 88SA04, 88TA1N, 88WO09, 89LE16). The atomic mass was measured to be 42.82 ± 0.80 MeV (87GI05), 43.62 ± 0.17 MeV (88WO09), and 43.90 ± 0.23 MeV (91OR01), which compare well with the predicted mass of 43.31 ± 0.50 MeV (88WA18). See also (86AN07). The half life has been measured to be $T_{1/2} = 5.3 \pm 0.6$ ms (88SA04), 5.08 ± 0.05 ms (88DU09), and 5.9 ± 3.0 ms (91RE02). Beta-delayed multi-neutron emission has been observed and branching ratios have been measured (88DU09, 89LE16, 91RE02).

A model of ^{17}B considered as a three-body system composed of a ^{15}B core and two outside neutrons was studied by (90RE16). The binding energy and radius were calculated. Shell model interactions in the cross-shell model space connecting the 0p and 1s0d shells were applied in the $A = 15$–20 boron isotopes by (92WA22).

^{17}C

(Fig. 9)

The atomic mass excess given by (88WA18) for ^{17}C is 21035 ± 17 keV. See also (86AN07). ^{17}C is then stable with respect to ^{16}C + n by 0.73 MeV. E_{β^-}(max) to ^{17}N$_{\rm g.s.}$ = 13.16 MeV. See also (86BI1A). The half-life of ^{17}C has been measured to be 202 ± 17 ms (86CU01), 220 ± 80 ms (86DU07), 180 ± 31 ms (88SA04), and 174 ± 31 ms (91RE02). Relative intensities of β-delayed gammas were measured by (86DU07, 86HU1A, 86JE1A) [see Table 17.1]. Observation of β-delayed neutron emission has been reported and the probability measured to be (32.0 ± 2.7)% by (91RE02). See also (88MU08). Total cross sections induced by ^{17}C on Cu were measured by (89SA10). See also (87SA25). An excited state of ^{17}C is reported at $E_x = 292 \pm 20$ keV [see (82AJ01)] and at 295 ± 10 keV (82FI10). Three closely spaced low-lying states are expected [$J^\pi = \frac{5}{2}^+, \frac{3}{2}^+, \frac{1}{2}^+$] (82CUZZ, 89WA06): it is not clear which is the ground state. See also (86AJ04).

Shell-model calculations of energy spectra and wave functions and predictions of half lives and β-decay modes are described in (89WA06). Hartree-Fock calculations of light neutron-rich nuclei including ^{17}C are discussed in (87SA15). See also the study of partitioning of a two component particle system in (87SN1A).

^{17}N

(Figs. 6 and 9)

GENERAL:

Theoretical papers and reviews: Energy spectra and wave functions of ^{17}N are calculated and the results used to predict ^{18}O(d, ^{3}He)^{17}N spectroscopic factors and electromagnetic transition rates (89WA06). Self-consistent calculations of light nuclei including ^{17}N are reviewed in (90LO11). Production of ^{17}N in heavy ion collisions is discussed in (86HA1B, 87RI03, 87YA1F, 89VO1F). See also (86AN07, 86PO06, 91SK02, 92KW01, 92WA22).

Experimental papers: Production of ^{17}N in heavy ion collisions or multinucleon transfer in collisions of light nuclei are discussed in (86BI1A, 87AN1A, 87AV1B, 87SA25, 87VI1A, 89CA25, 89SA10, 89YO02).

1. (a) ^{17}N(β^-)^{17}O$^* \rightarrow {}^{16}$O + n $Q_m = 4.537$
   (b) ^{17}N(β^-)^{17}O $Q_m = 8.680$

The half-life of ^{17}N is 4.173 ± 0.004 s. The decay is principally [see Table 17.5] to the neutron unbound states ^{17}O*(4.55, 5.38, 5.94) [$J^\pi = \frac{3}{2}^-, \frac{3}{2}^-, \frac{1}{2}^-$]. The nature of the decay is in agreement with $J^\pi = \frac{1}{2}^-$ for ^{17}N$_{\rm g.s.}$: see (82AJ01). For a comparison of the ^{17}N and ^{17}Ne decays see Table 17.6. For GT transition rates see (83SN03) and

(83RA29) and references in (86AJ04). See also the recent analysis of GT beta decay rates of (93CH1A).

2. ^{9}Be(^{9}Be, p)^{17}N $\qquad$ $Q_{\rm m} = 7.534$

See (88LA25).

3. ^{11}B(^{7}Li, p)^{17}N $\qquad$ $Q_{\rm m} = 8.415$

Observed proton groups and γ-rays are displayed in Table 17.7. Table 17.4 shows branching ratio and lifetime measurements. Recent measurements of the cross section at $E_{\rm c.m.} = 1.45$–6.10 are reported in (90DA03).

4. ^{14}C(^{6}Li, ^{3}He)^{17}N $\qquad$ $Q_{\rm m} = -5.697$

Angular distributions have been studied to ^{17}N*(1.91, 2.53, 3.63, 4.01, 5.17) at $E(^{6}\mathrm{Li}) = 34$ MeV and the results compared with those for the analog reaction to ^{17}O (reaction 20) (83CU04).

5. ^{15}N(t, p)^{17}N $\qquad$ $Q_{\rm m} = -0.109$

Observed proton groups are displayed in Table 17.8.

6. ^{18}O(γ, p)^{17}N $\qquad$ $Q_{\rm m} = -15.942$

The giant resonance at $E_{\rm x} = 23.5$ MeV decays to $^{17}\mathrm{N}_{\rm g.s.}$ and to the first three excited states of ^{17}N (82BA03). See also ^{18}O in (83AJ01).

7. ^{18}O(d, ^{3}He)^{17}N $\qquad$ $Q_{\rm m} = -10.448$

Observed groups of ^{3}He ions are displayed in Table 17.7. See also (82AJ01) and ^{20}F in (83AJ01).

Shell-model calculations of energy spectra and wave functions for ^{17}C and ^{17}N are presented in (89WA06), and the results are used to predict spectroscopic factors for this reaction. Arguments are given for J^{π} assignments for states in ^{16}N below neutron threshold.

8. ^{18}O(t, α)^{17}N $\quad Q_m = 3.873$

See Tables 17.4 and 17.7.

^{17}O
(Figs. 7 and 9)

GENERAL:

See Table 17.9.

$\mu = -1.89379(9)$ n.m. [see (89RA17)].

$Q = -25.78$ mb [see (89RA17)].

Isotopic abundance = $(0.038 \pm 0.003)\%$ (84DE1A).

For Coulomb excitation of ^{17}O*(0.87) see (82KU14).

1. ^{7}Li(^{14}N, α)^{17}O $\quad Q_m = 16.155$

See (77AJ02, 87SHZS)

2. ^{9}Be(^{16}O, ^{8}Be)^{17}O $\quad Q_m = 2.478$

See (82AJ01).

3. (a) ^{10}B(^{7}Li, p)^{16}N $\quad Q_m = 13.986 \quad E_b = 27.766$
   (b) ^{10}B(^{7}Li, d)^{15}N $\quad Q_m = 13.720$
   (c) ^{10}B(^{7}Li, t)^{14}N $\quad Q_m = 9.144$
   (d) ^{10}B(^{7}Li, α)^{13}C $\quad Q_m = 21.408$

See (77AJ02).

4. ^{10}B(^{9}Be, d)^{17}O $\quad Q_m = 11.070$

Cross sections for populating ^{17}O*(0.87) were measured at $E_{cm} = 2.38$, 2.89, 3.16 MeV by (86CU02).

5. (a) ^{11}B(^{6}Li, p)^{16}N $Q_m = 9.782$ $E_b = 23.562$
(b) ^{11}B(^{6}Li, d)^{15}N $Q_m = 9.516$
(c) ^{11}B(^{6}Li, t)^{14}N $Q_m = 4.940$
(d) ^{11}B(^{6}Li, α)^{13}C $Q_m = 17.204$

See (77AJ02).

6. ^{11}B(^{11}B, X)^{17}O

Cross sections for populating ^{17}O*(0.87, 3.06, 3.84) were measured at $E_{cm} = 2.22$–3.23 MeV by (86CU02).

7. ^{12}C(^{6}Li, p)^{17}O $Q_m = 7.605$

Angular distributions have been studied for $E(^{6}\text{Li}) = 3$–28 MeV [See (82AJ01, 86AJ04)]. More recently, differential cross sections at $E(^{6}\text{Li}) = 28$ MeV were measured by (86SM10). Many of the known levels in ^{17}O were populated. See Table 17.11. Hauser-Feshbach calculations and DWBA analyses were carried out for the data.

8. ^{12}C(^{7}Li, d)^{17}O $Q_m = 2.580$

See Table 17.6 in (77AJ02) and ^{19}F in (83AJ01).

9. ^{12}C(^{9}Be, α)^{17}O $Q_m = 9.732$

Angular distributions have been reported at $E(^{9}\text{Be}) = 16.1$–20 MeV [see (82AJ01)] and at $E(^{9}\text{Be}) = 12.0$–27.0 MeV (81JA1A; α_0, α_2). For excitation functions see (82AJ01, 86AJ04), and see (88GO1G).

10. ^{12}C(^{13}C, ^{8}Be)^{17}O $Q_m = -1.007$

Excitation functions at $E_{cm} = 13.4$–16.8 MeV and angular distributions at $E_{cm} =$ 13.8 and 16.38 MeV have been measured by (88JA14).

11. ^{13}C(α, γ)^{17}O $Q_m = 6.358$

At $E_\alpha = 3.65$ and 6.17 MeV [^{17}O*(9.15, 11.08)] $\Gamma_\alpha\Gamma_{\gamma1}/\Gamma = 0.65 \pm 0.07$ and 1.46 ± 0.13 eV, respectively. Assuming $\Gamma_\alpha/\Gamma = 0.45$ for the lower resonance, $\Gamma_{\gamma1}$ for the E1 transition from ^{17}O*(9.15) [$J^\pi = \frac{1}{2}^-$] to ^{17}O*(0.87) [$\frac{1}{2}^+$] is 1.44 ± 0.26 eV. The parameters of ^{17}O*(11.08) are discussed in Table 17.16. See (86AJ04).

12. (a) ^{13}C(α, n)^{16}O $\qquad Q_m = 2.215 \qquad E_b = 6.358$
(b) ^{13}C(α, α)^{13}C

The yield of neutrons increases monotonically for $E_\alpha = 0.475$ to 1 MeV: for $S(E)$ see (77AJ02, 82AJ01). Resonances observed in the yield of neutrons and through the anomalies in the elastic scattering are displayed in Table 17.14. See also (86AJ04). Cross sections for reaction (a) at $E_\alpha = 0.40$–1.20 MeV were measured by (89KEZZ). Distributions of alpha particle strength were obtained by (88LE05). See also (85CA41, 87BU1E).

A microscopic analysis of reactions (a) and (b) with the generator-coordinate method was carried out by (87DE38).

13. ^{13}C(^{6}Li, d)^{17}O $\qquad Q_m = 4.883$

Angular distributions are reported at $E(^6\text{Li}) = 35.5$ MeV to ^{17}O*(13.58 ± 0.02), which is strongly populated. Comparisons with ^{12}C(^{6}Li, d)^{16}O*(16.29) and with the results of reaction 14 below suggest that the peak corresponding to ^{17}O*(13.58) contains a state or states of spin $\frac{11}{2}^-$, $\frac{13}{2}^-$, or both, based on ^{16}O*(16.29) (78CL08). (d, α) angular correlations [$E(^6\text{Li}) = 26$, 29 and 34 MeV] indicate the involvement of ^{17}O states at 13.6 ± 0.1 [$l = 6$], 14.15 ± 0.1 [5], 15.1 ± 0.1 [5], 15.95 ± 0.15 [5], 16.6 ± 0.15 [6], 17.1 ± 0.15 [6], 19.6 ± 0.15 [7], 20.2 ± 0.15 [7], 21.2 [7], and 22.1 MeV, $\Gamma \sim 0.1$, 0.5, 0.7, and 0.25 MeV for ^{17}O*(14.2, 15.1, 16.0, 19.6, 20.2) (78AR15). See, however, (84CA39). For the earlier work see Table 17.7 in (77AJ02).

Measurements and analysis by (87CA30) of data at $E(^6\text{Li}) = 34$ MeV for deuteron peaks corresponding to ^{16}O*(16.1, 13.6) indicated that the reaction proceeds by a direct alpha transfer process which populates doublets of interfering ^{17}O levels.

14. ^{13}C(^{7}Li, t)^{17}O $\qquad Q_m = 3.891$

Angular distributions are reported to ^{17}O*(3.06) and to ^{17}O*(13.58), which is preferentially populated (see discussion in reaction 13), at $E(^7\text{Li}) = 35.7$ MeV. Narrow states at $E_x = 14.86$, 18.17 and 19.24 MeV are also strongly excited (78CL08). See (86AJ04) and for the earlier work see Table 17.6 in (77AJ02). Recent measurements of the cross section for $E_{c.m.} = 1.46$–6.48 MeV are reported in (90DA03).

15. ^{13}C(^{9}Be, αn)^{17}O $\qquad Q_m = 4.786$

Cross sections for population of ^{17}O*(0.87, 3.06, 3.84) were measured at E_{cm} = 2.76–4.82 MeV by (86CU02).

16. ^{13}C(^{13}C, ^{9}Be)^{17}O $\qquad Q_m = -4.288$

States of ^{17}O with E_x = 3.9, 5.2, 5.8 ± 0.1, 7.2, 7.6, 8.4 ± 0.06, 8.9, 9.8 ± 0.07, 10.55±0.06, 12.1±0.06, 13.3, 14.6 and 18.9±0.14 MeV have been reported (79BR04) at E(^{13}C) = 105 MeV.

17. ^{13}C(^{16}O, ^{12}C)^{17}O $\qquad Q_m = -0.803$

Angular distributions involving ^{17}O*(0, 0.87) have been studied for E(^{16}O) = 12–25 MeV: see (77AJ02, 82AJ01, 86AJ04). See also (89FR04). More recently, cross sections were measured for $E_{c.m.}$ = 4.8–9.8 MeV by (91DA05). A calculation involving application of the nuclear molecular-orbital model and Landau-Zener coupling effects is discussed in (90IM01).

18. ^{14}C(^{3}He, γ)^{17}O $\qquad Q_m = 18.760$

The capture cross sections at 90° for γ_0 and for γ_1 have been studied for E(^{3}He) = 3.2 to 7.5 MeV and angular distributions of the γ-rays have been studied at the six observed resonances: see Table 17.13.

19. (a) ^{14}C(^{3}He, n)^{16}O $\qquad Q_m = 14.617 \qquad E_b = 18.76$
(b) ^{14}C(^{3}He, ^{3}He)^{14}C
(c) ^{14}C(^{3}He, α)^{13}C $\qquad Q_m = 12.402$

See Table 17.13. See also (77AJ02), ^{13}C and ^{14}C in (86AJ01) and ^{16}O here.

20. ^{14}C(^{6}Li, t)^{17}O $\qquad Q_m = 2.964$

At E(^{6}Li) = 34 MeV angular distributions have been reported (86AJ04) to ^{17}O*(0, 0.87, 3.06, 3.84, 4.55, 5.70, 6.36, 7.17 (u), 7.38 (u), 7.76, 8.20, 8.47 (u), 9.18 (u), 9.71, 9.87 (u), 10.42, 11.24, 11.82, 12.01, 12.27, 13.00 (u), 13.6 (u), 14.76 (u), 15.20, 16.3 (u)) (81CU11, 83CU02, 83CU04; u = unresolved). (83CU02) suggests evidence for two 3p-2h bands in ^{17}O and (83CU04) for analog states in ^{17}N–^{17}O. See these two papers for spectroscopic factors.

21. ^{14}N(t, γ)^{17}O $\quad Q_m = 18.622$

The excitation functions for γ_0 and γ_1 have been measured for $E_t = 0.8$ to 3.3 MeV: broad resonances are observed at 2.2 and 2.8 MeV in the γ_0 cross section, and at 2.4 and 2.8 MeV in the γ_1 cross section. Both also exhibit a structure at 1.5 MeV. The data are consistent with the states in Table 17.14 and possibly with a state at ~ 19.3 MeV (80LI05). For the charged particle channels see (77AJ02).

22. (a) ^{14}N(α, p)^{17}O $\quad Q_m = -1.193$
(b) ^{14}N(α, αp)^{13}C $\quad Q_m = -7.551$

Angular distributions have been measured for ^{17}O states with $E_x < 7.6$ MeV in the range $E_\alpha = 8.1 \rightarrow 33.3$ MeV: see a listing of the references in (71AJ02). The sequential decay (reaction (b)) appears to take place via ^{17}O states with $8.46 \leq E_x \leq 13.57$ MeV. Those involved are believed to have $J \geq \frac{5}{2}$, $\Gamma_\alpha/\Gamma \geq 0.6$. See also the measurements at $E_\alpha = 48$ MeV of (87MI1C, 88BRZY).

23. (a) ^{14}N(^{6}Li, ^{3}He)^{17}O $\quad Q_m = 2.826$
(b) ^{14}N(^{6}Li, ^{3}Heα)^{13}C $\quad Q_m = -3.532$

Angular distributions (a) and angular correlations (b) have been measured at $E(^6\text{Li}) = 36$ MeV involving ^{17}O*(8.48, 10.7, 12.0, 13.53, 14.88). Comparisons are made with the results in the analog reaction (^{6}Li, t) involving states in ^{17}F. See (82AJ01, 86AJ04).

24. ^{14}N(^{7}Li, α)^{17}O $\quad Q_m = 16.155$

See (86NE1A).

25. (a) ^{15}N(d, γ)^{17}O $\quad Q_m = 14.046$ $\quad E_b = 14.046$
(b) ^{15}N(d, n)^{16}O $\quad Q_m = 9.903$
(c) ^{15}N(d, p)^{16}N $\quad Q_m = 0.266$

Radiative capture cross sections (reaction (a)) have been measured for $E_x = 25$–40 MeV by (86AN1H, 88CO1D). Excitation functions have been measured for $E_d = 0.5$–5.9 MeV (b) and 0.3–6.3 MeV (reaction (c)): see (77AJ02). Unresolved structures are observed in the neutron data. There is some evidence for structures at $E_d = 1.8$ MeV [p_0, p_1, p_3] and 2.4 MeV [p_2] [^{17}O*(15.6, 16.2)]: see (82AJ01). See also (86AJ04) and ^{16}N, ^{16}O here.

26. ^{15}N(d, d)^{15}N $E_b = 14.046$

Excitation functions for have been measured for $E_d = 1.4$ to 6.25 MeV. Structures are reported at ~ 1.4 and 1.8 MeV: see (82AJ01, 86AJ04).

27. (a) ^{15}N(d, t)^{14}N $Q_m = -4.576$
(b) ^{15}N(d, α)^{13}C $Q_m = 7.688$ $E_b = 14.046$

Differential cross sections and analyzing powers for reaction (a) were measured for $E_d = 88$, 89 MeV by (88SA19, 88SAZY). Yield curves for reaction (b) have been measured for $E_d = 0.8$ to 2.7 MeV. Structures are reported at $E_d = 1.06$, 1.25 and ~ 1.8 MeV. The latter has $\Gamma \sim 300$ keV: see (82AJ01).

28. ^{15}N(^{3}He, p)^{17}O $Q_m = 8.552$

Observed proton groups are displayed in Table 17.15. For the parameters of the first $T = \frac{3}{2}$ state see Table 17.16.

29. ^{15}N(α, d)^{17}O $Q_m = -9.802$

At $E_\alpha = 45.4$ MeV, the deuteron spectrum is dominated by the groups corresponding to states with $E_x = 7.742 \pm 0.020$ and 9.137 ± 0.030 MeV. These states are assigned $J^\pi = (\frac{11}{2}^-)$ and $(\frac{9}{2}^-)$ and arise from a dominant $(d_{5/2})^2_5 p^{-1}_{1/2}$ configuration: see (77AJ02).

30. ^{15}N(^{11}B, ^{9}Be)^{17}O $Q_m = -1.769$

See (82AJ01).

31. ^{16}O(n, γ)^{17}O $Q_m = 4.143$

The capture cross section for thermal neutrons is $\sigma_{capt.} = 202 \pm 28$ μb (77MC05). See also (81MUZQ). At thermal energies the branchings via ^{17}O*(0.87, 3.05) are (18 ± 3) and (82 ± 3)%; $E_\gamma = 870.89 \pm 0.22$ and 2184.47 ± 0.12 keV [the latter leads to $E_x = 3055.43 \pm 0.19$ keV for ^{17}O*(3.09); [see (86AJ04)]. The cross section for two-photon emission $\sigma_{2\gamma} < 3 \pm 19$ μb for $1200 < E_\gamma < 2943$ keV. The two-photon branching ratio is $(1.6 \pm 10) \times 10^{-2}$ (77MC05). The mechanism of p-wave neutron resonance capture was studied by measurements of gamma spectra from the $E_n = 434$ keV resonance ($E_x = 4552$ keV) by (88KI02, 92IG01). Partial radiative widths and off-resonance capture cross sections were obtained. See footnote [b]) in Table 17.17 and see Table 2.

32. $^{16}O(n, n)^{16}O$ $E_b = 4.143$

The scattering length (bound) $a = 5.805 \pm 0.005$ fm, $\sigma_{free} = 3.761 \pm 0.007$ b (79KO26). See also (81MUZQ). Resonances observed in the elastic scattering and in the (n, α) reaction are displayed in Table 17.17. A two-channel R-matrix analysis finds that five states contain nearly 100% of the $1d_{3/2}$ strength and have their eigenenergy at $E_x \approx 5.7$ MeV [the dominant state is $^{17}O^*(5.08)$]. Spectroscopic factors are deduced for 26 states in ^{17}O for $4.5 < E_x < 9.5$ MeV [see Table 17.12 in (77AJ02)]: the sum of these factors is 1% for $J^\pi = \frac{1}{2}^+$, 5% for $\frac{1}{2}^-$, 12% for $\frac{3}{2}^-$, 99% for $\frac{3}{2}^+$, 0.1% for $\frac{5}{2}^+$, 1% for $\frac{5}{2}^-$ and 14% for $\frac{7}{2}^-$. $T = \frac{3}{2}$ resonances are discussed by (81HI01): see Tables 17.16 and 17.17. See also the review of neutron resonance spectroscopy by (86WE1B).

Cross-section measurements are listed in Table 17.10 of (71AJ02) and in (77AJ02, 82AJ01). An optical model analysis of angular distributions leads to predictions of σ_R and σ_T for $E_n = 6$ to 19 MeV (83DA22). Analyzing power measurements for n_0 have been carried out at $E_n = 5$–23 MeV (86AJ04). More recently scattering cross sections have been reported for $E_n = 14.1$ MeV (86BA1M) and $E_n = 21.6$ MeV (90OL01). Optical model parameters were deduced. Small angle scattering cross sections at $E_n = 14.8$ MeV are reported by (92QI02). Neutron total cross section measurements from 160 to 575 MeV are reported by (88FR23) from an experiment which included a test of charge symmetry. An experimental study of p-wave strength functions is described in (88KO18).

A cascade statistical-model study of nucleon induced reactions in the range 50 MeV–1 GeV is reported in (90TA21). A resonating group study of the $^{16}O +$ single nucleon problem is discussed in (90HA38). See also the analyses reported in (92KA21) and (92KA1K).

Neutron elastic-scattering observables were calculated on the basis of the relativistic impulse approximation by (91KA22).

33. $^{16}O(n, n')^{16}O^*$ $E_b = 4.143$

A number of resonances have been observed in the cross sections for production of 6.13 and (6.92 + 7.12) MeV γ-rays: see Table 17.13 in (77AJ02) and (82AJ01). For cross-section measurements see Table 17.10 in (71AJ02) and (77AJ02, 82AJ01). Studies of circular polarization of gamma rays from inelastic scattering of partially polarized neutrons from a nuclear reactor are reported by (88LI34). See also the measurements at $E_n = 21.6$ MeV and DWBA coupled channels analysis reported in (90OL01).

34. (a) ^{16}O(n, p)^{16}N $\quad Q_m = -9.637 \quad E_b = 4.143$
(b) ^{16}O(n, d)^{15}N $\quad Q_m = -9.903$
(c) ^{16}O(n, t)^{14}N $\quad Q_m = -14.479$
(d) ^{16}O(n, ^{3}He)^{14}C $\quad Q_m = -14.617$

See (82AJ01). See also (81HAZJ, 82HA1A). Differential cross sections for neutron-induced reactions (a, b, c, d) have been measured for incident neutron energies of 27.4, 39.7, and 60.7 MeV by (86RO1F, 86SU15).

In a recent measurement of reaction (a) at $E_n = 298$ MeV, the Gamow-Teller and spin dipole strength functions were extracted (91HI05).

35. ^{16}O(n, α)^{13}C $\quad Q_m = -2.215 \quad E_b = 4.143$

Table 17.17 displays the results from a multilevel two-channel R-matrix analysis of the data from this reaction and from the elastic scattering of neutrons: see (82AJ01). See also (81HAZJ, 82HA1A). More recently differential cross sections were measured for incident neutron energies of 27.4, 39.7, and 60.7 MeV by (86RO1F, 86SU15).

36. ^{16}O(p, π^+)^{17}O $\quad Q_m = -136.207$

Angular distributions have been measured at $E_p = 185$ and 800 MeV [to ^{17}O*(0, 0.87, 3.05)] [see (82AJ01)], as well as at $E_p = 154$ to 185 MeV [for π^+ to ^{17}O*(0, 0.87)]. See (86AJ04). More recently angular distributions and analyzing powers at $E_p = 250$, 354, 489 MeV were measured to ^{17}O*(0, 5.22, 7.76, 15.78) by (88HU02) and to ^{17}O*(0, 5.22, 7.76, 14.20, 14.60) at $E_p = 200$ MeV by (87AZZZ, 88AZZZ). Studies of (p, π^+) reactions to the Δ_{1232} region are described in (88HU06).

A relativistic stripping model is applied to the ^{16}O(p, π^+)^{17}O reaction and discussed in (86CO28).

37. ^{16}O(d, p)^{17}O $\quad Q_m = 1.919$

Observed proton groups are displayed in Table 17.14 of (77AJ02). Angular distributions have been measured at many energies in the range $E_d = 0.3$–698 MeV [see (82AJ01, 86AJ04)] and at $E_d = 12.3$ MeV (90PI05). Reported level parameters are $\tau_m = 258.6 \pm 2.6$ ps [see Table 17.7 in (71AJ02)] and $E_x = 870.749 \pm 0.020$ keV [$E_\gamma = 870.725 \pm 0.020$ keV] for ^{17}O*(0.87) and $\Gamma_n = 97 \pm 5$ keV for ^{17}O*(5.09): see (82AJ01), and see (88GU1E). Recent measurements at $E_d = 12.3$ MeV (90PI05) determined high precision excitation energies for the first ten levels of ^{17}O (see Table 17.10). For applications, see (90CA32, 92LA08).

Theoretical studies of breakup and rearrangement reactions including ^{16}O(d, p)^{17}O carried out by means of a coupled-channels variational method are discussed in (86KA1A, 86KA1B).

See also ^{18}F in (83AJ01, 87AJ02).

38. (a) ^{16}O(^{7}Li, ^{6}Li)^{17}O $Q_m = -3.106$
(b) ^{16}O(^{9}Be, ^{8}Be)^{17}O $Q_m = 2.478$
(c) ^{16}O(^{11}B, ^{10}B)^{17}O $Q_m = -7.310$

Reaction (a) has been studied at $E(^{7}\mathrm{Li}) = 36$ MeV [see (82AJ01, 86AJ04) and more recently at $E(^{7}\mathrm{Li}) = 34$ MeV (88KE07). For reaction (b) see (79CU1A, 85CU1A) and the measurements at $E_{\mathrm{cm}} = 10.3$, 12.8 MeV reported by (88JA14). See also (88WE17). For reaction (c) see (82AJ01).

39. (a) ^{16}O(^{13}C, ^{12}C)^{17}O $Q_m = -0.803$
(b) ^{16}O(^{14}N, ^{13}N)^{17}O $Q_m = -6.410$

For reaction (a) see (82AJ01, 86AJ04) and the cross section measurements at $E_{\mathrm{cm}} = 7.8$, 14.6 MeV of (86PA10). For reaction (b) see (82AJ01).

40. ^{17}N(β^-)^{17}O $Q_m = 8.680$

The decay is principally to ^{17}O*(4.55, 5.38, 5.94): see Table 17.5.

41. (a) ^{17}O(γ, n)^{16}O $Q_m = -4.413$
(b) ^{17}O(γ, 2n)^{15}O $Q_m = -19.806$
(c) ^{17}O(γ, p)^{16}N $Q_m = -13.780$

Monoenergetic photons with $E_\gamma = 8.5$ to 39.7 MeV have been used to measure the (γ, n) and the (γ, 2n) [above 10 MeV] cross sections. The giant dipole resonance, 6 MeV broad, is centered at 23 MeV; a pygmy resonance is also observed at 13 MeV. The pygmy resonance [$J^\pi = \frac{3}{2}^-$] decays primarily to $^{16}\mathrm{O}_{\mathrm{g.s.}}$, (86AJ04), and the work of (85JU02) indicates that above $E_x \sim 17$ MeV nearly all of the decay is to excited states of ^{16}O. See, however, the experimental results of (89OR07), which determine that the neutron emission from the ^{17}O GDR to ^{16}O is primarily to the ground state with $\sim 4\%$ going to the 6.13 MeV 3^- level. Four resonances have been inferred at $E_x = 10.5$, 14.0, 16.6 and 21.0 MeV with $J^\pi = \frac{5}{2}^-, \frac{3}{2}^-, \frac{7}{2}^-$, and $\frac{7}{2}^-$ respectively (85JU02). Recent work of (90MC06) reanalyzes earlier data and reports that the

^{17}O levels at $E_x = 14.4$, 15.2 and 15.6 MeV should be assigned $T = \frac{1}{2}$. Most of the GDR strength decays to $T = 1$ states in ^{16}O: this implies a $T = \frac{3}{2}$ assignment for the main part of the GDR (86AJ04). A broad structure, of $T = \frac{1}{2}$ nature, with $28 < E_x < 36$ MeV is also reported (80JU01). For radiative widths see Table 17.13 in (82AJ01). Measurements of bremsstrahlung-weighted integral cross sections for reaction (c) carried out by (89OR07) indicated that 90% of the photoproton emission to ^{16}N populates the ground state (2^-) and the 0.298 MeV (3^-) levels. More recently, the GDR was studied with reaction (c) using quasimonoenergetic photons from $E_\gamma = 13.5$ to 43.15 MeV (92ZU01, 92ZU1B). Major peaks were observed at $E_\gamma = 15.1$, 18.1, 19.3, 20.3, 22.2, 23.1, 24.4 and ~ 26.5 MeV.

Comparisons of ^{17}O photonuclear data with shell model and continuum shell model calculations are discussed in (87KI1C).

42. ^{17}O(e, e)^{17}O

The ^{17}O charge radius is reported to be $\langle r^2 \rangle_{1/2} = 2.710 \pm 0.015$ fm (78KI01). The r.m.s. radius of the $1d_{5/2}$ neutron orbit deduced from the data is 3.56 ± 0.09 fm (82HI01). The elastic magnetic form factor was measured for $2.47 \leq q_{eff} \leq 3.65$ fm^{-1} by (88KA08). Inelastic scattering is reported to a number of ^{17}O states: see Tables 17.18 and 17.19. Excited states in ^{16}O up to $E_x = 15$ MeV were studied in high resolution at q = 0.8–2.6 fm^{-1} by (87MA52). Recent form-factor measurements for momentum transfers q = 1.4–1.9 fm^{-1} at 90° and q = 1.7 fm^{-1} at 160°, for levels between $E_x = 15$ and 27 MeV, were reported by (86MA48). See also footnote [e]) in Table 17.10. Note, however, the comments by (87MI25) and reply by (87MA40) concerning the spin assignments of (86MA48). See also (86AJ04) and reaction 50.

Calculations of charge and magnetic form factors in a consistent relativistic formalism are described in (86KI10, 86WA1D, 91BL14). See also (89FU05). Excitation energies, magnetic moments and M2 magnetic ground state transitions for five $T = \frac{3}{2}$ excited states were calculated in a microscopic 2p-1h model by (86TO13). Nuclear currents and amplitudes for elastic magnetic scattering in a relativistic mean-field theory were studied by (87FU06, 88FU04). A relativistic direct-interaction-based impulse approximation model is discussed in (89GA04).

Model dependence of *rms* radii as determined from elastic magnetic form factors was studied by (91CO12). See also (91GO1F, 91GO1G, 92GO07). See also the study by (92BO07) of ^{17}O(e, e′n)^{16}O as a tool for investigation of the role of two-body currents in quasi-free electron scattering.

43. ^{17}O($\pi^\pm$, $\pi^\pm$)^{17}O

At $E_{\pi^\pm} = 164$ MeV angular distributions to ^{17}O*(3.85, 4.55, 5.22, 5.69, 7.76, 8.1, 8.4, 15.7, 17.1) have been analyzed by DWBA. Evidence is suggested for E2 strength near 8 MeV and for M4 strength to the two states at $E_x = 15.7$ and 17.1 MeV

(84BL17). [See, however, caveat on p. 1990 of that reference, and the density of states above $E_x = 5$ MeV in Table 17.10.]

44. ^{17}O(n, α)^{14}C $\qquad Q_m = 1.818$

Cross sections were measured for thermal energies to $E_n \approx 1$ MeV by (91KO31). This reaction plays a role in the nucleosynthesis of heavy elements in nonstandard big-bang models. See also (91KO1P).

45. (a) ^{17}O(p, p)^{17}O
(b) ^{17}O(d, d)^{17}O

Angular distributions for the elastic scattering have been reported for $E_p = 8.6$ to 65.8 MeV and $E_d = 18$ MeV: see (82AJ01). Analyzing power measurements for $E_p = 89.7$ MeV are reported in (85VO12). For reaction (a) see also ^{18}F in (86AJ04, 83AJ01).

A coupled-channels variational-method calculation has been applied to reaction (a) and is discussed in (86KA1A).

46. (a) ^{17}O(^{3}He, ^{3}He)^{17}O
(b) ^{17}O(α, α)^{17}O

Elastic angular distributions have been measured at $E(^3\text{He}) = 11.0$ and 17.3 MeV [see (77AJ02)], and at 14 MeV (82AB04). Analyzing powers were measured at $E(^3\text{He}) = 33.3$ MeV [see (86AJ04) ; also A_y to ^{17}O*(0.87)]. For reaction (b) see (82AJ01, 86AJ04). More recently, differential cross sections were measured at $E_\alpha = 54.1$ MeV (87AB03).

Microscopic spin-orbit potentials for polarized ^{3}He scattering on ^{17}O have been calculated (87CO07) by a double folding model.

47. (a) ^{17}O(^{9}Be, ^{9}Be)^{17}O
(b) ^{17}O(^{10}B, ^{10}B)^{17}O

Fusion cross section measurements for reaction (b) are reported by (82CH07). See also (86AJ04, 82AJ01).

48. (a) ^{17}O(^{12}C, ^{12}C)^{17}O
(b) ^{17}O(^{13}C, ^{13}C)^{17}O
(c) ^{17}O(^{14}C, ^{14}C)^{17}O

Elastic angular distributions (reactions (a) and (b)) have been reported at $E(^{17}O) =$ 30.5 to 33.8 MeV [see (82AJ01)] and at $E(^{17}O) = 40$ to 70 MeV (86FR04; also ^{17}O*(0.87)) and 85.4, 120 and 140 MeV (82HE07). See also the comparison of reaction (a) with $^{16}O + ^{13}C$ by (89FR04). For fusion cross section and yield measurements see (82AJ01, 86AJ04).

The results of a barrier-penetration calculation for these reactions are discussed in (86HA13). The energy dependence of nucleus-nucleus potentials is explored in (87BA01). Molecular single-particle effects are studied in an asymmetric two-center shell model in (87MO27). See also (88MI25). The origin of the resonant structure in reaction (b) is treated in (88FR15). The nuclear Landau-Zener effect in reaction (a) is discussed in (88TH02, 88THZZ). Some features in inelastic scattering angular distributions that had been attributed to the existence of nucleon promotion are explained in terms of DWBA calculations by (87VO05).

See also (91TA11, 91TH04).

49. ^{17}O(^{15}N, ^{15}N)^{17}O

See (86AJ04).

50. (a) ^{17}O(^{16}O, ^{16}O)^{17}O
(b) ^{17}O(^{18}O, ^{18}O)^{17}O

Angular distributions involving ^{17}O*(0, 0.87) in reaction (a) have been studied at $E(^{16}O) = 22$ to 32 MeV and $E(^{17}O) = 25.7$ to 32.0 MeV [see (77AJ02)] as well as at $E(^{17}O) = 22$ MeV [see (86AJ04)]. A model independent value of 0.82 ± 0.07 is obtained for the coupling constant of the $1d_{5/2}$ neutron in ^{17}O. A review of magnetic electron scattering on ^{17}O then leads to a spectroscopic factor $S = 1.03 \pm 0.07$. This corresponds to $(91 \pm 7)\%$ of the single-particle value [see (82AJ01, 86AJ04)]. For fusion cross sections see (82AJ01) and (86TH01). The elastic scattering angular distribution in reaction (b) has been reported at $E(^{17}O) = 36$ MeV: see (82AJ01, 86AJ04).

Rotational coupling effects on nucleon molecular orbits in reaction (a) are studied in (87IMZY, 88IM02). See also (87IMZZ). Subbarrier interactions are discussed in (87PO11, 88BE1W). Calculations of Gamow states in a realistic two-center potential are described in (86MI22). Two-particle transfer is studied with a semiclassical approach in (87MA22). Parity dependence in heavy ion collisions is discussed in (86BA69).

51. (a) ^{17}O(^{22}Ne, ^{22}Ne)^{17}O
(b) ^{17}O(^{24}Mg, ^{24}Mg)^{17}O
(c) ^{17}O(^{27}Al, ^{27}Al)^{17}O
(d) ^{17}O(^{40}Ca, ^{40}Ca)^{17}O

See (82AJ01, 86AJ04). Reaction (d) has been described in a two-center shell model (89TH1B). See also (89TH1D).

52. ^{17}F(β^+)^{17}O $\qquad Q_m = 2.760$

See ^{17}F.

53. ^{18}O(p, d)^{17}O $\qquad Q_m = -5.820$

Angular distributions have been measured at a number of energies for $E_p = 17.6$ to 51.9 MeV: see (77AJ02, 82AJ01).

54. ^{18}O(d, t)^{17}O $\qquad Q_m = -1.787$

See Table 17.20. See also reaction 7 in ^{17}N.

55. ^{18}O(^{3}He, α)^{17}O $\qquad Q_m = 12.534$

See Tables 17.16 and 17.21. See also (82AJ01).

56. (a) ^{18}O(^{10}B, ^{11}B)^{17}O $\qquad Q_m = 3.409$
(b) ^{18}O(^{11}B, ^{12}B)^{17}O $\qquad Q_m = -4.674$

Angular distributions (reaction (a)) have been measured at $E(^{18}\text{O}) = 20$ and 24 MeV: see (77AJ02). For S-factor measurements see (77AJ02). Cross sections for reaction (b) are several orders of magnitude less than those for reaction (a) for $E(^{18}\text{O})_{\text{c.m.}} = 3$–7.7 MeV: see (77AJ02).

57. (a) ^{19}F(n, t)^{17}O $\qquad Q_m = -7.557$
(b) ^{19}F(p, ^{3}He)^{17}O $\qquad Q_m = -8.320$

See (77AJ02).

58. ^{19}F(d, α)^{17}O $\qquad Q_{\rm m} = 10.034$

Observed α-groups are displayed in Table 17.14 of (77AJ02). Angular distributions have been measured at many energies in the range $E_{\rm d} = 0.3$ to 27.5 MeV [see (77AJ02)] and at $E_{\rm d} = 2.75$ MeV [see (86AJ04)].

59. (a) ^{19}F(α, ^{6}Li)^{17}O $\qquad Q_{\rm m} = -12.339$
(b) ^{20}Ne(n, α)^{17}O $\qquad Q_{\rm m} = -0.591$

See (77AJ02). See also (88SH1E).

60. ^{23}Na(d, ^{8}Be)^{17}O $\qquad Q_{\rm m} = -0.528$

See (84NE1A).

^{17}F

(Figs. 8 and 9)

GENERAL:
See Table 17.22.

$$\mu = 4.72130 \pm 0.00025 \text{ n.m. (92MI1H)},$$
$$Q = 0.10 \pm 0.02 \text{ b (74MI21)}.$$

1. ^{17}F(β^+)^{17}O $\qquad Q_{\rm m} = 2.760$

The half-life of ^{17}F is 64.49 ± 0.16 s; log $ft = 3.358 \pm 0.002$. The log ft value for the transition to ^{17}O*(0.87) is > 8.6: see (82AJ01, 86AJ04). The β anisotropy has been measured with on-line isotope separation and low-temperature nuclear orientation (88SE11, 88VAZP, 89SE07). See also (88TA1N)

Gamow-Teller matrix elements were calculated for the ^{17}F β^+ decay in the relativistic scalar-vector shell model by (90NE12). The effect of exchange currents arising from quark degrees of freedom was studied by (88TA09). A relativistic analysis of semileptonic weak interactions is described in (87KI22). See also (87BA1U, 88BA1Y, 88BA55, 91NA05).

2. ^{12}C(^{14}N, ^{9}Be)^{17}F $\qquad Q_m = -10.435$

See (82AJ01).

3. ^{14}N(^{3}He, γ)^{17}F $\qquad Q_m = 15.843$

Excitation functions for γ_{0+1}, γ_2 and γ_3 have been studied for $E(^3\text{He}) \approx 3$–18 MeV. Resonances are reported corresponding to ^{17}F states at 20.1 ± 0.2 (γ_2) [$\Gamma = 1.07 \pm 0.16$ MeV], 20.4 ± 0.1 (γ_1) [$\Gamma = 0.7 \pm 0.1$] and 21.3 ± 0.1 MeV (γ_1) [$\Gamma = 0.9 \pm 0.1$] (83WA05): see Table 17.19 in (82AJ01).

4. ^{14}O(α, p)^{17}F $\qquad Q_m = 1.190$

This reaction is important in astrophysical processes. Analytic expressions for reaction rates are given in (88CA1N). The rates are calculated on the basis of $T = 1$ analog structure in ^{18}O and ^{18}Ne by (87WI11). See also the studies of this reaction in the framework of the generator coordinate method by (88FU02, 89FU01).

5. (a) ^{14}N(^{6}Li, t)^{17}F $\qquad Q_m = 0.047$
   (b) ^{14}N(^{6}Li, tα)^{13}N $\qquad Q_m = -5.771$

Angular distributions for reaction (a) involving ^{17}F*(8.43, 10.7, 11.9, 13.51, 14.84) have been measured at $E(^6\text{Li}) = 36$ MeV. For comparisons with the results in the analog reaction ^{14}N(^{6}Li, ^{3}He)^{17}O see (86AJ04). For the earlier work see (82AJ01).

6. ^{15}N(^{3}He, n)^{17}F $\qquad Q_m = 5.010$

Angular distributions have been reported to most of the states of ^{17}F with $E_x < 8.1$ MeV at $E(^3\text{He}) = 3.8$ and 4.8 MeV. Neutron groups have also been reported to ^{17}F states at $E_x = 11.195 \pm 0.007$, 12.540 ± 0.010 and 13.059 MeV, with $\Gamma < 20$, < 25 and < 25 keV, respectively. Angular distributions at $E(^3\text{He}) = 10.36$ and 11.88 MeV lead to $J^\pi = \frac{1}{2}^-$ for ^{17}F*(11.20) [L=0], $\frac{3}{2}^-$ or $\frac{5}{2}^-$ for ^{17}F*(12.54) and $\frac{3}{2}^-$, $\frac{5}{2}^-$ for ^{17}F*(13.06). These three states are probably the first three $T = \frac{3}{2}$ states in ^{17}F (69AD02). The branching ratios for transitions to ^{16}O*(0, 6.05, 6.13) for ^{17}F*(11.20) and for the analog $T = \frac{3}{2}$ state in ^{17}O are displayed in Table 17.16: the ratios of the reduced widths are quite different in the two mirror nuclei. See (77AJ02) for the references.

7. ^{16}O(p, γ)^{17}F $\qquad$ $Q_m = 0.601$

At low energies the direct capture to ^{17}F*(0, 0.50) is observed. Extrapolation of cross-section data leads to S(0) ≈ 8 keV·b: see (77AJ02). In addition to two $T = \frac{1}{2}$ resonances, five resonances corresponding to $T = \frac{3}{2}$ states are observed in the γ_1 and $\gamma_0 + \gamma_1$ yields: see Table 17.24 for the reported parameters. The lowest $T = \frac{3}{2}$ states of even parity at $E_x = 13.27$ and 14.02 MeV [$J^\pi = (\frac{1}{2}^+)$ and $\frac{5}{2}^+$] (see Table 17.24) are not observed here: $\Gamma_\gamma \leq 7$ and ≤ 11.8 eV, respectively (75HA06).

The $(\gamma_0 + \gamma_1)$ yield at 90° has been studied for $E_p = 15.75$ to 31.66 MeV: it shows the giant dipole resonance centered at $E_x = 22$ MeV with a width of ~ 5 MeV and a pygmy resonance centered at 17.5 MeV. The integrated strength of the mainly $T = \frac{1}{2}$ giant resonance is 10 MeV·mb; the observed strength distribution is in good agreement with odd parity 2p-1h, 1p shell excitation calculations. The pygmy resonance is due to $f_{7/2} \rightarrow d_{5/2}$. The main $f_{7/2}$ strength lies in two states at $E_x = 16.9$ and 18.0 MeV (75HA07). The γ_0 yield at 60° for $E_p = 20$ to 100 MeV and differential cross sections at $E_p = 20.8$, 28.35, 49.2 and 49.69 MeV have been measured (88HA04). Differential cross sections have been measured for ^{17}O excitation energies $E_x = 20$–40 MeV by (86AN1H, 88CO10), and it is reported that the (p, γ_0) data indicate a direct capture term and the excitation of giant dipole resonances based on excited states having a probable 2p-1h structure. See also (86PO1D, 87PO1C, 88PO1G). The ^{16}O + p bremsstrahlung cross sections have been measured at $E_p = 2.74$ MeV at 155° by (88PE12). For discussions of the ^{16}O(p, γ)^{17}F reaction in astrophysical processes see the reviews of (85CA41, 87RO1D, 88CA1N), and see (91RA1C).

8. (a) ^{16}O(p, p)^{16}O $\qquad$ $E_b = 0.601$

(b) ^{16}O(p, 2p)^{15}N $\qquad$ $Q_m = -12.127$

(c) ^{16}O(p, pn)^{15}O $\qquad$ $Q_m = -15.663$

(d) ^{16}O(p, pα)^{12}C $\qquad$ $Q_m = -7.161$

Yield curves for elastic protons, protons scattered to ^{16}O*(6.05, 6.13, 6.92, 7.12, 8.87) and for γ-rays from ^{16}O*(6.13, 6.92) have been studied at many energies up to $E_p = 46$ MeV: see (71AJ02, 77AJ02, 82AJ01). The observed resonances are displayed in Table 17.25. Absolute $\sigma(\theta)$ [$\theta = 110°$ to 160°] have been measured for $E_p = 0.60$ to 2.00 MeV to ±5% (83BR11). Cross sections for bremsstrahlung emission are reported in the vicinity of the $E_p = 2.66$ MeV resonance by (83TRZZ, 88PE12, 92DA19). A measurement of the lifetime of the state at $E_x = 3.105$ MeV in ^{17}F is reported in (90GOZN). The cross sections of the 6.13 MeV γ-ray at $E_p = 23.7$ and 44.6 MeV have been measured by (81NA14), and (79SC07) report the σ_t for $E_p = 190$ to 558 MeV. See also (82AJ01).

A_y measurements have been made for inelastic scattering to many excited states of ^{16}O for $E_p = 35$–200 MeV. A_y and spin transfer observables for p_0, p_2, p_3, and p_4 groups have been measured at $E_p = 35$–200 MeV and polarization transfer-coefficients have been studied at $E_p = 200$ MeV to 4^- states of ^{16}O. The spin rotation parameter Q has been measured for the elastic scattering at $E_p = 65$ MeV and 200 MeV. [See references in (86AJ04).] In more recent work, differential cross sections and analyzing powers have been measured at $E_p = 6.4$–7.7 MeV (92WI13), at $E_p = 13.5$ MeV for all narrow states below $E_x = 12.1$ MeV up to a momentum transfer of 3.2 fm^{-1} (89KE03), at $E_p = 35$ MeV (90OH04) and at $E_p = 318$ MeV for states with $E_x < 14$ MeV (91KE02), and at $E_p = 400$ MeV for excitation of the $E_x = 10.957$ MeV 0^-, $T = 0$ state (91KI08). See also (87KE1A, 88SEZU). Quasielastic spin observables for elastic scattering are reported for $E_p = 320$, 400, 500, 650, and 800 MeV. Cross sections and analyzing powers for $0^+ \rightarrow 0^-$ excitations in ^{16}O with $E_p = 200$ MeV are reported in (89SAZZ) See also (86GA31, 87PI02). Cross section measurements for gamma ray production relevant to astrophysics are discussed in (87LA11, 88LE08). See also (88SA1B). For earlier work see (82AJ01, 86AJ04), and see the compilation of cross sections in (86BA1N), and the reviews of (85KI1A, 88ZA06). See also the conference reports (86VD1C, 86YE1B, 87RO1F, 89PLZU).

For reaction (b) see (82REZZ, 85BO1A, 86CH1J, 86KU15, 86SA24, 91CO13). For reaction (c) and for fragmentation see (86AJ04) and see ^{16}O.

In recent theoretical work, a resonating group method study of ^{16}O + p is discussed in (90HA38), the alpha particle model is used to calculate elastic scattering observables in (88BE57, 92LI1D), and a Skyrme force approach to intermediate energy proton scattering is presented in (88CH08). A Dirac coupled-channels analysis for (p, p′) at $E_p = 800$ MeV is described in (88DE35). See also (88DE31, 91PH01). Off-shell effects from meson exchange in the nuclear optical potential are studied in (89EL02). See also the non-relativistic full-folding model descriptions of (90AR03, 90AR11, 90CR02, 90EL01, 91AR1K). Dirac optical potentials are obtained in (88HA08, 90PH02). A comparison of Dirac and Schrödinger descriptions is made in (90CO19). A relativistic microscopic optical potential is derived from the relativistic Brueckner-Bethe-Goldstone equation in (92CH1E). Relativistic effects on quasielastic spin observables are discussed in (88HO1K). Non relativistic multiple scattering theory is used for elastic scattering at $E_p = 800$ MeV in (87LU04). See also (92BE03). Effective interactions for elastic scattering above 300 MeV are discussed in (90RA12). A second-order relativistic impulse approximation model is used for $E_p = 500$ and 800 MeV in (88LU03). See also (88OT04). An empirical effective interaction for excitation of ^{16}O by 135 MeV protons is discussed in (89KE05). The excitation of the 7.12 dipole state in ^{16}O is shown to be non-collective (88AM03). Effects of vacuum polarization and Pauli blocking are treated in (88OT05). A review of relativistic theory of nuclear matter is presented in (88MA1X). Spin-independent isoscalar response functions and interpretation of polarization-transfer measurements are discussed in (86OR03). Recoil effects in the coordinate space Dirac equation have been studied (87OT02). Effects of short range correlations on the self energy in the optical model are studied by (92BO04). See also the calculation of (92OL02) concerning resonance shapes and the $A = 17$ theoretical discussion at the beginning of this compilation.

9. ^{16}O(p, n)^{16}F $\qquad Q_m = -16.199 \qquad E_b = 0.6005$

The analyzing power for the transition to the 4^- state $^{16}F^*(6.37)$ has been measured at $E_p = 135$ MeV (82MA11). See also (83WA29). More recently, polarization observables have been measured at $E_p = 135$ MeV by (89WAZZ). See also ^{16}F.

10. $^{16}O(p, d)^{15}O$ $\quad Q_m = -13.439$ $\quad E_b = 0.601$

The excitation function for d_0 at $\theta = 70°$ has been measured for $E_p = 21$ to 38.5 MeV. A strong resonance is observed at $E_p = 24$ MeV: see Table 17.25. The analyzing power has been measured for the d_0 group at $E_p = 65$ MeV (80HO18). Cross sections and analyzing powers have been measured at $E_p = 200$ MeV for the $\frac{1}{2}^-$ (ground state) and $\frac{3}{2}^-$ (6.18 MeV) levels in ^{15}O. See also (89WA16) and see (82AJ01) for the earlier work.

11. (a) $^{16}O(p, t)^{14}O$ $\quad Q_m = -20.404$ $\quad E_b = 0.601$
(b) $^{16}O(p, {}^3He)^{14}N$ $\quad Q_m = -15.242$

See (82AJ01) and ^{14}N, ^{14}O in (86AJ01).

12. $^{16}O(p, \alpha)^{13}N$ $\quad Q_m = -5.217$ $\quad E_b = 0.601$

Observed resonances are displayed in Table 17.25. Some broad structures have been reported above $E_p \approx 15$ MeV; particularly strong peaks appear at $E_p \approx 22$ and 25.5 MeV: see (77AJ02). Total cross sections were measured by the activation method up to $E_p = 30$ MeV by (89WA16).

This reaction is involved in explosive burning in stars. Numerical values of thermonuclear reaction rates are tabulated in (85CA41). See (77AJ02, 82AJ01) for the earlier work and see (79MO04).

13. $^{16}O(d, n)^{17}F$ $\quad Q_m = -1.623$

Parameters of the first excited state of ^{17}F are $E_x = 495.33 \pm 0.10$ keV, $\tau_m = 407 \pm 9$ ps: see (71AJ02). See also Table 17.21 in (71AJ02). For polarization measurements see (81LI23) and ^{18}F in (83AJ01). See also (86AJ04, 89VI1E). This reaction has been used in analysis of oxygen in flouride glasses (90BA1M).

14. $^{16}O({}^3He, d)^{17}F$ $\quad Q_m = -4.893$

At $E(^3\text{He})$ = 18 MeV, angular distributions of the deuterons to ^{17}F*(0, 0.50, 3.104±0.003, 3.857±0.004) have been measured. The spectroscopic factors for ^{17}F*(0, 0.50) are 0.94 and 0.83. Two-step processes appear to be involved in the excitation of ^{17}F*(3.10, 3.86). Angular distributions have also been measured at $E(^3\text{He})$ = 30 MeV (to ^{17}F*(5.1, 5.7)) and at $E(^3\text{He})$ = 33 MeV (d_0, d_1): see (82AJ01) for references.

15. ^{16}O(^{7}Li, ^{6}He)^{17}F $Q_m = -9.733$

Angular distributions for ^{6}He leading to the ^{17}F $\frac{5}{2}^+$ ground state were measured at E_{lab} = 34 MeV (88KE07). The data are structureless and are neither described by finite range DWBA nor by coupled-channels Born approximation calculations.

16. (a) ^{16}O(^{10}B, ^{9}Be)^{17}F $Q_m = -5.985$
(b) ^{16}O(^{11}B, ^{10}Be)^{17}F $Q_m = -10.627$
(c) ^{16}O(^{12}C, ^{11}B)^{17}F $Q_m = -15.356$
(d) ^{16}O(^{13}C, ^{12}B)^{17}F $Q_m = -16.932$
(e) ^{16}O(^{14}N, ^{13}C)^{17}F $Q_m = -6.950$
(f) ^{16}O(^{16}O, ^{15}N)^{17}F $Q_m = -11.526$

See (82AJ01, 86AJ04). Measurements of $\sigma(\theta)$ vs. Q-value for reaction (f) were made at E_{lab} = 72 MeV by (88AU03). Results were not compatible with a low-ℓ fusion window.

17. ^{17}O(p, n)^{17}F $Q_m = -3.542$

At E_p = 135.2 MeV differential cross sections are reported for the transitions to ^{17}F*(0, 0.5 ± 0.05, 4.84 ± 0.1, 5.89 ± 0.2, 6.34 ± 0.2, 7.26 ± 0.2, 7.64 ± 0.2, 9.3 ± 0.1, 14.3 ± 0.1). [Note known density of states.] The group to ^{17}F*(4.84) has $\Gamma = 1.8 \pm 0.05$ MeV (85PU1A). For a discussion of Gamow-Teller transition probabilities see (85WA24). For A_y measurements see (83PUZZ, 85PU1A). For the earlier work see (82AJ01).

18. ^{17}O(^{3}He, t)^{17}F $Q_m = -2.779$

Angular distributions have been studied at $E(^3\text{He})$ = 17.3 MeV [t_0, t_1]. Angular distributions and analyzing powers were measured at $E(^3\text{He})$ = 33 MeV [t_0]: see (82AJ01).

19. ^{17}F(p, γ)^{18}Ne $\qquad Q_{\mathrm{m}} = 3.921$

A $J^{\pi} = 3^{+}$ level in ^{18}Ne at $E_{\mathrm{x}} = 4.561 \pm 0.009$ MeV is reported in (91GA03), and the effects of this result on the ^{17}F(p, γ) thermonuclear reaction rate as well as astrophysical consequences are discussed.

20. ^{17}Ne(β^{+})^{17}F $\qquad Q_{\mathrm{m}} = 14.529$

See ^{17}Ne and Table 17.27.

21. ^{18}O(^{18}O, ^{19}N)^{17}F $\qquad Q_{\mathrm{m}} = -19.386$

See (83DE1A).

22. ^{19}F(p, t)^{17}F $\qquad Q_{\mathrm{m}} = -11.099$

See (77AJ02).

23. ^{20}Ne(p, α)^{17}F $\qquad Q_{\mathrm{m}} = -4.133$

Thermonuclear reaction rates for this reaction and other astrophysically important thermonuclear reactions are tabulated in (85CA41). Analytic expressions for the reaction rates are given in (88CA1N). See also the study of processes and effects in (89GU1I), and see (77AJ02) for earlier work.

24. ^{26}Mg(^{18}O, ^{27}Na)^{17}F $\qquad Q_{\mathrm{m}} = -13.347$

See (85FI08).

^{17}Ne

(Fig. 9)

1. (a) ^{17}Ne(β^+)^{17}F* $\rightarrow$ ^{16}O + p $Q_m = 13.928$
   (b) ^{17}Ne(β^+)^{17}F $\rightarrow$ ^{13}N + α $Q_m = 8.711$
   (c) ^{17}Ne(β^+)^{17}F $Q_m = 14.529$

The half-life of ^{17}Ne has been reported as 109.0 ± 1.0 ms (71HA05) and 109.3 ± 0.6 ms (88BO39): the weighted mean is 109.2 ± 0.6 and we adopt it. The decay is primarily to the proton unstable states of ^{17}F at 4.65, 5.49, 6.04 and 8.08 MeV with $J^\pi = \frac{3}{2}^-, \frac{3}{2}^-, \frac{1}{2}^-$ and $\frac{3}{2}^-$, but decay to alpha unstable states has also been observed: see Table 17.27. The super-allowed decay to the analog state [^{17}F*(11.20)] has $\log ft = 3.29^{+0.04}_{-0.07}$. The character of the decay leads to $J^\pi = \frac{1}{2}^-$ for ^{17}Ne$_{\rm g.s.}$ (71HA05). See Table 17.6 for a comparison of the mirror ^{17}N and ^{17}Ne decays and Table 17.16 for the decay of ^{17}F*(11.20). See also (86AJ04), and see the recent analysis of GT beta-decay rates of (93CH1A).

^{17}Na

(Not illustrated)

^{17}Na has not been observed: its mass excess is predicted to be 35.61 MeV by (66KE16). It is then unbound with respect to breakup into ^{16}Ne + p by 4.3 MeV and with respect to breakup into ^{14}O + 3p by 5.7 MeV (86AJ04). See also (83ANZQ, 85AN28, 88WA18, 92AV1B).

^{17}Mg, ^{17}Al, ^{17}Si, ^{17}P

(Not observed)

See (83ANZQ, 88WA18, 92AV1B).

Table 17.1
Beta decay of ^{17}C [a])

^{17}N state		
J^{π}_{n}	$E_{\rm x}$ (keV)	Branch(%) [b])
$\frac{3}{2}^-$	1374	21(10)
$\frac{1}{2}^+$	1850	40(7)
$\frac{5}{2}^-$	1907	20(8)
$\frac{5}{2}^+$	2526	19(9)

[a]) (86DU07). See also (89WA06).
[b]) These intensities are relative ones for decay to bound states. To obtain absolute intensities, one would scale by a factor $(1 - {\rm P_n})$ where the fraction of decays leading to neutron-unstable states ${\rm P_n} = 0.320 \pm 0.027$ (91RE02).

Table 17.2
Energy levels of ^{17}N [a])

E_x in ^{17}N (MeV ± keV)	$J^\pi; T$	τ or Γ	Decay	Reactions
0	$\frac{1}{2}^-; \frac{3}{2}$	$\tau_{1/2} = 4.173 \pm 0.004$ s	β^- [b])	1–8
1.3739 ± 0.3	$\frac{3}{2}^-$	$\tau_m = 93 \pm 35$ fs	γ	3, 5–8
1.8496 ± 0.3	$\frac{1}{2}^+$	41^{+20}_{-9} ps	γ	3, 5–8
1.9068 ± 0.3	$\frac{5}{2}^-$	11 ± 2 ps	γ	3–8
2.5260 ± 0.5	$\frac{5}{2}^+$	33 ± 3 ps	γ	3–5, 7, 8
3.1289 ± 0.5	$\frac{7}{2}^-$	275 ± 80 ps	γ	3, 5, 7, 8
3.2042 ± 0.9	$\frac{3}{2}^-$	< 30 fs	γ	3, 5, 7, 8
3.6287 ± 0.7	$(\frac{7}{2}, \frac{9}{2})^-$ [c])	12 ± 2 ps	γ	3–5
3.663 ± 4	$\frac{1}{2}^-$	< 350 fs	γ	3, 5
3.9060 ± 2.0	$(\frac{3}{2}, \frac{5}{2})^-$ [c])	52 ± 22 fs	γ	3, 5
4.0064 ± 2.0	$\frac{3}{2}^{(+)}$ [c])	< 15 fs	γ	3–5, 7
4.209 ± 3	$\frac{5}{2}^+$	< 70 fs	γ	3, 5
4.415 ± 3	$(\frac{3}{2}, \frac{5}{2})^-$ [c])	$(< 60$ fs$)$	γ	3, 5
5.170 ± 2	$(\frac{9}{2}^+)$ [c])	< 60 fs	γ	3–5, 7
5.195 ± 3	$\frac{3}{2}^+$ [c])	< 95 fs	γ	3, 5
5.515 ± 3	$\frac{3}{2}^-$	< 100 fs	γ	3, 5, 7
5.772 ± 3	$\frac{1}{2}, \frac{3}{2}^+$ [c])	< 120 fs	γ	3, 5
(6.08 ± 30)				3
6.233 ± 8				3, 5
6.449 ± 3				3, 5
6.615 ± 19				3, 5
6.938 ± 15				5
6.981 ± 20	$\frac{3}{2}^-$ [c])			3, 5, 7
7.013 ± 22				3, 5, 7
7.17 ± 40				3
7.37 ± 40				3
7.63 ± 40				3
7.73 ± 40				3
8.00 ± 25				3
8.14 ± 40				3
8.55 ± 40		broad		3
8.93 ± 40		broad		3
9.26 ± 40		broad		3
9.74 ± 40		broad		3
10.14	$(\frac{1}{2}, \frac{3}{2})^-$			7

[a]) See also (84BA24) and Table 17.3.
[b]) See also Tables 17.4 and 17.5.
[c]) Arguments presented in the appendix of (89WA06) favor assigments (E_x(MeV), J^π) = (3.629, $\frac{9}{2}^-$; 3.906, $\frac{5}{2}^-$; 4.006, $\frac{3}{2}^+$; 4.415, $\frac{5}{2}^-$; 5.170, $\frac{9}{2}^+$; 5.195, $\frac{3}{2}^+$; 5.772, $\frac{3}{2}^+$).

Table 17.3
Analog correspondences and structure of states in ^{17}N and ^{17}O [a]

J^π	$E_x(^{17}\text{N})$	$E_x(^{17}\text{O})$	Configuration
$\frac{1}{2}^-$	0.000	11.078	$p_{1/2}^{-1} \otimes (sd)^2; 0_1^+$
$\frac{3}{2}^-$	1.374	12.466	$p_{1/2}^{-1} \otimes (sd)^2; 2_1^+$
$\frac{5}{2}^-$	1.907	12.998	$p_{1/2}^{-1} \otimes (sd)^2; 2_1^+$
$\frac{7}{2}^-$	3.129	14.230	$p_{1/2}^{-1} \otimes (sd)^2; 4_1^+$
$\frac{9}{2}^-$	3.629	14.760	$p_{1/2}^{-1} \otimes (sd)^2; 4_1^+$
$\frac{3}{2}^-$	3.663	14.791	$p_{1/2}^{-1} \otimes (sd)^2; 0_2^+$
$\frac{3}{2}^-$	3.204	14.286	$p_{1/2}^{-1} \otimes (sd)^2; 2_2^+$
$\frac{5}{2}^-$	3.906	[b]	$p_{1/2}^{-1} \otimes (sd)^2; 2_2^+$
$\frac{5}{2}^-$	4.415	[b]	$p_{1/2}^{-1} \otimes (sd)^2; 3_1^+$
$\frac{7}{2}^-$	[b]	[b]	$p_{1/2}^{-1} \otimes (sd)^2; 3_1^+$
$\frac{3}{2}^-$	5.515	16.580	$p_{1/2}^{-1} \otimes (sd)^2; 0_1^+$
$\frac{1}{2}^+$	1.850	12.944	$^{14}\text{C}(gs) \otimes {}^{19}\text{F}(gs)$
$\frac{5}{2}^+$	2.526	13.635	$^{14}\text{C}(gs) \otimes {}^{19}\text{F}(0.197)$
$\frac{3}{2}^+$	4.006	15.199	$^{14}\text{C}(gs) \otimes {}^{19}\text{F}(1.554)$
$\frac{5}{2}^+$	4.209	15.368	
$\frac{9}{2}^+$	5.170	16.243	$^{14}\text{C}(gs) \otimes {}^{19}\text{F}(2.780)$
$\frac{3}{2}^+$	5.195	[b]	

[a]) This information was provided by D.J. Millener in a private communication.
[b]) Uncertain.

Table 17.4
Radiative transitions and lifetimes of ^{17}N states [a]

E_i (MeV)	E_f (MeV)	Mtpl.	Branch (%)	Γ_γ/Γ_w [b] (W.u.)	τ_m
1.37	0	M1	100	0.13 ± 0.05	95 ± 35 fs
1.85	0	E1	86.5 ± 2.5		41^{+20}_{-9} ps
	1.37	E1	13.5 ± 2.5	$(3.2 \pm 1.5) \times 10^{-5}$	
1.91	0	E2	77.0 ± 2.5	0.9 ± 0.2	11 ± 2 ps
	1.37	M1	23.0 ± 2.5	$(5 \pm 1) \times 10^{-3}$ [c]	
2.53	0	M2	11 ± 1	0.22 ± 0.04	33 ± 3 ps
	1.37	E1	34 ± 3	$(1.0 \pm 0.2) \times 10^{-5}$	
	1.85	E2	12.0 ± 1.5	8.1 ± 1.6	
	1.91	E1	41.0 ± 2.5		
3.13 [d]	1.91	M1	100	0.06 ± 0.02	275 ± 80 fs
3.20 [e]	0	M1	88 ± 4	> 0.025 [f]	< 30 fs
	1.91	M1	12 ± 4	> 0.05	
3.63 [g]	1.91	E2	47 ± 10	0.8 ± 0.2	12 ± 2 ps
	3.13	M1	53 ± 10	0.010 ± 0.03	
3.66	1.85	E1	100	$> 7 \times 10^{-4}$	< 350 fs
3.91	1.91	M1	100	$(8^{+5}_{-3}) \times 10^{-2}$	52 ± 22 fs
4.01	1.85		$\geq 15 \pm 5$ [h]		
	2.53	(M1)	85 ± 5	0.55	< 15 fs
4.21	1.37		100		< 70 fs
4.42	1.91		100		(< 60 fs)
5.17	2.53	E2	37 ± 7	> 15	< 60 fs
	3.13		63 ± 7		
5.20	1.85		~ 42		< 95 fs
	1.91		~ 58		
5.52	0		~ 50		< 100 fs
	1.37		~ 50		
5.77	1.37		~ 25		< 120 fs
	1.91		~ 25		
	4.01		~ 50 [h]		

[a]) See Tables 17.5 in (77AJ02, 82AJ01) for references and additional detail.
[b]) Assuming pure multipole transitions and J^π from Table 17.2: see also Table 2.
[c]) $\Gamma_\gamma/\Gamma_w = 0.4^{-0.4}_{+1.3}$ (E2).
[d]) Branches to ^{17}N*(0,1.37,1.85, 2.53) are, respectively, < 2, < 5, < 2 and < 3%.
[e]) Branches to ^{17}N*(1.37, 1.85, 2.53) are, respectively, < 5, < 6 and < 3%.
[f]) $\delta = -0.06 \pm 0.08$ or 2.1 ± 0.4. All other δ are consistent with 0.
[g]) Branches to ^{17}N*(0, 1.37, 1.85, 2.53, 3.20) are, respectively, < 10, < 10, < 7, < 3, < 2%.
[h]) This branch is uncertain.

Table 17.5
Beta decay of ^{17}N [a]

Decay to ^{17}O*(keV)	J^π	Branch(%)	log ft
0	$\frac{5}{2}^+$	1.6 ± 0.5	7.29 ± 0.11 [f]
871	$\frac{1}{2}^+$	3.0 ± 0.5	6.80 ± 0.07
3055.2 ± 0.3 [b]	$\frac{1}{2}^-$	0.34 ± 0.06	7.08 ± 0.08
3841	$\frac{5}{2}^-$	$< 7 \times 10^{-3}$	> 8.5
4551.2 ± 1.3 [c]	$\frac{3}{2}^-$	38.0 ± 1.3 [e]	4.41 ± 0.02
5083 ± 21 [c]	$\frac{3}{2}^+$	0.6 ± 0.4	5.9 ± 0.5
5389.0 ± 1.2 [c,d]	$\frac{3}{2}^-$	50.1 ± 1.3 [e]	3.86 ± 0.02
5738	$(\frac{1}{2}^+)$	< 0.23	> 6.0
5868	$\frac{3}{2}^+$	< 0.15	> 6.0
5951.8 ± 1.9 [c,d]	$\frac{1}{2}^-$	6.9 ± 0.5 [e]	4.35 ± 0.03
6356	$\frac{1}{2}^+$	< 0.08	> 6.0

[a]) See Table 17.3 in (86AJ04) and Table 17.2 in (82AJ01) for references and additional information.
[b]) Direct ground state decay $< 1.5\%$.
[c]) From neutron groups. [The E_x were calculated on the basis of 4144.3 ± 0.8 keV for E_b for a neutron in ^{17}O.] Γ_n for ^{17}O*(4.55, 5.08, 5.38, 5.94) are, respectively, 54.8 ± 0.4, 113 ± 55, 63.2 ± 1.1 and 60.5 ± 3.2 keV. See also Table 17.17.
[d]) See, however, Tables 17.17 and 17.10.
[e]) Calculated to lead to a total neutron emission probability of $(95 \pm 1)\%$ [100% less the branches to ^{17}O*(0, 0.87, 3.06)].
[f]) $\log f_1 t = 9.56 \pm 0.13$ (71TO08).

Table 17.6
Comparison of ^{17}N and ^{17}Ne β-decay [a]

Final state in		J^π	Γ_n [b,c]	Γ_p [b]	$(ft)^-$ [d,e]	$(ft)^+$ [d]	δ [f]
^{17}O	^{17}F		(keV)	(keV)			
3.06	3.10	$\frac{1}{2}^-$	0	19	$(1.2 \pm 0.2) \times 10^7$	$(1.3^{+0.2}_{-0.3}) \times 10^7$	0.1 ± 0.3
4.55	4.70	$\frac{3}{2}^-$	55	230	$(2.57 \pm 0.13) \times 10^4$	$(3.79 \pm 0.07) \times 10^4$	0.47 ± 0.08
5.38	5.52	$\frac{3}{2}^-$	63	69	$(7.2 \pm 0.3) \times 10^3$	$(6.51 \pm 0.12) \times 10^3$	-0.10 ± 0.04
5.94	6.04	$\frac{1}{2}^-$	61	28	$(2.24 \pm 0.16) \times 10^4$	$(3.53 \pm 0.11) \times 10^4$	0.58 ± 0.12

[a]) (88BO39). See also Table 17.4 in (86AJ04) and see Table 17.3 in (82AJ01) for references.
[b]) Γ_n and Γ_p are the neutron and proton widths of the ^{17}O and ^{17}F states, respectively.
[c]) Γ_n for ^{17}O*(4.55, 5.08, 5.38, 5.94) are reported to be, respectively, 54.8 ± 0.4, 113 ± 55, 63.2 ± 1.1 and 60.5 ± 3.2 keV.
[d]) $(ft)^-$ and $(ft)^+$ are for the ^{17}N and ^{17}Ne decays, respectively.
[e]) See Tables 17.5 and 17.27.
[f]) $\delta \equiv [(ft)^+/(ft)^-] - 1$.

Table 17.7
Excited states of ^{17}N from ^{11}B(^{7}Li, p), ^{18}O(d, ^{3}He) and ^{18}O(t, α) [a])

E_x (keV): A	E_x (keV): B	l	J^π	C^2S
	0	1	$\frac{1}{2}$	2.02
1373.7 ± 0.5	1374.1 ± 0.4	1	$\frac{3}{2}^-$	0.38
1850.0 ± 0.5	1849.5 ± 0.3	0	$\frac{1}{2}^+$	0.41 ± 0.14
1906.8 ± 0.4	1906.9 ± 0.5		$\frac{5}{2}^-$	
2526.3 ± 1.0	2525.9 ± 0.6	2	$\frac{5}{2}^+$	0.53 ± 0.17
3128.7 ± 0.6	3129.2 ± 0.6		$\frac{7}{2}^{(-)}$	
3203 ± 2	3204.4 ± 0.9	1	$\frac{3}{2}^-$	0.05
3628.7 ± 0.7			$> \frac{3}{2}$ [d])	
3663 ± 4			$(\frac{1}{2}, \frac{3}{2})^-$	
3906.0 ± 2.0			$\leq \frac{7}{2}$	
4006.4 ± 2.0	4000	(1)	$\frac{3}{2}^{(-)}$	0.04
4208 ± 3			$\leq \frac{5}{2}$	
4415 ± 3			$\leq \frac{7}{2}$	
5170 ± 2	5170	(2)	$\frac{3}{2} \leq J \leq \frac{9}{2}$ [e])	0.08
5195 ± 3			$(\frac{1}{2}, \frac{3}{2}, \frac{5}{2})^+$	
5514 ± 3	$\equiv 5523$	1	$\frac{3}{2}^-$	1.83
5770 ± 3			$\leq \frac{7}{2}$	
6080 ± 30				
6240 ± 25				
6430 ± 30				
6610 ± 25				
6990 ± 20	6990 [c])	1	$\frac{3}{2}^-$ [f])	0.32
7170 ± 40				
7370 ± 40				
	7510	(1)	$(\frac{1}{2}, \frac{3}{2})^-$	0.09
7630 ± 40				
7730 ± 40				
8000 ± 25				
8140 ± 40				
8550 ± 40 [b])				
8930 ± 40				
9260 ± 40				
9740 ± 40				
	10140	(1)	$(\frac{1}{2}, \frac{3}{2})^-$	0.5

A: ^{11}B(^{7}Li, p)^{17}N; B: ^{18}O(t, α)^{17}N and ^{18}O(d, ^{3}He)^{17}N.

[a]) See also Tables 17.4 in (77AJ02, 82AJ01) for references and additional information. See also (81MA1A).

[b]) This state and the ones below are broad.

[c]) Unresolved.

[d]) Probably $(\frac{7}{2}, \frac{9}{2})^-$.

[e]) Probably $(\frac{7}{2}, \frac{9}{2})^+$.

[f]) See (81MA1A) for confirmation of $J^\pi = \frac{3}{2}^-$ for $E_x = 1.37, 5.51, 6.99$ MeV.

Table 17.8
States of ^{17}N from ^{15}N(t, p) [a]

E_x (keV)	L	J^π	E_x (keV)	L	J^π
0 [b]	0	$\frac{1}{2}^-$	4420 ± 7 [b]	2	$(\frac{3}{2}, \frac{5}{2})^-$
1372 ± 6 [b]	2	$(\frac{3}{2}, \frac{5}{2})^-$	5179 ± 4 [c]	5	$(\frac{9}{2}^+)$
1851 ± 4	1	$(\frac{1}{2}, \frac{3}{2})^+$		1	$((\frac{1}{2}, \frac{3}{2})^+)$
1909 ± 3 [b]	2	$(\frac{3}{2}, \frac{5}{2})^-$	5517 ± 6	(2)	
2524 ± 4	3	$(\frac{5}{2}, \frac{7}{2})^+$	5780 ± 6	(1)	
3127 ± 6 [b]	4	$(\frac{7}{2}, \frac{9}{2})^-$	6233 ± 8 [d]	(2)	
3201 ± 5 [b]	2	$(\frac{3}{2}, \frac{5}{2})^-$	6449 ± 3	(4, 5)	
3625 ± 6 [b]	4	$(\frac{7}{2}, \frac{9}{2})^-$	6627 ± 30	weak	
3664 ± 6 [b]	0	$\frac{1}{2}^-$	6938 ± 15		
3906 ± 5 [b]	2	$(\frac{3}{2}, \frac{5}{2})^-$	6981 ± 20	(3, 4)	
4011 ± 6	(1)		7013 ± 22		
4213 ± 6	3	$\frac{5}{2}^+$ [e]			

[a]) (79FO14): $E_t = 15.0$ MeV; DWBA analysis.
[b]) Predominantly 2p-1h states.
[c]) Unresolved states.
[d]) ^{17}N*(6.08) is not observed.
[e]) The $\frac{7}{2}^+$ possibility can be eliminated because the 4.21 $\rightarrow$ 1.37 MeV transition would then have too large an M2 strength ($>$ 500 W.u.). See (86AJ04).

Table 17.9
^{17}O – General

Reference	Description
	Shell Model
86BO1C	Argument for modification of the accepted values for single-particle energies in ^{17}O
86ED03	Particle-hole description of dipole states in ^{17}O
86YA1B	Effective shell-model operators; calculated D-shell splitting
87BR30	Empirically optimum M1 operator for sd-shell nuclei
87LI1F	Double delta & surface delta interactions & spectra of O isotopes in the (s-d) shell (A)
88BR11	Semi-empirical effective interactions for the 1s-0d shell
88MI1J	Shell model transition densities for electron & pion scattering
89OR02	Empirical isospin-nonconserving hamiltonians for shell-model calculations
89WU1C	Contribution of the 2p-1h multiple scattering correlation to spectra of ^{17}O & ^{15}O (A)
90LI1Q	Contrib. of 2h-1p multiple scat. correl. & self-screening effect to spectra of ^{17}O & ^{15}O
91SK02	Effective transition operators in the sd shell
92JA13	Kinetic-energy operator in the effective shell-model interaction applied to ^{16}O & ^{17}O
92KW01	Clustering of 1p-shell nuclei in the framework of the shell model
92WA22	Effective interactions for the 0p1s0d nuclear shell-model space
92ZH07	Magnetic moments & form factors of ^{17}O and ^{41}Ca
	Collective and Cluster Models
91LI41	Equilibrium deformation & pairing force calculated for $A = 17$–29 nuclei (Nilsson levels)
92BA50	Vertex constants & the nucleon-nucleon potential in the generator coordinate method
92JA13	Kinetic-energy operator in the effective shell-model interaction applied to ^{16}O & ^{17}O
92KW01	Clustering of 1p-shell nuclei in the framework of the shell model
92NA04	Shell-model operator for K(j)-band splitting in odd-A nuclei
	Special States
86AN07	Predicted masses and excitation energies in higher isospin multiplets for $9 \leq A \leq 60$
86BO1C	Argument for modification of the accepted values for single-particle energies in ^{17}O
86CA27	Quadrupole moments of sd-shell nuclei
86ED03	Particle-hole description of dipole states in ^{17}O
87LI1F	Double delta & surface delta interactions & spectra of O isotopes in the (s-d) shell (A)
88MI1J	Shell model transition densities for electron & pion scattering
89BA60	Investigation of E1 strength in Coulomb excitation of light nuclei
89JI1D	Strength of tensor force and s-d-shell effective interactions
89OR02	Empirical isospin nonconserving hamiltonians for shell-model calculations
89WU1C	Contribution of the 2p-1h multiple scattering correlation to the spectra of ^{17}O & ^{15}O (A)
	Electromagnetic transitions and giant resonances
86CA27	Quadrupole moments of sd-shell nuclei
86ED03	Particle-hole description of dipole states in ^{17}O
86TO13	Isovector magnetic quadrupole strengths in ^{17}O; microscopic 2p-1h model
87BR30	Empirically optimum M1 operator for sd-shell nuclei

Table 17.9
^{17}O – General

Reference	Description
	Electromagnetic transitions and giant resonances (continued)
89BA60	Investigation of E1 strength in Coulomb excitation of light nuclei
91SK02	Effective transition operators in the sd shell
92ZU01	Giant dipole resonance in ^{17}O observed with the (γ, p) reaction
92ZU1B	Errata of 92ZU01
	Astrophysical questions
86LA1C	Chemical composition (including O) of 30 cool carbon stars in the galactic disk
87DO1A	^{12}C/^{13}C & ^{16}O/^{17}O isotopic ratios in seven evolved stars (types MS, S & SC)
87HA1D	Oxygen isotopic abundances in 26 evolved Carbon stars
87MC1A	Oxygen isotopes in refractory stratospheric dust particles: proof of extraterrestrial origin
87WA1F	Abundances in red giant stars: C & O isotopes in C-rich molecular envelopes
88DU1B	Spectrophotometry & chemical composition of the O-poor bipolar nebula NGC 6164-5
89BO01	Accurate energy deter. of 5673-keV state in ^{18}F & implications in ^{17}O nucleosynthesis
89JI1A	Nucleosynthesis inside thick accretion disks around massive black holes
89LA19	^{17}O(^{3}He, d)^{18}F reaction & its implication in ^{17}O destruction in the CNO cycle in stars
89ME1C	Isotope abundances of solar coronal material derived from solar energetic particle meas.
90LA1J	Revised reaction rates for H-burning of ^{17}O & oxygen isotopic abundances in red giants
91PA1C	Extremum problem treatment of C, N & O abundances in late-type star atmospheres (A)
91SA1F	Extragalactic ^{18}O/^{17}O ratios imply high-mass stars preferred in starburst systems
	Applications
89TA1Y	Separation of nitrogen & oxygen isotopes by liquid chromatography
92LA08	Ion beam analysis of laser-irradiated borosilicate glass
	Complex reactions involving ^{17}O
Review:	
88BE14	Heavy ion excitation of giant resonances
Other Articles:	
86BA13	Electromagnetic decay of giant quadrupole resonances of ^{208}Pb via inelastic ^{17}O scat.
86MA1O	Study of breakup for light neutron rich projectiles (A)
86ME06	Quasi-elastic, deep-inelastic, quasi-compound nucleus mechanisms from ^{89}Y + ^{19}F
86SC29	Partition of excitation energy in peripheral heavy-ion reactions
87BE02	Excitation of the high energy nuclear continuum in ^{208}Pb by 22 MeV/u ^{17}O & ^{32}S
87LI04	Multistep effects in ^{17}O + ^{208}Pb near the Coulomb barrier
87NA01	Linear momentum & angular momentum transfer in ^{154}Sm + ^{16}O
87RI03	Isotopic distributions of fragments from ^{40}Ar + ^{68}An at $E = 27.6$ MeV/u
88AN1C	Multiple angular scattering of ^{16,17}O, ^{40}Ar, ^{86}Kr & ^{100}Mo at 20–90 MeV/u
88BA39	Coulomb excitation of giant resonances in ^{208}Pb by $E = 84$ MeV/u ^{17}O projectiles
88BE15	γ-decay of isoscalar & isovector giant resonances following heavy ion inelastic scat.
88BE56	Formation of light nuclei in ^{11}B & ^{20}Ne induced reactions at energies of 18–20 MeV/u

Table 17.9
^{17}O – General

Reference	Description
	Complex Reactions (continued)
88GA11	Neutron pickup & 4-body processes in reactions of $^{16}O + ^{197}Au$ at 26.5 & 32.5 MeV/u
88HO04	Characterization of GQR in ^{208}Pb as reported from π^-/π^+ vs. $^{16}O/^{17}O$ scat.
89SA10	Total cross sections of reactions induced by neutron-rich light nuclei
89TE02	Dissipative mechanisms in the 120 MeV $^{19}F + ^{64}Ni$ reaction
89YO02	Quasi-elastic & deep inelastic transfer in $^{16}O + ^{197}Au$ for $E < 10$ MeV/u
	Hypernuclei
86MO1A	The ΛN interaction & structures of the ^{16,17,18}O hypernuclei
87CO1E	Hypernuclear currents in a relativistic mean-field theory
88IT02	Pi-mesonic decay of hypernuclei & pion wavefunction
88MA1W	Pions in nuclear interior: sensitive test by hypernuclear decay
89BA1E	Production of hypernuclei in relativistic ion beams
89BA2N	Strangeness production by heavy ions
89MA30	Λ-hyperon(s) in the nuclear medium; relativistic mean field theory analysis
91KO1C	Calculation of low-excited states of $^{13}_{\Lambda}C$ & $^{17}_{\Lambda}O$ lambda hypernuclei
	Antiproton interactions
Reviews:	
87GR1I	Low energy antiproton physics in the early LEAR era
Other Articles:	
86DU10	Microscopic calculation of antiproton atomic-like bound states in light nuclei
86KO1E	Search for $\bar{p}$-atomic X-rays; observed spin-dependence of $\bar{p}$-nucleus interaction (LEAR)
86RO23	Meas. of the $4f$ strong interaction level width in light antiprotonic atoms (LEAR)
87GR20	Widths of $4f$ antiprotonic levels in the O region & Dover-Richard potential shell model
87HA1J	Widths of $4f$ antiprotonic levels in the O region using realistic wavefunctions
87SP05	Spin & isospin efcts. in a relativ. impulse approx. treatment of $\bar{p}$-atom shifts & widths
92PY1A	High-precision calculations of nuclear quadrupole moments for light nuclei
	Ground State Properties
86CA27	Quadrupole moments of sd-shell nuclei
86MC13	Resolution of the magnetic moment problem in relativistic theories
86TO1A	Weak interaction probes of light nuclei
86WU1B	Charge dependence of Brueckner's G-matrix & Nolen-Schiffer-Okamoto anomaly (A)
87AB03	Measurement & folding-potential analysis of the elastic α-scattering on light nuclei
87BR30	Empirically optimum M1 operator for sd-shell nuclei
87CH1E	Nuclear binding & quark confinement; calculated Nolen-Schiffer anomaly
87FU06	Nuclear currents in a relativistic mean-field theory
87IC02	Isoscalar currents & nuclear magnetic moments
88AR1I	Relativistic & quark contributions to nuclear magnetic moments

Table 17.9
^{17}O – General

Reference	Description
	Ground State Properties (continued)
88CH1T	Microscopic calculation of ^{15}O–^{15}N, ^{17}F–^{17}O Coulomb displacement energies (A)
88FU04	Convection currents in nuclei in a relativistic mean-field theory
88NI05	Nuclear magnetic moments & spin-orbit current in the relativistic mean field theory
88SH07	Magnetic response of closed-shell ± 1 nuclei in Dirac-Hartree approximation
89CH24	Medium induced magnetization current & nuclear magnetic moments
89NE02	Magnetic moments of closed-shell ± 1 nuclei in the relativistic shell model
89SA10	Total cross sections of reactions induced by neutron-rich light nuclei
90MO36	Meson exchange current corrections to magnetic moments in quantum hadro-dynamics
91CO12	Wave function effects & the elastic magnetic form factor of ^{17}O
91HA15	QCD sum rules in a nuclear medium & the Okamoto-Nolen-Schiffer anomaly
91ZH06	Relativistic Hartree study of deformed sd-shell nuclei
92MA45	Coulomb displacement energies in relativistic & non-relativistic self-consistent models
92SU02	Nolen-Schiffer anomaly of mirror nucl: effects of valence nucleon orbits & CSB
92ZH07	Magnetic moments & form factors of ^{17}O & ^{41}Ca

Table 17.10
Energy levels of ^{17}O

E_x in ^{17}O (MeV ± keV)	$J^\pi; T$	τ_m or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
0	$\frac{5}{2}^+; \frac{1}{2}$		stable	1, 2, 7–9, 13, 14, 17, 18, 20–23, 28–31, 36–60
0.87073 ± 0.10 [a])	$\frac{1}{2}^+$	$\tau_m = 258.6 \pm 2.6$ ps	γ	1, 2, 7–11, 13, 14, 17, 18, 20–23, 28–31, 36–40, 42, 45, 46, 48, 50, 53–55, 57–59
3.05536 ± 0.16	$\frac{1}{2}^-$	$\tau_m = 120^{+80}_{-60}$ fs	γ	7–9, 13, 14, 20, 22, 23, 28, 30, 31, 36–40, 42, 45, 53, 54, 58
3.84276 ± 0.42 [a])	$\frac{5}{2}^-$	$\tau_m \leq 25$ fs	γ	7–9, 13–16, 20, 22, 23, 28, 29, 37, 38, 42, 43, 53, 54, 58
4.5538 ± 1.6 [a])	$\frac{3}{2}^-$	$\Gamma = 40 \pm 5$	γ, n	7, 9, 13, 14, 20, 22, 23, 28, 29, 32, 37, 38, 40, 41–43, 53, 54, 58
5.0848 ± 0.9 [a])	$\frac{3}{2}^+$	96 ± 5	γ, n	2, 8, 9, 13, 14, 22, 23, 28, 32, 37, 40–42, 53, 54
5.21577 ± 0.45 [a])	$\frac{9}{2}^-$	< 0.1	γ, n	8, 9, 13–16, 22, 23, 28–30, 32, 37, 42, 43, 53, 58
5.3792 ± 1.4 [a])	$\frac{3}{2}^-$	28 ± 7	γ, n	9, 22, 23, 28, 32, 37, 38, 40–42, 53, 54, 58
5.69726 ± 0.33 [a])	$\frac{7}{2}^-$	3.4 ± 0.3	γ, n	2, 4, 13, 14, 20, 22, 23, 28, 29, 32, 37, 41–43, 54
5.73279 ± 0.52 [a])	$(\frac{5}{2}^-)$	< 1	n	2, 7, 8, 13, 14, 20, 22, 23, 32, 37, 58
5.86907 ± 0.55 [a])	$\frac{3}{2}^+$	6.6 ± 0.7	n	8, 9, 13, 14, 22, 23, 28, 32, 37, 58
5.939 ± 4	$\frac{1}{2}^-$	32 ± 3	γ, n	7, 8, 13, 14, 22, 23, 28, 32, 37, 40, 42, 54, 58
6.356 ± 8	$\frac{1}{2}^+$	124 ± 12	γ, n	7, 9, 20, 22, 28, 32, 41, 42
6.862 ± 2	$(\frac{5}{2}^+)$	< 1	γ, n	7, 8, 9, 13, 14, 22, 23, 28, 32, 37, 42, 54, 58
6.972 ± 2	$(\frac{7}{2}^-)$	< 1	γ, n	8, 9, 13, 14, 22, 23, 28, 32, 42, 58
7.1657 ± 0.8	$\frac{5}{2}^-$	1.38 ± 0.05	n, α	7–9, 12–14, 22, 28, 32, 35
7.202 ± 10	$\frac{3}{2}^+$	280 ± 30	n, α	13, 14, 22, 32, 35
7.3792 ± 1.0	$\frac{5}{2}^+$	0.64 ± 0.23	γ, n, α	7–9, 9–11, 28, 29, 32, 35, 42, 54, 58
7.3822 ± 1.0	$\frac{5}{2}^-$	0.96 ± 0.20	γ, n, α	6, 9, 12–14, 22, 29, 32, 35, 41, 42, 54, 58

Table 17.10 (continued)
Energy levels of ^{17}O

E_x in ^{17}O (MeV ± keV)	$J^\pi; T$	τ_m or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
7.559 ± 20	$\frac{3}{2}^-$	500 ± 50	n, α	32, 35, 37
7.576 ± 2	$(\frac{7}{2}^+)$ [e])	< 0.1	γ, n, α	7, 8, 12–14, 22, 28, 32, 42
7.6882 ± 0.9	$\frac{7}{2}^-$	14.4 ± 0.3	γ, n, α	7, 8, 12–14, 28, 32, 35, 41
7.757 ± 9	$\frac{11}{2}^-$		γ	20, 28–30, 42, 43
7.956 ± 6	$\frac{1}{2}^+$	90 ± 9	n, α	12, 28, 32, 35
7.99 ± 50	$\frac{1}{2}^-$	270 ± 30	n, α	32, 35
8.070 ± 10	$\frac{3}{2}^+$	85 ± 9	n, α	12, 28, 32, 35
8.200 ± 7	$\frac{3}{2}^-$	60	γ, n, α	12, 20, 28, 32, 35, 41, 54
8.3424 ± 0.9	$\frac{1}{2}^+$	11.4 ± 0.5	γ, n, α	12, 28, 32, 35, 42
8.4023 ± 0.8	$\frac{5}{2}^+$	6.17 ± 0.13	γ, n, α	8, 12–14, 28, 32, 35, 42
8.4660 ± 0.8	$(\frac{9}{2}^+)$ [f])	2.13 ± 0.11	(γ), n, α	7, 8, 12–14, 28, 32, 35, 42, 54
8.5007 ± 0.8	$\frac{5}{2}^-$	6.89 ± 0.22	γ, n, α	8, 12–14, 28, 32, 35, 41, 42
8.6870 ± 1.0	$\frac{3}{2}^-$	55.3 ± 0.6	γ, n, α	12, 28, 32, 35, 41, 54
8.885 ± 14 [b])	$\frac{7}{2}^-, \frac{9}{2}^-$	6	γ	42
8.897 ± 8	$\frac{3}{2}^+$	101 ± 3	n, α	8, 12–14, 28, 29, 32, 35, 42
8.9672 ± 1.7	$\frac{7}{2}^-$	26 ± 2	γ, n, α	8, 12–14, 28, 32, 35, 41, 42
9.147 ± 4	$\frac{1}{2}^-$	4 ± 3	γ, n, α	8, 11–14, 54
9.15 ± 20	$\frac{9}{2}^-$		γ	28–30, 32
9.18	$\frac{7}{2}^-$	3	α	12–14
9.1939 ± 0.8	$\frac{5}{2}^+$	3.53 ± 0.13	n, α	12–14, 32
9.42	$\frac{3}{2}^-$	120	n	32
9.492 ± 4	$\frac{5}{2}^-$	15 ± 1	n, α	7, 11, 14, 28, 32, 54
9.7119 ± 0.9	$\frac{7}{2}^+$	23.1 ± 0.3	n, α	12, 14, 20, 28, 32
9.7833 ± 0.9	$\frac{3}{2}^+$	11.7 ± 0.3	n, α	12, 14, 32
9.8589 ± 0.9	$(\frac{5}{2}^-)$	4.01 ± 0.23	n, α	12, 14, 28, 32
9.8765 ± 1.3	$(\frac{1}{2}^-)$	16.7 ± 1.7	n, α	12, 14, 28, 32
9.976 ± 20	$\frac{5}{2}^+$	~ 80	n, α	12
10.045 ± 20		~ 100	n, α	12
10.1678 ± 1.0	$\frac{7}{2}^-$	49.1 ± 0.8	n, α	12, 32
10.336 ± 15	$\frac{5}{2}^+, \frac{7}{2}^-$	150	n, α	12, 28
10.423 ± 3		14 ± 3	n, α	12, 20
10.49	$\frac{5}{2}^+, \frac{7}{2}^-$	75 ± 30	n, α	12
10.5591 ± 1.0	$(\frac{7}{2}^-)$	42.5 ± 1.1	n, α	12, 16, 28, 32, 33
10.777 ± 3	$\frac{1}{2}^+, \frac{7}{2}^-$	74 ± 3	n, α	12, 14, 23, 28, 33

Table 17.10 (continued)
Energy levels of ^{17}O

E_x in ^{17}O (MeV ± keV)	$J^\pi; T$	τ_m or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
10.9129 ± 2.8	$(\frac{5}{2}^+)$	41.7 ± 1.4	n, α	12, 28, 32, 33
11.036 ± 3	$T = \frac{1}{2}$	31 ± 3	n, α	12, 28
11.0787 ± 0.8 [c])	$\frac{1}{2}^-; \frac{3}{2}$	2.4 ± 0.3	γ, n, α	11, 12, 28, 32, 42, 54, 55
11.238		80 ± 3	n, α	7, 12, 20
11.51	$\geq \frac{3}{2}$	190	n	32, 33
11.622		65 ± 2	n, α	12
11.750 ± 10		40 ± 25	γ, n, α	12, 42
11.815 ± 15		12 ± 3	n, α	12, 20
12.005 ± 15	$\geq \frac{3}{2}$	270	γ, n, α	12, 20, 23, 32, 33, 42
12.11 ± 20		150 ± 50	n, α	12, 16, 33
12.22 ± 20		≤ 20	γ	42
12.274 ± 15		100 ± 30	n, α	12, 20
12.38 ± 20			n, α	12, 32
12.420 ± 15			n, α	12
12.4660 ± 1.0	$\frac{3}{2}^-; \frac{3}{2}$	6.9 ± 1.1	γ, n, α	12, 32, 33, 42, 54, 55
12.595 ± 15		75 ± 30	n, α	12
12.669 ± 15		~ 5	γ, n, α	12, 32, 33, 42
12.81 ± 25			n, α	12
12.93 ± 20		≥ 150	n, α	12
12.944 ± 5	$\frac{1}{2}^+; \frac{3}{2}$	6 ± 2	n, α	12, 32, 33, 54, 55
12.9982 ± 1.0	$\frac{5}{2}^-; \frac{3}{2}$	2.5 ± 1.0	γ, n, α	12, 32, 42, 55
13.076 ± 15		16 ± 4	n, α	12
13.484 ± 15		~ 120	n, α	12
13.58 ± 20	$(\frac{11}{2}^-, \frac{13}{2}^-)$	68 ± 19	(γ)	13, 14, 42
13.609 ± 15		250 ± 100	n, α	12
13.6353 ± 2.5	$(\frac{5}{2})^+; \frac{3}{2}$	9 ± 5	n, α	32, 54, 55
(13.67)		400	n	32
14.15 ± 100	$(\frac{9}{2}^+, \frac{11}{2}^+)$	~ 100		13
14.2303 ± 1.7	$\frac{7}{2}^-; \frac{3}{2}$	20.5 ± 1.6	γ, n, α	32, 42, 55
14.286 ± 3	$T = \frac{1}{2}$ [d])	7.5 ± 4	n, α	32, 55
14.451 ± 3		40 ± 6	γ, n, α	32
14.72	$\frac{9}{2}^-; \frac{3}{2}$	35 ± 11		
14.76 ± 100	$(\geq \frac{3}{2})$	340	γ, n	32, 42
14.791 ± 3	$(\frac{1}{2}^-; \frac{3}{2})$	36 ± 13	(γ), n, α	32, 41
15.00		180	n, d, α	27, 32

Table 17.10 (continued)
Energy levels of ^{17}O

E_x in ^{17}O (MeV ± keV)	$J^\pi; T$	τ_m or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
15.1 ± 100	$(\frac{9}{2}^+, \frac{11}{2}^+)$	~ 500		13
15.199 ± 3	$T = \frac{1}{2}$ [d])	52 ± 14	γ, n, d, α	20, 27, 32, 42
15.368 ± 3	$(\frac{5}{2}^+; \frac{3}{2})$	40 ± 6	n, d, α	26, 32
(15.6)	$T = \frac{1}{2}$ [d])	~ 300	p, d, α	25–27
15.78 ± 20	$(\frac{13}{2}^-; \frac{3}{2})$ [e])	≤ 30	γ	42
15.95 ± 150	$(\frac{9}{2}^+, \frac{11}{2}^+)$	~ 700		13
16.243 ± 4	$(\frac{9}{2}^+; \frac{3}{2})$	21 ± 10	n, p, d, α	25, 32
16.58 ± 10	$(\frac{1}{2}, \frac{3}{2})^-; \frac{3}{2}$	~ 300	γ	42, 54
16.6 ± 150	$(\frac{11}{2}^-, \frac{13}{2}^-)$			13
17.06 ± 20	$\frac{11}{2}^-; \frac{1}{2}$ [e])	≤ 20	γ	13, 42, 43
17.436 ± 11	$(T = \frac{3}{2})$	66 ± 20	n, α	32
17.92 ± 20		98 ± 16	γ	42
18.110 ± 4	$\frac{3}{2}^-; \frac{3}{2}$	46 ± 12	n, α	32, 54
18.72 ± 20		87 ± 33		42
19.6 ± 150	$(\frac{13}{2}^+, \frac{15}{2}^+)$	~ 250		13
19.82 ± 40	$\frac{3}{2}$	550 ± 50	γ, t	21, 42
20.14 ± 20	$\frac{11}{2}^-; \frac{1}{2}$ [e])	31 ± 5	γ	42
20.2 ± 150	$(\frac{13}{2}^+, \frac{15}{2}^+)$	~ 250		13
20.39 ± 50	$\frac{5}{2}, \frac{7}{2}^-$	660 ± 70	γ, t	21
20.58 ± 50	$\frac{1}{2}$	570 ± 80	γ, t	21
20.70 ± 20	$(\frac{9}{2}^-; \frac{3}{2})$ [e])	≤ 20	γ	42
21.05 ± 50	$\frac{3}{2}$	470 ± 60	γ, t	21
21.2	$(\frac{13}{2}^+, \frac{15}{2}^+)$			13
21.7 ± 100	$\frac{5}{2}^+$	~ 750	γ, ^{3}He, α	18, 19
22.1 ± 100	$\frac{7}{2}^-$	~ 750	γ, n, ^{3}He, α	13, 18, 19
22.5 ± 200	$\frac{3}{2}^{(-)}$	~ 1000	γ, ^{3}He	18
23		~ 6000	γ, n	41, 42
23.0	$\frac{1}{2}^+$	~ 400	γ, ^{3}He	18, 19
23.5			γ, ^{3}He	18
24.4			γ, ^{3}He	18

[a]) (90PI05).
[b]) See also (71AJ02).
[c]) See also Tables 17.16 and 17.19, and see Table 17.6 in (77AJ02).
[d]) $T = \frac{1}{2}$ assignments based on evidence of excitation in ^{17}O(γ, n_0) reported in (90MC06).
[e]) (87MI25) and private communication from D.M. Manley.
[f]) (87MA52) and private communication from D.J. Millener.

Table 17.11

^{17}O states from $^{12}C(^{6}Li, p)^{17}O$ [a])

Level	Excitation energy (MeV ± keV)	σ_{tot} (μb)	Level	Excitation energy (MeV ± keV)
0	0	110 ± 2	18	8.40
1	0.869 ± 10	36 ± 1	19	8.476 ± 12
2	3.056 ± 8	60 ± 1	20	8.702 ± 12
3	3.844 ± 7	138 ± 2	21	8.905 ± 8
4	4.555 ± 8	141 ± 2	22	8.966 ± 15
5	5.079 ± 15	55 ± 1	23	9.181 ± 9
6	5.217 ± 8	285 ± 4	24	9.487 ± 8
7	5.380 ± 9	79 ± 1	25	9.719 ± 15
8	5.719 ± 12	222 ± 3	26	9.866 ± 11
9	5.877 ± 14	202 ± 3	27	10.426 ± 8
10	6.861 ± 2	370 ± 5	28	10.549 ± 9
11	6.974 ± 5	176 ± 2	29	10.694 ± 8
12	7.175 ± 14	146 ± 2	30	10.92
13	7.388 ± 14	391 ± 5	31	11.03
14	7.580 ± 16	404 ± 5	32	11.815 ± 20
15	7.690 ± 15	186 ± 3	33	12.02 ± 20
16	7.773 ± 16	439 ± 5	34	12.25 ± 20
17	8.210 ± 25		35	12.430 ± 15

[a]) (86SM10).

Table 17.12
Resonances in ^{13}C(α, n) and ^{13}C(α, α) [a])

E_{res} (MeV ± keV)	$\Gamma_{c.m.}$ (keV)	Γ_α/Γ	J^π	E_x (MeV)
1.0563 ± 1.5	1.5 ± 0.2		$\frac{5}{2}$	7.1669
1.3367 ± 1.5	$0.6^{+0.2}_{-0.1}$			7.3813
1.3406 ± 1.5	$0.8^{+0.3}_{-0.2}$			7.3842
1.590 ± 2	≤ 1		$\frac{7}{2}^-$	7.575
1.745 ± 6	≤ 15		$\frac{5}{2}^+$	7.693
2.083 ± 8	75	0.03	$\frac{1}{2}^-$	7.952
2.250 ± 8	110	0.05	$\frac{3}{2}^+$	8.080
2.407 ± 8	70	0.11	$\frac{3}{2}^-$	8.200
2.604 ± 4	9 ± 3	0.44	$\frac{1}{2}^+$	8.350
2.680 ± 3	4 ± 3	0.08	$\frac{5}{2}^+$	8.408
2.763 ± 3	7 ± 3	0.97	$\frac{7}{2}^+$	8.472
2.808 ± 3	5 ± 3	0.26	$\frac{5}{2}^-$	8.506
3.059 ± 5	50 ± 3	0.06	$\frac{3}{2}^-$	8.698
(3.1)	broad		$\frac{1}{2}^-$	(8.7)
3.318 ± 8	101 ± 3	0.50	$\frac{3}{2}^+$	8.896
3.415 ± 4	21 ± 3	0.04	$\frac{7}{2}^-$	8.970
3.645 ± 4	4 ± 3	0.45	$\frac{1}{2}^-$	9.146
(3.69)	3	1.00	$\frac{7}{2}^-$	(9.18)
3.714 ± 4	5.5 ± 1	0.20	$\frac{5}{2}^+$	9.199
4.096 ± 4	15 ± 1	0.85	$\frac{5}{2}^-$	9.491
(4.3)			$\frac{3}{2}^-$	(9.6)
4.394 ± 5	16 ± 1	0.70	$\frac{7}{2}^+$	9.719
4.465 ± 15	≈ 25	0.90	$\frac{3}{2}^+$	9.773
4.583 ± 5	14			9.863
4.600 ± 15	≈ 10			9.876
4.730 ± 20	≈ 80	0.78	$\frac{5}{2}^+$	9.976
4.820 ± 20	≈ 100			10.044
(4.94)	138	0.85	$\frac{5}{2}+$	(10.14)
4.993 ± 5	45	0.15	$\frac{7}{2}-$	10.177
(5.08)	122	0.60	$\frac{7}{2}^+$	(10.2)
5.200 ± 15	150		$\frac{5}{2}^+, \frac{7}{2}^-$	10.335
5.315 ± 3	14 ± 3			(10.423)
5.40	75 ± 30		$\frac{5}{2}^+, \frac{7}{2}^-$	10.49
5.492 ± 3	51 ± 2		$\frac{7}{2}^-, \frac{9}{2}^+$	(10.558)

Table 17.12 (continued)
Resonances in ^{13}C(α, n) and ^{13}C(α, α) [a])

E_{res} (MeV $\pm$ keV)	$\Gamma_{\mathrm{c.m.}}$ (keV)	Γ_α/Γ	J^π	E_{x} (MeV)
(5.68)	≤ 25	1.00	$(\frac{7}{2}^+)$	(10.70)
5.778 ± 3	74 ± 3		$\frac{1}{2}^+, \frac{7}{2}^-$	(10.777)
5.945 ± 3	46 ± 2		$\frac{5}{2}$	(10.904)
6.117 ± 3	31 ± 3			(11.036)
6.168	5.0 ± 1.1		$\frac{1}{2}^-; T = \frac{3}{2}$	(11.075 ± 0.005)
6.380 ± 3	80 ± 3			(11.237)
6.883 ± 3	65 ± 2			(11.621)
7.051 ± 10	40 ± 25			11.750
7.136 ± 15	12 ± 3			11.815
7.384 ± 15				12.004
7.52 ± 20	150 ± 50			12.11
7.736 ± 15	100 ± 30			12.273
7.88 ± 20				12.38
7.927 ± 15				12.419
7.976	8 ± 2		$\frac{3}{2}^-; T = \frac{3}{2}$	12.457 ± 0.005
8.156 ± 15	75 ± 30			12.594
8.253 ± 15	≈ 5			12.668
8.44 ± 25				12.81
8.59 ± 20	≥ 150			12.93
8.612	6 ± 2		$\frac{1}{2}^+; T = \frac{3}{2}$	12.943 ± 0.006
8.676	≤ 3		$\frac{5}{2}^-; T = \frac{3}{2}$	12.992 ± 0.006
8.72 ± 20				13.03
8.785 ± 15	16 ± 4			13.075
9.319 ± 15	≈ 120			13.483
9.483 ± 15	250 ± 100			13.609

[a]) See references listed in Tables 17.8 of (77AJ02, 82AJ01). See also Table 17.17 here.

Table 17.13
States of ^{17}O from ^{14}C + ^{3}He [a])

E_{res} (MeV)	Resonant for	$\Gamma_{c.m.}$ (MeV)	E_x (MeV)	J^π
3.6 ± 0.1	γ_0, (γ_1), α_0, α_1	0.75	21.7	$\frac{5}{2}^+$
4.1 ± 0.1	γ_0, n_0, n_{3+4}, α_0, α_1	0.75	22.1	$\frac{7}{2}^-$
4.6 ± 0.2	γ_1	≈ 1	22.5	$\frac{3}{2}^{(-)}$
5.1 ± 0.1	γ_0, ^{3}He	≈ 0.4	23.0	$\frac{1}{2}^+$
5.7 ± 0.1	γ_1		23.5	
6.9 ± 0.1	γ_1		24.4	

[a]) For references see Table 17.9 in (77AJ02).

Table 17.14
States of ^{17}O from ^{14}N(t, γ)^{17}O [a])

					Lower limit	
J^π	E_x (MeV)	Γ (MeV)	$\Gamma_t\Gamma_{\gamma_0}$ (keV)^2	$\Gamma_t\Gamma_{\gamma_1}$ (keV)^2	Γ_{γ_0} (eV)	Γ_{γ_1} (eV)
$\frac{3}{2}^\mp$	19.76 ± 0.06	0.55 ± 0.05	0.54 ± 0.1	1.25 ± 0.15	1.0	2.3
$\frac{5}{2}^\mp$, $\frac{7}{2}^-$	20.39 ± 0.05	0.66 ± 0.07	2.9 ± 0.3		4.3	
$\frac{1}{2}^\pm$	20.58 ± 0.05	0.57 ± 0.08		2.9 ± 0.5		5.1
$\frac{3}{2}^\mp$	21.05 ± 0.05	0.47 ± 0.06	2.7 ± 0.4	3.0 ± 0.4	5.8	6.5

[a]) (80LI05).

Table 17.15
Levels of ^{17}O from ^{15}N(^{3}He, p)^{17}O [a]

E_x (MeV) [b]	L [c]	E_x (MeV) [b]	L [c]
0	$(1+3)$	8.192	0
0.874	1	8.322	
3.053	0	8.390	
3.845	2	8.492	(2)
4.549	0	8.682	
5.081	(1)	8.900	
5.215	(4)	8.955	
5.381	0	9.16	(4)
5.698	2	9.495	
5.873	(1)	9.712	
5.938	0	9.856	
6.37		(10.24)	
6.861	(0)	10.33	
6.973	$(1+3)$	10.57	
7.162	2	10.782	
7.382	2	10.913	
7.561		11.032 ± 0.004 [d]	
7.687		11.075 ± 0.004 [e]	
7.761	4		
7.938			
8.054	(1)		

[a] For references see Table 17.10 in (82AJ01).
[b] ± 10 keV, except where shown otherwise.
[c] $E(^{3}\text{He}) = 18$ MeV.
[d] $T = \frac{1}{2}$.
[e] $J^{\pi} = \frac{1}{2}^{-}$; $T = \frac{3}{2}$: see Table 17.16.

Table 17.16
Decay properties of the lowest $T = \frac{3}{2}$ states in $A = 17$ [a]

	^{17}O*(11.0787 ± 0.0008) [b]			^{17}F*(11.1928 ± 0.0021) [c]	
J^π	$\frac{1}{2}^-$			$\frac{1}{2}^-$	
$\Gamma_{c.m.}$ (keV)	2.4 ± 0.3 [b]			0.18 ± 0.03 [d]	
	Branching ratio (%)	Partial widths		Branching ratio (%) [e]	Partial widths
p- or n-decay to States in ^{16}O* J^π					
0 0^+	81 ± 6	1.88 ± 0.12 keV		10.7 ± 0.6	19 ± 3 eV [f]
6.05 0^+				11 ± 3	20 ± 7 eV [e]
6.13 3^-	5 ± 2	0.12 ± 0.05 keV		25 ± 2	45 ± 9 eV [e]
6.92 2^+				< 4	< 8 eV [e]
7.12 1^-				18 ± 3	32 ± 8 eV [e]
θ^2 (g.s.)/θ^2 (6.13)		0.31 ± 0.14 [g]			0.065 ± 0.019 [g]
α-decay to ^{13}C or ^{13}N:	7 ± 1 [h]	$\Gamma_{\alpha_0} =$ 0.34 ± 0.09 keV [i]	^{13}N* (0): ^{13}N* (2.36):	1.1 ± 0.5 29 ± 9	2.1 ± 1 eV [e] 52 ± 19 eV [e]
γ-decay:		$\Gamma_{\gamma_1} = 10 \pm 3$ eV [i]			$\Gamma_{\gamma_1} =$ 6.0 ± 2.5 eV [j]

[a]) See also Table 2 in (73AD1A) and reaction 11, and see Table 17.11 in (86AJ04).
[b]) (81HI01) [see for IMME parameters for six $T = \frac{3}{2}$ states].
[c]) (71HA05, 73AD1A, 76HI09, 88BO39) and see references in Table 17.11 in (82AJ01).
[d]) Calculated from direct measurement of $\Gamma_{p_0} = 19 \pm 3$ eV (76HI09) and weighted mean of $\Gamma_{p_0}/\Gamma = 0.104 \pm 0.006$ obtained from measurements of (71HA05, 73AD1A, 88BO39).
[e]) Branching ratios measured by (88BO39). Partial widths obtained using total width of 180 ± 30 eV and these branching ratios.
[f]) (76HI09).
[g]) (73AD1A).
[h]) (76MC11).
[i]) Using $\Gamma_{\alpha_0}\Gamma_{\gamma_1}/\Gamma_{tot} = 1.46 \pm 0.13$ eV and $\Gamma_{\alpha_0}\Gamma_{n_0}/\Gamma_{tot} = 0.27$ keV ± 20% [see footnote [f]) in Table 17.11 (86AJ04)] and the Γ_{n_0} and Γ_{tot} values shown above, these values are calculated for Γ_{α_0} and Γ_{γ_1}.
[j]) (75HA06).

Table 17.17
Resonances in ^{16}O(n, n) and ^{16}O(n, α) [a]

E_n (keV)	$\Gamma_{c.m.}$ (keV)	Γ_n (keV)	Γ_α (keV)	J^π	E_x (keV)
433 ± 2 [b]	45	45		$\frac{3}{2}^-$	4551
1000 ± 2	96	96		$\frac{3}{2}^+$	5084
1140 [c]	≤ 0.1				5216
1312 ± 2	42	41.5		$\frac{3}{2}^-$	5378
1651 ± 2	3.4 ± 0.3	3.4		$\frac{7}{2}^-$	5697
1689 ± 2	≤ 1			[d]	5732
1833 ± 2	6.6 ± 0.7	6.6		$\frac{3}{2}^+$	5868
1908 ± 4	32 ± 3	31.5		$\frac{1}{2}^-$	5938
2351 ± 8 [i]	124 ± 12	124		$\frac{1}{2}^+$	6355
2889 ± 2	≤ 1			[d]	6861
3006 ± 2	≤ 1			[d]	6971
3211.70 ± 0.17	1.38 ± 0.05	1.38 ± 0.05 [e]	0.0033	$\frac{5}{2}^-$	7164.5
3250 ± 10	280 ± 30	280	0.07	$\frac{3}{2}^+$	7201
3438.38 ± 0.19	0.64 ± 0.23	0.64 ± 0.23 [e]	0.01	$\frac{5}{2}^+$	7377.7
3441.73 ± 0.14	0.96 ± 0.20	0.96 ± 0.20 [e]	0.003	$\frac{5}{2}^-$	7380.8
3630 ± 20	500 ± 50	500	0.08	$\frac{3}{2}^-$	7558
3647 [c]	≤ 0.1				7574
3767.76 ± 0.22	14.4 ± 0.3	13.0 ± 0.6 [e]	0.01	$\frac{7}{2}^-$	7687.5
4053 ± 8	90 ± 9	84	6.7	$\frac{1}{2}^+$	7956
4090 ± 50	270 ± 30	250	16	$\frac{1}{2}^-$	7991
4162 ± 8	85 ± 9	71	15	$\frac{3}{2}^+$	8058
4290 ± 20	69 ± 7	68	0.8	$\frac{1}{2}^-$	(8179)
4310 ± 10	52	48	4.0	$(\frac{3}{2}^-)$	8197
4463.41 ± 0.26	11.4 ± 0.5	8.1 ± 0.3	2.2	$\frac{1}{2}^+$	8341.7
4527.12 ± 0.07	6.17 ± 0.13	4.75 ± 0.11	0.54	$\frac{5}{2}^+$	8401.6
4594.83 ± 0.09	2.13 ± 0.11	1.18 ± 0.04	(7.6)	$\frac{7}{2}^+$	8465.3
4631.78 ± 0.12	6.89 ± 0.22	2.86 ± 0.08	1.9	$\frac{5}{2}^-$	8500.0
4829.9 ± 0.4	55.3 ± 0.6	48.9 ± 1.1	1.8	$\frac{3}{2}^-$	8686.3
5050	78	68	9.5	$\frac{3}{2}^+$	8893
5127.0 ± 1.6	26.3 ± 1.9	23.5 ± 1.9		$\frac{7}{2}^-$	8965.7
5368.90 ± 0.09	3.53 ± 0.13	2.37 ± 0.08		$\frac{5}{2}^+$	9193.2
5610	120	120		$\frac{3}{2}^-$	9420
5640	140			$\geq \frac{3}{2}$	9448
5919.67 ± 0.14	23.1 ± 0.3	18.0 ± 0.6		$\frac{7}{2}^+$	9711.1
5995.68 ± 0.15	11.7 ± 0.3	10.3 ± 0.3		$\frac{3}{2}^+$	9782.6
6076.08 ± 0.15	4.01 ± 0.23	3.37 ± 0.23		$(\frac{5}{2}^-)$	9858.2
6094.8 ± 1.0	16.7 ± 1.7	10.9 ± 1.2		$(\frac{1}{2}^-)$	9875.8

Table 17.17 (continued)
Resonances in ^{16}O(n, n) and ^{16}O(n, α) [a]

E_n (keV)	$\Gamma_{c.m.}$ (keV)	Γ_n (keV)	Γ_α (keV)	J^π	E_x (keV)
6404.6 ± 0.5	49.1 ± 0.8	22.3 ± 0.6		$(\frac{7}{2}^-)$	10167.1
6820.7 ± 0.6	42.5 ± 1.1	17.2 ± 0.7 [e]		$(\frac{7}{2}^-)$	10558.4
7199.3 ± 1.3	41.7 ± 1.4	26.4 ± 0.9 [e]		$(\frac{5}{2}^+)$	10914.4
7373.31 ± 0.18	2.4 ± 0.3	1.88 ± 0.12 [e]		$\frac{1}{2}^-$ [f]	11078.0
7830	190			$\geq \frac{3}{2}$	11507
8320	270			$\geq \frac{3}{2}$	11968
8740	130				12363
8848.8 ± 0.6	6.9 ± 1.1	1.27 ± 0.14 [e]		$\frac{3}{2}^-$ [f]	12465.3
9050	95				12654
9353 ± 6	6 ± 2	0.21 ± 0.14 [e]		$\frac{1}{2}^+$ [f]	12939
9414.9 ± 0.6	2.5 ± 1.0	0.40 ± 0.06 [e]		$\frac{5}{2}^-$ [f]	12997.5
10092.5 ± 2.4	9 ± 5	0.24 ± 0.09 [e]		$(\frac{5}{2}^+)$ [f]	13634.6
10130	400				13670
10725.5 ± 1.5	20.5 ± 1.6	2.07 ± 0.16 [e]		$(\frac{7}{2}^-)$ [f]	14229.6
10785 ± 3	7.5 ± 4	0.80 ± 0.16 [g]		[j]	14286
10960 ± 3	40 ± 6	13 ± 6 [g]			14450
11140	340			$(\geq \frac{3}{2})$	14619
11322 ± 3	36 ± 13	3.2 ± 1.0 [g]		$(\frac{1}{2})$ [h]	14790
11540	180				14995
11756 ± 3	52 ± 14	11 ± 3 [g]		[j]	15198
11936 ± 3	40 ± 6	7 ± 1 [g]		$(\frac{5}{2}^+)$ [h]	15368
12867 ± 4	21 ± 10	2 ± 0.5 [g]		$(\frac{9}{2}^+)$ [h]	16243
14136 ± 11	66 ± 20	8.0 ± 2.4 [g]		[f]	17435
14853 ± 4	43 ± 12	1.0 ± 0.3 [e]		$\frac{3}{2}^-$	18109

[a]) See Tables 17.12 in (77AJ02) and (82AJ01).
[b]) $\Gamma_{\gamma_0} = (1.80 \pm 0.35)$ eV, $\Gamma_{\gamma_1} = (1.85 \pm 0.35)$ eV (92IG01).
[c]) Not observed in σ_t.
[d]) Not $\frac{1}{2}^+$.
[e]) Γ_{n_0}.
[f]) $T = \frac{3}{2}$.
[g]) $(J \pm \frac{1}{2})\Gamma_{n_0}$ (81HI01).
[h]) J^π assignment by comparison with ^{17}N states presumed to be analogs; then $T = \frac{3}{2}$ (81HI01).
[i]) See also (80JO1A).
[i]) $T = \frac{1}{2}$ based on evidence of excitation in ^{16}O(γ, n_0) reported in (90MC06).

Table 17.18
Transition properties and ground-state relative widths from ^{17}O(e, e′) [a])

E_x (MeV)	J^π	Mtpl.	Γ (keV)	B(E$\lambda\uparrow$) ($e^2\cdot fm^{2\lambda}$)	Mtpl [b])	Γ_{γ_0} (Mλ) [b]) (eV)	B(M$\lambda\uparrow$) [b]) ($e^2\cdot fm^{2\lambda}$)
0.87	$\frac{1}{2}^+$	E2		2.18 ± 0.16			
3.06	$\frac{1}{2}^-$	E3		14.1 ± 3.9			
3.84	$\frac{5}{2}^-$	E3		93.0 ± 8.3	M2	$(4.6 \pm 1.8) \times 10^{-3}$	$(5 \pm 2) \times 10^{-2}$
4.55	$\frac{3}{2}^-$	E3		20 ± 12	M2	$(1.8 \pm 0.7) \times 10^{-2}$	$(5.4 \pm 2.1) \times 10^{-2}$
5.09	$\frac{3}{2}^+$	E2		2.05 ± 0.20			
5.22	$\frac{9}{2}^-$	E3		319 ± 13	M2	$< 1 \times 10^{-2}$	$< 4 \times 10^{-2}$
5.38	$\frac{3}{2}^-$	E3		47.9 ± 4.3	M2	$(4.5 \pm 2.2) \times 10^{-2}$	$(6 \pm 3) \times 10^{-2}$
5.70	$\frac{7}{2}^-$	E3		97.0 ± 6.5	M2	0.15 ± 0.10	0.3 ± 0.2
5.73	$(\frac{5}{2}^-)$	E3		134 ± 21			
5.87	$\frac{3}{2}^+$	E2		2.13 ± 0.22			
5.94	$\frac{1}{2}^-$	E3		25.3 ± 5.1			
6.36	$\frac{1}{2}^+$	E2		1.43 ± 0.21			
6.86	$\frac{5}{2}^+$	E2		0.83 ± 0.25			
6.97	$(\frac{7}{2}^-)$	E3		75.5 ± 5.6			
7.17	$\frac{5}{2}^-$	E3		11.1 ± 2.9			
7.20	$\frac{3}{2}^+$	E2		1.79 ± 0.25			
7.38	$\frac{5}{2}^+$	E2		< 0.8			
7.38	$\frac{5}{2}^-$	E3		36.9 ± 2.4			
7.56	$\frac{3}{2}^-$	E3		< 15			
7.58	$\frac{7}{2}^+$	E2		4.20 ± 0.51			
7.69	$\frac{7}{2}^-$	E3		33.9 ± 4.9			
7.76	$\frac{11}{2}^-$	E3		287 ± 14			
7.96	$\frac{1}{2}^+$	E2		2.00 ± 0.38			
8.20	$\frac{3}{2}^-$	E3		11.0 ± 1.3			
8.34	$\frac{1}{2}^+$	E2		0.48 ± 0.07			
8.40	$\frac{5}{2}^+$	E2		2.10 ± 0.34			
8.47	$\frac{9}{2}^+$	E2		10.05 ± 1.19			
8.50	$\frac{5}{2}^-$	E3		< 7			
8.69	$\frac{3}{2}^-$	E3		5.2 ± 1.2			
8.90	$(\frac{9}{2}^-)$	E3		13.3 ± 2.3			
8.97	$\frac{7}{2}^-$	E3		36.3 ± 4.1			
9.15	$(\frac{1}{2}^-, \frac{9}{2}^-)$	E3		< 2.3			
9.18	$\frac{7}{2}^-$	E3		2.4 ± 1.0			

Table 17.18 (continued)
Transition properties and ground-state relative widths from ^{17}O(e, e′) [a]

E_x (MeV)	J^π	Mtpl.	Γ (keV)	B(Eλ ↑) ($e^2 \cdot fm^{2\lambda}$)	Mtpl [b]	Γ_{γ_0} (Mλ) [b] (eV)	B(Mλ ↑) [b] ($e^2 \cdot fm^{2\lambda}$)
9.19	$\frac{5}{2}^+$	E2		0.48 ± 0.16			
9.42	$\frac{3}{2}^-$	E3		17.6 ± 4.8			
9.49	$\frac{5}{2}^-$	E3		6.5 ± 1.0			
9.71	$\frac{7}{2}^+$						
9.86 [c]	$(\frac{5}{2}^-)$						
9.88 [c]	$(\frac{1}{2}^-)$						
11.04 [d]							
11.08 [d]	$\frac{1}{2}^-$				M2		$(6.7 \pm 2.1) \times 10^{-2}$
12.22							
12.47	$\frac{3}{2}^-$				M2		$(7 \pm 3) \times 10^{-2}$
12.94 [e]	$\frac{1}{2}^+$						
13.00 [e]	$\frac{5}{2}^-$				M2		$(7 \pm 3) \times 10^{-2}$
13.58	$(\frac{11}{2}^-)$		68 ± 19				
14.23	$\frac{7}{2}^-$				M2		$(51 \pm 8) \times 10^{-2}$
14.45							
14.72	$\frac{9}{2}^-$				M2		$(30 \pm 10) \times 10^{-2}$
15.78 ± 0.02 [f]			< 30		M4		177 ± 17
16.50 ± 0.02 [f,g]			≤ 20				
17.06 ± 0.02 [f]			< 20		M4		76 ± 6
17.92 ± 0.02 [f]			98 ± 16				
18.72 ± 0.02 [f]			87 ± 33				
18.83 ± 0.02 [f,g]			≤ 20				
19.85 ± 0.04 [f]			530 ± 150				
20.14 ± 0.02 [f]			31 ± 5		M4		349 ± 18
20.70 ± 0.02 [f]			< 20		M4		177 ± 10

[a]) (87MA52) except where footnote is shown. See also Table 17.19 and see Tables 17.13, 17.14 in (86AJ04) for earlier work.
[b]) These data are from (78KI01) for the levels at E_x = 3.84–5.70 MeV, from (83RA1B) for E_x = 11.08–14.72 MeV, and from (86MA48) for levels at E_x = 15.78–20.20 MeV. See also Table 17.13 in (86AJ04).
[c]) Unresolved doublet.
[d]) Unresolved doublet.
[e]) Unresolved doublet.
[f]) (86MA48).
[g]) Weakly excited.

Table 17.19
Some inelastic groups observed in ^{17}O(e, e′) [a]

E_x (MeV)	Γ (keV)	E_x (MeV)	Γ (keV)
11.71 ± 0.05 [b]	narrow	14.76 ± 0.10 [b]	> 300
11.95 ± 0.05 [b]	~ 250	15.24 ± 0.10 [b]	~ 200
12.22 ± 0.02 [c]	≤ 20	16.52 ± 0.05 [b]	~ 300
12.66 ± 0.05 [b]	~ 90	17.92 ± 0.02 [c]	98 ± 16
12.96 ± 0.05 [b]	~ 200	18.72 ± 0.02 [c]	87 ± 33
13.56 ± 0.05 [b]	~ 150	22.0 [b,d]	
14.14 ± 0.10 [b]	~ 100	23.0 [b,d]	
14.72 ± 0.02 [c]	35 ± 11		

[a]) See also Table 17.18 for other inelastic groups and more recent data, and see (86AJ04).
[b]) (77NO06).
[c]) See references and comments in Table 17.14 of (86AJ04).
[d]) C1.

Table 17.20
States of ^{17}O from ^{18}O(d, t) [a]

E_x [b] (MeV)	$J^\pi; T$ [b]	l	C^2S
0	$\frac{5}{2}^+; \frac{1}{2}$	2	1.53
0.87	$\frac{1}{2}^+; \frac{1}{2}$	0	0.21
3.06	$\frac{1}{2}^-; \frac{1}{2}$	1	1.08
3.84	$\frac{5}{2}^-; \frac{1}{2}$	> 2	
4.55	$\frac{3}{2}^-; \frac{1}{2}$	1	0.12
5.09	$\frac{3}{2}^+; \frac{1}{2}$	2	0.10
5.38	$\frac{3}{2}^-; \frac{1}{2}$	1	0.53
5.70	$\frac{7}{2}^-; \frac{1}{2}$		
5.94	$\frac{1}{2}^-; \frac{1}{2}$	1	0.06
6.86		$\neq 1$	
7.38 [c]	$\frac{5}{2}^+; \frac{5}{2}^-$	$\neq 2$	
8.20	$\frac{3}{2}^-; \frac{1}{2}$	1	0.15
8.47	$\frac{7}{2}^+; \frac{1}{2}$		
8.69	$\frac{3}{2}^-; \frac{1}{2}$	1	0.10
9.15	$\frac{1}{2}^-; \frac{1}{2}$	1	0.10
9.49	$\frac{5}{2}^-; \frac{1}{2}$		
11.08	$\frac{1}{2}^-; \frac{3}{2}$	1	0.96
11.41 ± 0.01 [a]	$T = \frac{1}{2}$ [a]	(1)	0.04
12.12 ± 0.01 [a]	$T = \frac{1}{2}$ [a]	(1)	0.24
12.47	$\frac{3}{2}^-; \frac{3}{2}$ [d]	1	0.24
12.76 ± 0.01 [a]	$T = \frac{1}{2}$ [a]	(1)	0.17
12.94	$\frac{1}{2}^+; \frac{3}{2}$ [d]	0	0.19 ± 0.05
13.64	$\frac{5}{2}^+; \frac{3}{2}$ [d]	2	0.29 ± 0.12
16.58 ± 0.01 [a]	$\frac{3}{2}^-; \frac{3}{2}$ [d]	1	0.93
18.14 ± 0.01 [a]	$\frac{3}{2}^-; \frac{3}{2}$ [d]	1	0.17

[a] (77MA10): $E_d = 52$ MeV; DWBA analysis. See also Table 17.16 in (82AJ01). Comparisons of the (d, t) and (d, ^{3}He) reactions to analog states of ^{17}N and ^{17}O have been made by (77MA10).
[b] From Table 17.10, unless footnote is shown.
[c] Unresolved.
[d] See also (81MA1A).

Table 17.21

$T = \frac{3}{2}$ states of ^{17}O from ^{18}O(^{3}He, α)^{17}O [a]

E_x (MeV $\pm$ keV)	l_n	J^π	C^2S [b]
11.082 ± 6	1	$(\frac{1}{2})^-$	0.49
12.471 ± 5	1	$(\frac{3}{2})^-$	0.27
12.950 ± 8	0	$\frac{1}{2}^+$	0.096
12.994 ± 8			
13.640 ± 5	2	$(\frac{5}{2})^+$	0.39
14.219 ± 8			
14.282 ± 12			
15.101 ± 8			

[a]) See also Table 17.16, and Table 17.17 in (82AJ01).

[b]) Calculated assuming $C^2S = 4$ for ^{15}O*(6.18) in ^{16}O(^{3}He, α)^{15}O.

Table 17.22
^{17}F – General

Reference	Description
	Ground State Properties
Review:	
89RA17	Table of nuclear moments
Other Articles:	
86CA27	Shell-model calculations of quadrupole moments of sd-shell nuclei
86MC13	Resolution of the magnetic moment problem in relativistic theories
86WU1B	Charge dependence of Brueckner's G-matrix & the Nolen-Schiffer-Okamoto anomaly
87BR30	Empirically optimum M1 operator for sd-shell nuclei
87DE03	Compared mag. moments from non-relativistic HF mean-fields & relativistic approach
87FU06	Nuclear currents in a relativistic mean-field theory
88CH1T	Microscopic calculation of ^{15}O-^{15}N, ^{17}F-^{17}O Coulomb displacement energies (A)
88FU04	Convection currents in nuclei in a relativistic mean-field theory
88NI05	Nuclear magnetic moments & spin-orbit current in the relativistic mean field theory
88SH07	Magnetic response of closed-shell $\pm$ 1 nuclei in Dirac-Hartree approximation
89CH24	Medium induced magnetization current & nuclear magnetic moments
89FU05	Relativistic Hartree calculations of odd-A nuclei
89NE02	Magnetic moments of closed-shell $\pm$ 1 nuclei in the relativistic shell model
91HA15	QCD sum rules in a nuclear medium & the Okamoto-Nolen-Schiffer anomaly
91ZH06	Relativistic Hartree study of deformed sd-shell nuclei
92AV1B	Proton-neutron interaction used to help calculate masses of $Z > N$ nuclei
92MA45	Coulomb displacement energies in relativistic & non-relativistic self-consistent models
92SU02	Nolen-Schiffer anomaly of mirror nuclei: valence nucleon orbits & chrg. sym. breaking
	Other topics
86AN07	Predicted masses and excitation energies in higher isospin multiplets for $9 \leq A \leq 60$
86CA27	Shell-model calculations of quadrupole moments of sd-shell nuclei
86YA1B	Effective shell-model operators; calculated spin-orbit splitting
87BR30	Empirically optimum M1 operator for sd-shell nuclei
87BU07	Projectile-like fragments from ^{20}Ne + ^{197}Au - counting simultaneously emitted neutrons
87RI03	Isotopic distributions of fragments produced in ^{40}Ar + ^{68}Zn at 27.6 MeV/u
89BA1E	Production of hypernuclei in relativistic ion beams
89BA2N	Strangeness production by heavy ions
91NI02	Production of pionic atoms with the (e, e$'$) reaction
91SK02	Effective transition operators in the sd shell
91ZH06	Relativistic Hartree study of deformed sd-shell nuclei
92BE21	Search for the 70 keV resonance in ^{17}O(p, α)^{14}N
92KW01	Clustering of 1p-shell nuclei in the framework of the shell model

Table 17.23
Energy levels of ^{17}F [a])

E_x in ^{17}F (MeV ± keV)	J^π; T	τ or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
0	$\frac{5}{2}^+$; $\frac{1}{2}$	$\tau_{1/2} = 64.49 \pm 0.16$ s	β^+	1–7, 13–24
0.49533 ± 0.10	$\frac{1}{2}^+$	$\tau_m = 412 \pm 9$ ps	γ	2–7, 13–20, 22
3.104 ± 3	$\frac{1}{2}^-$	$\Gamma = 19 \pm 1$	γ, p	3–8, 13, 14, 20, 22
3.857 ± 4	$\frac{5}{2}^-$	1.5 ± 0.2	γ, p	3–8, 13, 14, 22
4.64 ± 20	$\frac{3}{2}^-$	225	p	5, 6, 8, 13, 17, 20
5.00 ± 20	$\frac{3}{2}^+$	1530	p	8
5.220 ± 10	$\frac{9}{2}^-$			5, 6, 16
5.488 ± 11	$\frac{3}{2}^-$	68	p	5, 6, 8, 20
5.672 ± 20	$\frac{7}{2}^-$	40	p	5, 6, 8
5.682 ± 20	$(\frac{5}{2}^-)$ [b])	< 0.6	p	5, 6, 8
5.82 ± 20	$\frac{3}{2}^+$	180	p	5, 8, 17
6.037 ± 9	$\frac{1}{2}^-$	30	p	5, 6, 8, 20
6.56 ± 20	$\frac{1}{2}^+$	200	p	8
6.697 ± 7	$\frac{5}{2}^+$	$\leq 1.6 \pm 0.2$	p	5, 6, 8
6.774 ± 20	$(\frac{3}{2}^+)$	4.5	p	8
7.027 ± 20	$\frac{5}{2}^-$	3.8	p	6, 8
7.356 ± 20	$(\frac{3}{2}^+)$	10 ± 2	p, α	6, 8, 12
7.448 ± 20		≤ 5	p	8
7.454 ± 20		7 ± 2	p, α	8, 12
7.471 ± 20		5 ± 2	p	8
7.479 ± 20	$\frac{3}{2}^+$	795	p	8
7.546 ± 20	$\frac{7}{2}^-$	30	p	8
7.75 ± 40	$(\frac{1}{2}^+)$	179 ± 30	p, α	8, 12
7.95 ± 30		10 ± 3	p	8
8.01 ± 40		50 ± 20	p, α	7, 11
8.07 ± 30	$\frac{5}{2}^{(+)}$	100 ± 20	p, α	6, 8, 12
8.075 ± 10	$(\frac{1}{2}, \frac{3}{2})^-$		p	6, 20
8.2	$\frac{3}{2}^{(-)}$	700 ± 250	p, α	8, 12
8.383 ± 10	$\frac{5}{2}^{(-)}$	11 ± 5	p, α	8, 12
8.416 ± 20	$(\frac{7}{2}^+)$	45 ± 10	p, α	8, 12
8.436 ± 10	$(\frac{1}{2}, \frac{3}{2})^-$		p	20
8.75 ± 60	$\frac{5}{2}^{(+)}$	170 ± 30	p, α	8, 12
8.76	$\frac{3}{2}^+$	90 ± 20	p	8
8.825 ± 25	$(\frac{1}{2}, \frac{3}{2})^-$		p	20
8.98 ± 20	$\frac{7}{2}^-$	165 ± 30	p, α	8, 12

Table 17.23 (continued)
Energy levels of ^{17}F [a])

E_x in ^{17}F (MeV ± keV)	J^π; T	τ or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
9.17 ± 60	$\frac{3}{2}^{(+)}$	140 ± 30	p, α	8, 12, 17
9.450 ± 50		200 ± 40	p	20
9.92	$\frac{9}{2}^+$	90 ± 30	p, α	8, 12
10.030 ± 60		170 ± 40	p	20
10.04 ± 40	$\frac{7}{2}$	280 ± 100	p	8
10.22 ± 40		250 ± 80	α	12
10.40 ± 40	$\frac{5}{2}^{(+)}$	160 ± 40	p	8
10.499 ± 30	$\frac{7}{2}^-$	165 ± 25	p, α	8, 12
10.660 ± 20		90 ± 60	p	20
10.79 ± 40		120 ± 40	p, (α)	8, 12
10.91 ± 100	$\frac{1}{2}^-$	560 ± 100	p	8
10.95 ± 40		190 ± 50	p, (α)	8, 12
11.1929 ± 2.3	$\frac{1}{2}^-$; $\frac{3}{2}$	0.18 ± 0.03	γ, p, α	6–8, 12, 20
11.43 ± 40		240 ± 50	p, α	8, 12
11.58 ± 50		160 ± 30	p	8
12.00 ± 40		120 ± 40	p, α	8, 12
12.25 ± 40	$\frac{3}{2}^-$	300 ± 30	p	8
12.355 ± 20	$\frac{1}{2}^-$	190 ± 20	p	8
~ 12.50	$\frac{7}{2}^-$	~ 600	p	8
12.5501 ± 0.9	$\frac{3}{2}^-$; $\frac{3}{2}$	2.83 ± 0.12	γ, p, α	6–8, 12
13.061 ± 4	$\frac{5}{2}^-$; $\frac{3}{2}$	2 ± 1	γ, p, α	6–8, 12
13.080 ± 4	$(\frac{1}{2}^+)$; $\frac{3}{2}$	2 ± 1	p, α	8, 12
13.13 ± 100	$\frac{5}{2}^-$	520 ± 50	p	8
13.781 ± 4	$\frac{5}{2}^+$; $\frac{3}{2}$	12 ± 5	p, α	8, 12
14.00 ± 50	$\frac{7}{2}^-$	260 ± 30	p	8
14.176 ± 6	$\frac{3}{2}^-$; $\frac{3}{2}$	30 ± 5	γ, p	7, 8
14.3038 ± 3.1	$\frac{7}{2}^-$; $\frac{3}{2}$	19.3 ± 1.6	γ, p, α	7, 8, 12
14.38 ± 50	$\frac{5}{2}^-$	610 ± 50	p	8, 17
14.71 ± 100	$\frac{1}{2}^-$	470 ± 100	p	8
14.809 ± 20	$\frac{1}{2}^+$	190 ± 25	p	8
15.6		~ 550	p	8
17.1	$\frac{5}{2}^-$	1500	p	8
20.1 ± 200		1070 ± 60	γ, ^{3}He	3
20.4 ± 100		700 ± 100	γ, ^{3}He	3

Table 17.23 (continued)
Energy levels of ^{17}F [a])

E_x in ^{17}F (MeV ± keV)	$J^\pi; T$	τ or $\Gamma_{c.m.}$ (keV)	Decay	Reactions
20.9	$\frac{9}{2}^+$	600	p	8
21.3 ± 100		900 ± 100	γ, ^{3}He	3
21.8	$(\frac{9}{2}^+)$	400	p	8
22.7	$\frac{7}{2}^+$	600	p	8
23.8	$\frac{7}{2}^+$	600	p	8
25.4	$\frac{7}{2}^-$	1500	p	8
27.2	$\frac{5}{2}^-$	1500	p	8
28.9	$\frac{5}{2}^+$	2000	p	8

[a]) See also Table 17.25, and see (86AJ04).
[b]) Appears to be analog of ^{17}O*(5.733) (D.J. Millener, private communication).

Table 17.24
Resonances in ^{16}O(p, γ)^{17}F [a])

E_p (MeV ± keV)	Resonant in [b])	Γ_γ (eV)	Γ (keV)	E_x (MeV)	$J^\pi; T$
2.66	γ_1	$(12 \pm 2) \times 10^{-3}$		3.11	$\frac{1}{2}^-; \frac{1}{2}$
3.47	γ_0	0.11 ± 0.02	< 1.5	3.86	$\frac{5}{2}^-; \frac{1}{2}$
11.275 ± 6	γ_1	6.0 ± 2.5 [c])	≤ 1.6	11.204	$\frac{1}{2}^-; \frac{3}{2}$
12.707 ± 1	$\gamma_0 + \gamma_1$	11.3 ± 3.4 [c])	1.8 ± 0.5	12.550	$\frac{3}{2}^-; \frac{3}{2}$
13.255 ± 6	$\gamma_0 + \gamma_1$	2.8 ± 1.8 [c])	5.0 ± 1.5	13.065	$\frac{5}{2}^-; \frac{3}{2}$
14.435 ± 10	γ_0	72 ± 37 [e])	41 ± 10	14.174	$\frac{3}{2}^-; \frac{3}{2}$
14.583 ± 6 [d])	$\gamma_0 + \gamma_1$	13.4 ± 7.0 [c])	28 ± 5	14.313	$\frac{7}{2}^-; \frac{3}{2}$

[a]) See also Table 17.25 and Table 17.20 in (82AJ01).
[b]) γ_0 and γ_1 correspond to transitions to ^{17}F*(0, 0.50), respectively.
[c]) These Γ_γ are based on J^π and Γ_{p_0}/Γ determinations quoted by (75HA06). The B(E1) values for these four states are 4.7 ± 2.0, 5.4 ± 1.6, 1.2 ± 0.8 and 4.4 ± 2.3 [$\times 10^{-3}$] $e^2 \cdot$ fm^2.
[d]) See the text of reaction 7 for discussion of the observed pygmy and giant resonances (75HA07).
[e]) See also Table 17.18 in (77AJ02).

Table 17.25

Resonances in ^{16}O(p, p)^{16}O and ^{16}O(p, α)^{13}N [a])

E_p (MeV ± keV)	$\Gamma_{c.m.}$ (keV)	Particles out	Γ_{p_0}/Γ	^{17}F* (MeV)	J^π; T
2.663 ± 7	19 ± 1	p_0		3.105	$\frac{1}{2}^-$
3.47	1.53 ± 0.2	p_0		3.86	$\frac{5}{2}^-$
4.304 ± 20 [b])	225	p_0		4.649	$\frac{3}{2}^-$
4.672 ± 20 [b])	1530	p_0		4.995	$\frac{3}{2}^+$
5.231 ± 20	68	p_0		5.521	$\frac{3}{2}^-$
5.392 ± 20	40	p_0		5.672	$\frac{7}{2}^-$
5.402 ± 20	< 0.6	p_0		5.682	$\frac{1}{2}^+$
5.546 ± 20	180	p_0		5.817	$\frac{3}{2}^+$
5.779 ± 20	30	p_0		6.036	$\frac{1}{2}^-$
6.332 ± 20	200	p_0		6.556	$\frac{1}{2}^+$
6.482 ± 7 [c])	$\leq 1.6 \pm 0.2$	p_0	$\geq 0.25 \pm 0.04$	6.697	$\frac{5}{2}^+$
6.564 ± 20	4.5	p_0		6.774	$\frac{3}{2}^+$
6.833 ± 20	3.8	p_0, $\gamma_{6.13}$		7.027	$\frac{5}{2}^-$
7.183 ± 20	10 ± 2	p_0, p_2, α_0		7.356	$\frac{3}{2}^+$
7.280 ± 20	≤ 5	p_0		7.448	
7.287 ± 20	7 ± 2	p_0, p_1, p_2, α		7.454	
7.305 ± 20	5 ± 2	p_0, p_2		7.471	
7.313 ± 20	795	p_0		7.479	$\frac{3}{2}^+$
7.385 ± 20	30	p_0, p_2, $\gamma_{6.13}$		7.546	$\frac{7}{2}^-$
7.60 ± 40	179 ± 30	p_0, p_1, α_0		7.75	$\frac{1}{2}^+$
7.81 ± 30	10 ± 3	p_2		7.95	$(\frac{11}{2}^-)$
7.88 ± 40	50 ± 20	p_0, $\gamma_{6.13}$, $\gamma_{6.92}$, α_0		8.01	
7.94 ± 30	100 ± 20	p_0, p_1, α_0		8.07	$\frac{5}{2}^{(+)}$
8.1	700 ± 250	(p_0), p_1, α_0		8.2	$\frac{3}{2}^{(-)}$
8.275 ± 10	11 ± 5	p_0–p_3, α_0		8.383	$\frac{5}{2}^{(-)}$
8.310 ± 20	45 ± 10	p_0–p_3, $\gamma_{6.13}$, $\gamma_{6.92}$, α_0		8.416	$(\frac{7}{2}^+)$
8.66 ± 60	170 ± 30	p_2, p_3, p_4, α_0		8.75	$\frac{5}{2}^{(+)}$
8.68	90 ± 20	p_0	0.2	8.76	$\frac{3}{2}^+$
8.91	165 ± 30	p_0–p_4, $\gamma_{6.13}$, $\gamma_{6.92}$, α_0	0.34 ± 0.05	8.98 ± 0.02	$\frac{7}{2}^-$
9.11	140 ± 30	p_0–p_4, $\gamma_{6.13}$, $\gamma_{6.92}$, α_0	0.55 ± 0.05	9.17 ± 0.06	$\frac{3}{2}^{(+)}$
9.91	90 ± 30	p_0, p_2, α_0	0.095 ± 0.005	9.92	$\frac{9}{2}^+$
10.04 ± 40	280 ± 100	p_0, p_1		10.04	$\frac{7}{2}$
10.23 ± 40	250 ± 80	α_0		10.22	
10.42 ± 40	160 ± 40	p_0, p_1, p_3		10.40	$(\frac{5}{2}^+)$

Table 17.25 (continued)
Resonances in ^{16}O(p, p)^{16}O and ^{16}O(p, α)^{13}N [a]

E_p (MeV ± keV)	$\Gamma_{c.m.}$ (keV)	Particles out	Γ_{p_0}/Γ	^{17}F* (MeV)	J^π; T
10.525 ± 30	165 ± 25	p_0, p_2, α_0	0.28 ± 0.03	10.499	$\frac{7}{2}^-$
(10.75 ± 50)		p_0, p_1, α_0		(10.71)	$(\frac{7}{2}^-)$
10.83 ± 40	120 ± 40	p_0, p_2, (p_3), (α_0)		10.79	
10.96 ± 100	560 ± 100	p_0	0.25 ± 0.07	10.91	$\frac{1}{2}^-$
11.00 ± 40	190 ± 50	(p_2), p_3, (α_0)		10.95	
11.2636 ± 2.0 [d]	0.20 ± 0.04	p_0, p_2, p_4, α_0	0.093 ± 0.013	11.1929 ± 2.1	$\frac{1}{2}^-$; $\frac{3}{2}$
11.52 ± 40	240 ± 50	p_2, α_0		11.43	
11.67 ± 50	160 ± 30	p_0, p_3		11.58	
12.12 ± 40	120 ± 40	p_2, α_0		12.00	
12.39 ± 40	300 ± 30	p_0, p_2	0.26 ± 0.03	12.25	$\frac{3}{2}^-$
12.500 ± 20	190 ± 20	p_0, p_1, p_4	0.31 ± 0.03	12.355	$\frac{1}{2}^-$
≈ 12.65	≈ 600	p_0	≈ 0.09	≈ 12.50	$\frac{7}{2}^-$
12.7077 ± 2.0 [e]	2.83 ± 0.12	p_0, p_2, p_4, p_5, α_0, α_1	0.332 ± 0.018	12.5505 ± 2.3	$\frac{3}{2}^-$; $\frac{3}{2}$
(13.06 ± 100)		p_0		(12.88)	$(\frac{7}{2}^-)$
(13.06 ± 50)		p_0		(12.88)	$(\frac{1}{2}^+)$
13.250 ± 4	2 ± 1	p_0, p_{1+2}, p_{3+4}, p_5, α_0	0.15 ± 0.04	13.060	$\frac{5}{2}^-$; $\frac{3}{2}$
13.271 ± 4	2 ± 1	p_0–p_4	0.04 ± 0.02	13.080	$(\frac{1}{2}^+)$; $\frac{3}{2}$
13.32 ± 100	520 ± 50	p_0	0.163 ± 0.016	13.13	$\frac{5}{2}^-$
14.017 ± 4	12 ± 5	p_0, p_{1+2}, p_{3+4}, α_0	0.02 ± 0.01	13.781	$\frac{5}{2}^+$; $\frac{3}{2}$
(14.20 ± 50)		p_0		(13.95)	$(\frac{1}{2}^+)$
14.25 ± 50	260 ± 30	p_0	0.08 ± 0.01	14.00	$\frac{7}{2}^-$
14.438 ± 6	27 ± 5	p_0, p_{3+4}	0.04 ± 0.02	14.177	$\frac{3}{2}^-$; $\frac{3}{2}^+$
14.5730 ± 3.0 [f]	19.3 ± 1.6	p_0, p_{1+2}, p_{3+4}, p_5, α_0	0.085 ± 0.008	14.3038 ± 3.1	$\frac{7}{2}^-$; $\frac{3}{2}$
14.65 ± 50	610 ± 50	p_0	0.10 ± 0.01	14.38	$\frac{5}{2}^-$
(14.94 ± 100)		p_0			$(\frac{3}{2}^-)$
15.00 ± 100	470 ± 100	p_0	0.25 ± 0.03	14.71	$\frac{1}{2}^-$
15.110 ± 20	190 ± 25	p_0	0.150 ± 0.015	14.809	$\frac{1}{2}^+$
(15.245 ± 100)		p_0		(14.94)	$(\frac{5}{2}^+)$
(15.30 ± 50)		p_0		(14.98)	$(\frac{3}{2}^+)$
(15.37 ± 100)		p_0		(15.05)	$(\frac{3}{2}^-)$
(15.545 ± 100)		p_0		(15.22)	$(\frac{7}{2}^-)$
15.9 [g]	≈ 550	p_0, p_{1+2}		15.6	
17.6	1500	p_0, p_{3+4}		17.1	$\frac{5}{2}^-$
20.4	600	p_0		19.8	$\frac{3}{2}^+$

Table 17.25 (continued)
Resonances in $^{16}O(p, p)^{16}O$ and $^{16}O(p, \alpha)^{13}N$ [a]

E_p (MeV ± keV)	$\Gamma_{c.m.}$ (keV)	Particles out	Γ_{p_0}/Γ	$^{17}F^*$ (MeV)	$J^\pi; T$
21.6	600	p_0, (α)		20.9	$\frac{9}{2}^+$
22.6	400	p_0, (α)		21.8	$(\frac{9}{2}^+)$
23.5	600	p_0, p_5		22.7	$\frac{7}{2}^+$
24.7	600	p_0, (α)		23.8	$\frac{7}{2}^+$
26.4	1500	p_0, (α)		25.4	$\frac{7}{2}^-$
28.3	1500	p_0		27.2	$\frac{5}{2}^-$
30.1	2000	p_0		28.9	$\frac{5}{2}^+$

[a]) See earlier references and comments in Tables 17.20 (71AJ02), 17.19 (77AJ02) and 17.21 (82AJ01). See also Table 17.24 here. Uncertainties in E_p (below 12.7 MeV) have been increased because of a possible error in calibrating the magnet used in many of the measurements reported in (71AJ02). See also (64DA02), and see comments in (86AJ04).
[b]) E_r, not E_λ, is used for calculating E_x.
[c]) (82SE01). Uncertainty in E_p estimated by reviewer (86AJ04). See also (82AJ01).
[d]) $\Gamma_{p_0} = 19 \pm 3$ eV (76HI09).
[e]) $\Gamma_{p_0} = 0.94 \pm 0.06$ keV, $\Gamma_{\alpha_0} = 62 \pm 16$ eV, $\Gamma_{\alpha_1} = 53 \pm 22$ eV (76HI09). See also (86AJ04).
[f]) $\Gamma_{p_0} = 1.65 \pm 0.12$ keV, $\Gamma_{\alpha_0} = 2.6 \pm 0.7$ keV (76HI09).
[g]) See also Table 17.20 of (71AJ02) for possible other resonances.

Table 17.26
Energy levels of ^{17}Ne [a]

E_x(MeV)	$J^\pi; T$	$\tau_{1/2}$ (ms)	Decay	Reaction
0	$\frac{1}{2}^-; \frac{3}{2}$	109.2 ± 0.6	β^+ [b])	1

[a]) Preliminary evidence for excited states of ^{17}Ne (reported in (77AJ02)) has not been published.
[b]) See also Tables 17.5, 17.6 and 17.27.

Table 17.27

β^+ decay of ^{17}Ne [a])

Decay to ^{17}F* (MeV)	J^π	Total branching ratio (%)		log ft [c])	Decay branches [d])
		Ref. [a])	Ref. [b])		
0.0	$\frac{5}{2}^+$	0.55 ± 0.17 [e])		$9.56^{1u}{}^{+0.16}_{-0.12}$ [f])	
0.495	$\frac{1}{2}^+$	0.61 ± 0.10 [e])		$6.80^{+0.08}_{-0.06}$ [f])	
3.10	$\frac{1}{2}^-$	$0.10^{+0.03}_{-0.01}$	0.48 ± 0.07	$7.12^{+0.05}_{-0.11}$	p_0
4.65	$\frac{3}{2}^-$	16.54 ± 0.14	16.2 ± 0.7	4.57 ± 0.05	p_0
5.49	$\frac{3}{2}^-$	59.16 ± 0.4	54.4 ± 0.7 [g])	3.810 ± 0.015	p_0
6.04	$\frac{1}{2}^-$	7.8 ± 0.2	10.6 ± 0.2	4.545 ± 0.018	p_0
8.08	$\frac{3}{2}^-$	7.3 ± 0.9	6.83 ± 0.11	3.93 ± 0.06	p_0, p_1, α_0
8.2	$\frac{3}{2}^-$	1.7 ± 0.3	2.08 ± 0.08 [g])	4.51 ± 0.09	p_0
8.43	$\frac{1}{2}^-$	4.0 ± 0.9	6.51 ± 0.26	4.05 ± 0.10	p_0, p_1, p_3, α_0
9.4 [h])		0.6 ± 0.2		$4.43^{+0.19}_{-0.13}$	p_0, p_1/p_2, α_0
10.0 [h])		0.7 ± 0.3		$4.06^{+0.26}_{-0.16}$	p_0, p_4, α_0
10.66 [h])		0.007 ± 0.004		$5.7^{+0.4}_{-0.2}$	p_0, α_0
10.9	$\frac{1}{2}^-$	0.016 ± 0.006		$5.14^{+0.22}_{-0.17}$	p_0, α_0
11.193	$\frac{1}{2}^-$	0.64 ± 0.14	$0.71^{+0.1}_{-0.05}$	3.31 ± 0.11	p_0, p_1, p_2, p_4, α_0, α_1
12.23		0.001 ± 0.0006		$4.98^{+0.41}_{-0.23}$	p_0

[a]) (88BO39). See also Table 17.21 in (86AJ04).

[b]) (71HA05).

[c]) We are grateful to Dr. M. Martin for providing these log ft values calculated for the branchings measured in (88BO39).

[d]) Proton decay to states ^{16}O*(0.0, 6.05, 6.13, 6.92, 7.16) are indicated by p_0, p_1, p_2, p_3, p_4, respectively. Alpha decay to ^{13}N*(0.0, 2.36) are indicated by α_0, α_1 respectively.

[e]) Based on assumption that log ft values are the same as for the ^{17}N mirror decays.

[f]) From ^{17}N β^- decay.

[g]) Obtained by (88BO39) from addition of several of the peaks in (71HA05).

[h]) New levels observed by (88BO39) with measured energies, $E_x = 9.450 \pm 0.050$, 10.030 ± 0.060, 10.660 ± 0.020 MeV and widths $\Gamma = 200 \pm 40$, 170 ± 40, 90 ± 60 keV, respectively.

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(Closed 31 December 1992)

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86DR1B DRUMM ET AL, PROC. 11TH AINSE NUCL. PHYS. CONF. AT MELBOURNE (1986) 44
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86FUZV FUJITA ET AL, INT. CONF. NUCL. PHYS., HARROGATE, UK, IOP (1986) 317
86GA10 GAUL AND BICKEL, PHYS. REV. C34 (1986) 326
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86GA1I GAARDE, INT. CONF. NUCL. PHYS., HARROGATE, UK, IOP (1986) 173
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86HA13 HAIDER AND MALIK, J. PHYS. G12 (1986) 537
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86KI1C KIM, PHYS. REV. LETT. 57 (1986) 2508
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86PA10 PAPADOPOULOS ET AL, PHYS. REV. C34 (1986) 196
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87BA10 BAI ET AL, Z. PHYS. A326 (1987) 269
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87BA1T BACHELIER ET AL, PROC. XI INT. CONF. PART. NUCL., KYOTO, (PANIC 87) 268
87BA1U BAHCALL, REV. MOD. PHYS. 59 (1987) 505
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87BA31 BARZ ET AL, PHYS. LETT. B191 (1987) 232
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87BA50 BAUER, NUCL. PHYS. A471 (1987) 604
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87BO54 BOFFI ET AL, NUOVO CIM. A98 (1987) 291
87BR20 BRZYCHCZYK ET AL, PHYS. LETT. B194 (1987) 473
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87CO1E COHEN AND FURNSTAHL, PHYS. REV. C35 (1987) 2231
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87GI05 GILLIBERT ET AL, PHYS. LETT. B192 (1987) 39
87GI1C GIBBS AND GIBSON, ANN. REV. NUCL. PART. SCI. 37 (1987) 411
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87GM04 GMITRO, KAMALOV AND MACH, PROG. THEOR. PHYS. SUPPL. 91 (1987) 60
87GO05 GOUWELOOS AND THIES, PHYS. REV. C35 (1987) 631
87GO19 GODRE AND WAGHMARE, PRAMANA 28 (1987) 41
87GO1C GOLOVKOV AND GOLDBERG, PROC. 37TH MTG. NUCL. SPECTROSCOPY STRUC. AT. NUCL., JURMALA, USSR, NAUKA (1987) 388
87GO1E GOERLACH, PROC. INTER. EUROPHYS. CONF. IN SWEDEN (1987) 146
87GO30 GODRE AND WAGHMARE, PHYS. REV. C36 (1987) 1632
87GR04 GREGOIRE ET AL, PHYS. LETT. B186 (1987) 14
87GR16 GREBEN, PHYS. LETT. B192 (1987) 287
87GR1I GREEN AND NISKANEN, PROG. PART. NUCL. PHYS. 18 (1987) 93
87GR20 GREEN AND WYCECH, NUCL. PHYS. A467 (1987) 744
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87HA1D HARRIS ET AL, ASTROPHYS. J. 316 (1987) 294
87HA1E HARRIS AND LAMBERT, ASTROPHYS. J. 318 (1987) 868
87HA1J HAAPAKOSKI, MOD. PHYS. LETT. A2 (1987) 359
87HA37 HASAN, KOHLER AND VARY, PHYS. REV. C36 (1987) 2180
87HA40 HAUSMANN ET AL, PHYS. LETT. B199 (1987) 17
87HA42 HASAN, KOHLER AND VARY, PHYS. REV. C36 (1987) 2649
87HI10 HINNEFELD ET AL, PHYS. REV. C36 (1987) 989
87HO1C HODGSON, CONTEMP. PHYS. 28 (1987) 365
87HO1F HOFSTADTER, AUST. PHYS. 24 (1987) 236
87HU11 HUSSEIN ET AL, J. PHYS. G13 (1987) 967
87HU1C HUMANIC ET AL, BULL. AM. PHYS. SOC. 32 (1987) 1564
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87IC02 ICHII, BENTZ AND ARIMA, NUCL. PHYS. A464 (1987) 575
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87IM1C IMANISHI AND VON OERTZEN, PHYS. REP. 155 (1987) 29
87IMZZ IMANISHI, PARK AND VON OERTZEN, BULL. AM. PHYS. SOC. 32 (1987) 1567
87IS04 ISLAM, FINLAY AND PETLER, NUCL. PHYS. A464 (1987) 395
87JA1B JACKSON AND BOGGILD, NUCL. PHYS. A470 (1987) 669

87JE02 JENNEWEIN, SCHOCH AND ZETTL, NUCL. PHYS. A468 (1987) 381
87KA04 KAPS ET AL, Z. PHYS. A326 (1987) 97
87KA13 KANAZAWA ET AL, PHYS. REV. C35 (1987) 1828
87KA39 KARAPIPERIS AND KOBAYASHI, ANN. PHYS. 177 (1987) 1
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87KH1A KHUBEIS AND ZIEGLER, NUCL. INSTRUM. METHODS PHYS. RES. B24-25 (1987) 691
87KH1B KHANKHASAYEV, PROC. XI INT. CONF. PART. NUCL., KYOTO, (PANIC 87) 334
87KI1C KISSENER, ROTTER AND GONCHAROVA, FORTSCHR. PHYS. 35 (1987) 277
87KI22 KIM, PHYS. LETT. B198 (1987) 9
87KO12 KOX ET AL, PHYS. REV. C35 (1987) 1678
87KO15 KOZIK ET AL, Z. PHYS. A326 (1987) 421
87KO1E KOZMYR, PROC. 37TH MTG. NUCL. SPECTROSCOPY STRUC. AT. NUCL., JURMALA, USSR, NAUKA (1987) 332
87KO1F KOHNO ET AL, PROC. XI INT. CONF. PART. NUCL., KYOTO, (PANIC 87) 566
87KO30 KOHNO ET AL, NUCL. PHYS. A470 (1987) 609
87KR19 KRAMP ET AL, NUCL. PHYS. A474 (1987) 412
87KR1B KROTSCHECK, NUCL. PHYS. A465 (1987) 461
87KR1F KRUMOVA, PETKOV AND STOITSOV, BULG. J. PHYS. 14 (1987) 501
87KU02 KURONEN, KEINONEN AND TIKKANEN, PHYS. REV. C35 (1987) 591
87LA11 LANG ET AL, PHYS. REV. C35 (1987) 1214
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87LE12 LE BRUN, NATHAN AND HOBLIT, PHYS. REV. C35 (1987) 2005
87LE1B LENZ, PROG. THEOR. PHYS. SUPPL. 91 (1987) 27
87LH01 L'HOTE ET AL, PHYS. LETT. B198 (1987) 139
87LI04 LILLEY ET AL, NUCL. PHYS. A463 (1987) 710
87LI1F LI, YAO AND ZHANG, HIGH ENERGY PHYS. NUCL. PHYS. 11 (1987) 397
87LI30 LINDGREN ET AL, CAN. J. PHYS. 65 (1987) 666
87LO01 LOZANO AND VITTURI, PHYS. REV. C35 (1987) 367
87LU02 LUMPE AND RAY, PHYS. REV. C35 (1987) 1040
87LU04 LUMPE AND RAY, PHYS. LETT. B186 (1987) 263
87LY04 LYNCH, NUCL. PHYS. A471 (1987) 309C
87MA04 MAHALANABIS, Z. PHYS. A326 (1987) 131
87MA09 MA AND AUSTERN, NUCL. PHYS. A463 (1987) 620
87MA1B MASUDA, NITTO AND UCHIYAMA, PROG. THEOR. PHYS. 78 (1987) 972
87MA1I MATTHEWS ET AL, PROC. XI INT. CONF. PART. NUCL., KYOTO, (PANIC 87) 360
87MA1K MATTHEWS, BULL. AM. PHYS. SOC. 32 (1987) 1575
87MA1M MA ET AL, KEXUE TONGBAO 32 (1987) 12
87MA22 MAGLIONE ET AL, PHYS. LETT. B191 (1987) 237
87MA30 MAVROMATIS ET AL, NUCL. PHYS. A470 (1987) 185
87MA40 MANLEY AND KELLY, PHYS. REV. C36 (1987) 1646
87MA52 MANLEY ET AL, PHYS. REV. C36 (1987) 1700
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87MC1B MC LERRAN, PROC. HADRONIC SESSION OF THE 22ND RENCONTRE DE MORIOND, VOL. 2, LES ARCS, FRANCE (1987) 399
87ME12 MEIRAV ET AL, PHYS. REV. C36 (1987) 1066
87ME1B MEWALDT AND STONE, BULL. AM. PHYS. SOC. 32 (1987) 1037
87MI1A MIAN, PHYS. REV. C35 (1987) 1463
87MI1B MITCHELL ET AL, BULL. AM. PHYS. SOC. 32 (1987) 1109
87MI25 MILLENER, PHYS. REV. C36 (1987) 1643
87MIZY MIDDLETON ET AL, BULL. AM. PHYS. SOC. 32 (1987) 1578
87MO27 MOON, PARK AND SCHEID, PHYS. REV. C36 (1987) 2341
87MU03 MUZYCHKA AND PUSTILNIK, SOV. J. NUCL. PHYS. 45 (1987) 57
87NA01 NAMBOODIRI ET AL, PHYS. REV. C35 (1987) 149

87NA04 NAVARRO AND ROIG, NUCL. PHYS. A465 (1987) 628
87NA13 NAGARAJAN andRES AND LOZANO, PHYS. LETT. B192 (1987) 297
87NA1C NADASEN ET AL, BULL. AM. PHYS. SOC. 32 (1987) 1076
87NA1D NAGATA ET AL, NUCL. INSTRUM. METHODS PHYS. RES.B18 (1987) 515
87NG01 VAN SEN ET AL, NUCL. PHYS. A464 (1987) 717
87NU02 NUHN, SCHEID AND PARK, PHYS. REV. C35 (1987) 2146
87OC01 O'CONNELL ET AL, PHYS. REV. C35 (1987) 1063
87OH08 OHKUBO AND BRINK, PHYS. REV. C36 (1987) 966
87OH1B OHTA AND FUJITA, PROC. XI INT. CONF. PART. NUCL., KYOTO, (PANIC 87) 744
87OL1A OLSON ET AL, BULL. AM. PHYS. SOC. 32 (1987) 1015
87OS01 OSIPOWICZ, LIEB AND BRUSSERMANN, NUCL. INSTRUM. METHODS PHYS. RES. B18 (1987) 232
87OS03 OSMAN, INDIAN J. PURE APPL. PHYS. 25 (1987) 1
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87PA01 PARKER, HOGAN AND ASHER, PHYS. REV. C35 (1987) 161
87PA1D PAUL, FINK AND HOLLOS, NUCL. INSTRUM. METHODS PHYS. RES.B29 (1987) 393
87PA24 PANTIS AND PEARSON, PHYS. REV. C36 (1987) 1408
87PI02 PIEKAREWICZ, PHYS. REV. C35 (1987) 675
87PI1B PILE ET AL, PROC. XI INT. CONF. PART. NUCL., KYOTO, (PANIC 87) 594
87PI1C PILE ET AL, BULL. AM. PHYS. SOC. 32 (1987) 1560
87PL03 PLAGA ET AL, NUCL. PHYS. A465 (1987) 291
87PO11 PONISCH AND KOONIN, PHYS. REV. C36 (1987) 633
87PO1C POYARKOV AND SIZOV, SOV. J. NUCL. PHYS. 45 (1987) 940
87PR03 PRICE AND WALKER, PHYS. REV. C36 (1987) 354
87PR1A PRAPKOS, ARNOULD AND ARCORAGI, ASTROPHYS. J. 315 (1987) 209
87QU02 QUESNE, PHYS. LETT. B188 (1987) 1
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87RA02 RAE, KEELING AND ALLCOCK, PHYS. LETT. B184 (1987) 133
87RA1D RAMATY AND MURPHY, SPACE SCI. REV. 45 (1987) 213
87RA22 RAE, KEELING AND SMITH, PHYS. LETT. B198 (1987) 49
87RA28 RAJASEKARAN, ARUNACHALAM AND DEVANATHAN, PHYS. REV. C36 (1987) 1860
87RA36 RAHMAN ET AL, NUOVO CIM. A98 (1987) 513
87RE02 REDDER ET AL, NUCL. PHYS. A462 (1987) 385
87RI03 RICHERT AND WAGNER, NUCL. PHYS. A466 (1987) 132
87RI1A RICHTER, BULL. AM. PHYS. SOC. 32 (1987) 1071
87RO04 ROUSSEL ET AL, PHYS. LETT. B185 (1987) 29
87RO06 ROWE, ROCHFORD AND LE BLANC, NUCL. PHYS. A464 (1987) 39
87RO10 ROYER ET AL, NUCL. PHYS. A466 (1987) 139
87RO1D ROLFS, TRAUTVETTER AND RODNEY, REP. PROG. PHYS. 50 (1987) 233
87RO1F ROMANOVSKII ET AL, PROC. 37TH MTG. NUCL. SPECTROSCOPY STRUC. AT. NUCL., JURMALA, USSR, NAUKA (1987) 286
87RU1A RUFA ET AL, J. PHYS. G13 (1987) L143
87RY03 RYCKEBUSCH ET AL, PHYS. LETT. B194 (1987) 453
87SA01 SAMANTA ET AL, PHYS. REV. C35 (1987) 333
87SA15 SAGAWA AND TOKI, J. PHYS. G13 (1987) 453
87SA1D SAWA, SOL. PHYS. 107 (1987) 167
87SA25 SAINT-LAURENT, NUCL. INSTRUM. METHODS PHYS. RES. B26 (1987) 273
87SA55 SAAD ET AL, NUOVO CIM. A98 (1987) 529
87SC11 SCHMIEDER ET AL, NUCL. INSTRUM. METHODS PHYS. RES. A256 (1987) 457
87SC34 SCALIA, NUOVO CIM. A98 (1987) 571
87SH1B SHVEDOV AND NEMETS, PROC. 37TH MTG. NUCL. SPECTROSCOPY STRUC. AT. NUCL., JURMALA, USSR, NAUKA(1987) 390
87SH1C SHEN ET AL, PHYS. ENERG. FORTIS PHYS. NUCL. 11 (1987) 104
87SH21 SHEN ET AL, Z. PHYS. A328 (1987) 219

87SH23 SHEN ET AL, NUCL. PHYS. A472 (1987) 358
87SHZS SHVEDOV, NEMETS AND RUDCHIK, PROC. 37TH MTG. NUCL. SPECTROSCOPY STRUC. AT. NUCL., JURMALA, USSR, NAUKA (1987) 389
87SK02 SKALSKI, Z. PHYS. A326 (1987) 263
87SN1A SNEPPEN, NUCL. PHYS. A470 (1987) 213
87SP05 SPARROW, PHYS. REV. C35 (1987) 1410
87SP11 SPERBER, STRYJEWSKI AND ZIELINSKA-PFABE, PHYS. SCR. 36 (1987) 880
87SU03 SUGIMITSU ET AL, NUCL. PHYS. A464 (1987) 415
87SU07 SUOMIJARVI ET AL, PHYS. REV. C36 (1987) 181
87SU08 SUZUKI, OKAMOTO AND KUMAGAI, PROG. THEOR. PHYS. 77 (1987) 196
87SU12 SUZUKI, OKAMOTO AND KUMAGAI, PHYS. REV. C36 (1987) 804
87TA1C TANG, AIP CONF. PROC. 162 (1987) 174
87TE01 TELLEZ-ARENAS, LOMBARD AND MAILLET, J. PHYS. G13 (1987) 311
87TH03 THAYYULLATHIL, COHEN AND BRONIOWSKI, PHYS. REV. C35 (1987) 1969
87TI01 TIERETH ET AL, NUCL. PHYS. A464 (1987) 125
87TO10 TOHYAMA, PHYS. REV. C36 (1987) 187
87TO1B TOWNER, PHYS. REP. 155 (1987) 263
87TR01 TROST, LEZOCH AND STROHBUSCH, NUCL. PHYS. A462 (1987) 333
87TZ1A TZENG AND KUO, CHIN. J. PHYS. 25 (1987) 326
87VA03 VAN ROOSMALEN, PHYS. REV. C35 (1987) 977
87VA26 VAN HEES, WOLTERS AND GLAUDEMANS, PHYS. LETT. B196 (1987) 19
87VAZY VAN VERST ET AL, BULL. AM. PHYS. SOC. 32 (1987) 1547
87VD1A VDOVIN, GOLOVIN AND LOSCHAKOV, SOV. J. PART. NUCLEI 18 (1987) 573
87VE03 VESPER, DRECHSEL AND OHTSUKA, NUCL. PHYS. A466 (1987) 652
87VI02 VIDEBACK ET AL, PHYS. REV. C35 (1987) 2333
87VI04 VINH MAU, NUCL. PHYS. A470 (1987) 406
87VI1B VIOLA, NUCL. PHYS. A471 (1987) 53C
87VO05 VOIT AND VON OERTZEN, PHYS. REV. C35 (1987) 2321
87WA1B WADA AND HORIUCHI, PHYS. REV. LETT. 58 (1987) 2190
87WA1F WANNIER AND SAHAI, ASTROPHYS. J. 319 (1987) 367
87WI11 WIESCHER ET AL, ASTROPHYS. J. 316 (1987) 162
87WU05 WUNSCH AND ZOFKA, PHYS. LETT. B193 (1987) 7
87XI01 XIA AND HE, PHYS. REV. C35 (1987) 1789
87YA02 YAMAZAKI ET AL, PHYS. REV. C35 (1987) 355
87YA1B YAZICI AND IRVINE, J. PHYS. G13 (1987) 615
87YA1C YAMAMOTO, PROC. XI INT. CONF. PART. NUCL., KYOTO, (PANIC 87) 582
87YA1D YAMAZAKI ET AL, PROC. XI INT. CONF. PART. NUCL., KYOTO, (PANIC 87) 670
87YA1E YAVIN, CAN. J. PHYS. 65 (1987) 647
87YA1F YAKOVLEV, SOV. J. NUCL. PHYS. 46 (1987) 244
87YO04 YOKOYAMA AND HORIE, PHYS. REV. C36 (1987) 1657
87YO1A YOUNG, BULL. AM. PHYS. SOC. 32 (1987) 1565
87ZA08 ZAVARZINA AND SERGEEV, SOV. J. NUCL. PHYS. 46 (1987) 261
87ZE05 ZELEVINSKII AND MAZEPUS, IZV. AKAD. NAUK SSSR SER. FIZ. 51 (1987) 884
87ZU1A ZUR LOYE ET AL, SCIENCE 238 (1987) 1558
88AD07 ADAMS ET AL, PHYS. REV. C38 (1988) 2771
88AD08 ADACHI AND LIPPARINI, NUCL. PHYS. A489 (1988) 445
88AH04 AHRENS ET AL, NUCL. PHYS. A490 (1988) 655
88AI1C AIELLO ET AL, EUROPHYS. LETT. 6 (1988) 25
88AJ01 AJZENBERG-SELOVE, NUCL. PHYS. A490 (1988) 1
88AL06 ALHASSID, IACHELLO AND SHAO, PHYS. LETT. B201 (1988) 183
88AL08 ALEIXO ET AL, PHYS. REV. C37 (1988) 1062
88AL1K AL-KOFAHI ET AL, BULL. AM. PHYS. SOC. 33 (1988) 1730
88AL1N ALBERICO ET AL, PHYS. REV. C38 (1988) 1801
88AM03 AMOS, DE SWINARSKI AND BERGE, NUCL. PHYS. A485 (1988) 653

88AN18 ANTONOV ET AL, NUOVO CIM. A100 (1988) 779
88AN1C ANNE ET AL, NUCL. INSTRUM. METHODS PHYS. RES. B34 (1988) 295
88AN1D ANDREANI, VANGIONIFLAM AND AUDOUZE, ASTROPHYS. J. 334 (1988) 698
88AR1D ARDITO ET AL, EUROPHYS. LETT. 6 (1988) 131
88AR1I ARIMA, HYPERFINE INTERACT. 43 (1988) 47
88AR22 ARTEMOV ET AL, SOV. J. NUCL. PHYS. 48 (1988) 596
88ARZU ARTEMOV ET AL, PROC. 38TH MTG. NUCL. SPECTROSCOPY STRUC. AT. NUCL., BAKU, USSR, NAUKA (1988) 381
88AS03 ASSENBAUM, LANGANKE AND SOFF, PHYS. LETT. B208 (1988) 346
88AU03 AUGER AND FERNANDEZ, NUCL. PHYS. A481 (1988) 577
88AU1A AUSHEV ET AL, PROC. 38TH MTG. NUCL. SPECTROSCOPY STRUC. AT. NUCL., BAKU, USSR, NAUKA (1988) 369
88AY03 AYIK, SHAPIRA AND SHIVAKUMAR, PHYS. REV. C38 (1988) 2610
88AZZZ AZIZ ET AL, BULL. AM. PHYS. SOC. 33 (1988) 961
88BA15 BAYE AND DESCOUVEMONT, NUCL. PHYS. A481 (1988) 445
88BA1Y BAHCALL, DAVIS AND WOLFENSTEIN, NATURE 334 (1988) 487
88BA21 BADALA ET AL, NUCL. PHYS. A482 (1988) 511C
88BA39 BARRETTE ET AL, PHYS. LETT. B209 (1988) 182
88BA43 BANDYOPADHYAY AND SAMADDAR, NUCL. PHYS. A484 (1988) 315
88BA55 BARKER AND FERGUSON, PHYS. REV. C38 (1988) 1936
88BE14 BERTRAND, BEENE AND HOREN, NUCL. PHYS. A482 (1988) 287C
88BE15 BEENE, VARNER AND BERTRAND, NUCL. PHYS. A482 (1988) 407C
88BE1D BECCHETTI ET AL, 5TH INTL. CONF. ON CLUSTERING IN NUCLEI (KYOTO, JAPAN 1988)
88BE1J BELYAEVA AND ZELENSKAYA, PROC. 38TH MTG. NUCL. SPECTROSCOPY STRUC. AT. NUCL., BAKU, USSR, NAUKA (1988) 449
88BE1W BECKERMAN, REP. PROG. PHYS. 51 (1988) 1047
88BE24 BEHERA AND ROUTRAY, J. PHYS. G14 (1988) 1073
88BE2A BESLIU AND JIPA, REV. ROUM. PHYS. 33 (1988) 409
88BE2B BELOSTOTSKY ET AL, PROC. INTL. SYMP. ON MODERN DEVELOPMENTS IN NUCL. PHYS., NOVOSIBIRSK, USSR 1987 (SINGAPORE: WORLD SCI. 1988) 191
88BE2O BEISE ET AL, AIP CONF. PROC. 176 (1988) 534
88BE49 BELJAEVA AND ZELENSKAJA, IZV. AKAD. NAUK SSSR 52 (1988) 942
88BE56 BELOZYOROV ET AL, IZV. AKAD. NAUK SSSR 52 (1988) 2171
88BE57 BEREZHNOY, MIKHAJLUK AND PILIPENKO, IZV. AKAD. NAUK SSSR 52 (1988) 2185
88BEYJ BELOZEROV ET AL, PROC. 38TH MTG. NUCL. SPECTROSCOPY STRUC. AT. NUCL., BAKU, USSR, NAUKA (1988) 380
88BL02 BLOCKI ET AL, NUCL. PHYS. A477 (1988) 189
88BL07 BLESZYNSKI ET AL, PHYS. REV. C37 (1988) 1527
88BL10 BLUNDEN AND MCCORQUODALE , PHYS. REV. C38 (1988) 1861
88BL1H BLANPAIN ET AL, NUCL. INSTRUM. METHODS PHYS. RES. B34 (1988) 459
88BL1I BLUNDEN, AIP CONF. PROC. 176 (1988) 636
88BO04 BOSCA AND GUARDIOLA, NUCL. PHYS. A476 (1988) 471
88BO10 BOZZOLO, CIVITARESE AND VARY, PHYS. REV. C37 (1988) 1240
88BO13 BORDERIE ET AL, PHYS. LETT. B205 (1988) 26
88BO1D BOGDANOWICZ, NUCL. PHYS. A479 (1988) 323C
88BO39 BORGE ET AL, NUCL. PHYS. A490 (1988) 287
88BO40 BOFFI, NICROSINI AND RADICI, NUCL. PHYS. A490 (1988) 585
88BR04 BRANDAN, PHYS. REV. LETT. 60 (1988) 784
88BR11 BROWN ET AL, ANN. PHYS. 182 (1988) 191
88BR1N BRECHTMANN AND HEINRICH, Z. PHYS. A330 (1988) 407
88BR20 BRANDAN, FRICKE AND MCVOY, PHYS. REV. C38 (1988) 673
88BR29 BRANDAN AND SATCHLER, NUCL. PHYS. A487 (1988) 477
88BRZY BROWN, MIDDLETON AND AZIZ, BULL. AM. PHYS. SOC. 33 (1988) 1022

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88CA10 CAVINATO, MARANGONI AND SARUIS, PHYS. REV. C37 (1988) 1823
88CA1G CARDELLA ET AL, NUCL. PHYS. A482 (1988) 235C
88CA1N CAUGHLAN AND FOWLER, AT. DATA NUCL. DATA TABLES 40 (1988) 283
88CAZV CAUSSYN ET AL, BULL. AM. PHYS. SOC. 33 (1988) 1562
88CH08 CHEON, PHYS. REV. C37 (1988) 1088
88CH1H CHRIEN ET AL, PHYS. REV. LETT. 60 (1988) 2595
88CH1T CHEN, YANG AND WU, HIGH ENERGY PHYS. NUCL. PHYS. 12 (1988) 822
88CH28 CHAUDHURI, BHATTACHARYA AND KRISHAN, NUCL. PHYS. A485 (1988) 181
88CH30 CHAMPAGNE ET AL, Z. PHYS. A330 (1988) 377
88CH48 CHRIEN, NUCL. PHYS. A478 (1988) 705C
88CIZZ CISKOWSKI ET AL, BULL. AM. PHYS. SOC. 33 (1988) 1583
88CL03 CLAUSEN, PETERSON AND LINDGREN, PHYS. REV. C38 (1988) 589
88CL04 CLARKE ET AL, J. PHYS. G14 (1988) 1399
88CL1C CLAYTON, ASTROPHYS. J. 334 (1988) 191
88CO10 CORVISIERO ET AL, NUCL. PHYS. A483 (1988) 9
88CO15 COMAY, KELSON AND ZIDON, PHYS. LETT. B210 (1988) 31
88CO1D COLGATE, EPSTEIN AND HAXTON, BULL. AM. PHYS. SOC. 33 (1988) 1491
88CO1G CO ET AL, NUCL. PHYS. A485 (1988) 463
88CS01 CSEH AND LEVAI, PHYS. REV. C38 (1988) 972
88CU1A CUMMINGS, CHRISTIAN AND STONE, BULL. AM. PHYS. SOC. 33 (1988) 1069
88DA11 DATTA ET AL, J. PHYS. G14 (1988) 937
88DE09 DEVRIES ET AL, PHYS. LETT. B205 (1988) 22
88DE1A DEYOUNG ET AL, BULL. AM. PHYS. SOC. 33 (1988) 928
88DE22 DE BOER ET AL, J. PHYS. G14 (1988) L131
88DE31 DE SWINIARSKI AND PHAM, NUOVO CIM. A99 (1988) 117
88DE35 DESWINIARSKI, PHAM AND RAYNAL, PHYS. LETT. B213 (1988) 247
88DH1A DHUGA AND ERNST, AIP CONF. PROC. 163 (1988) 484
88DI02 DIETRICH AND BERMAN, AT. DATA NUCL. DATA TABLES 38 (1988) 199
88DI07 DIMITROVA, PETKOV AND STOITSOV, NUCL. PHYS. A485 (1988) 233
88DO05 DOBELI ET AL, PHYS. REV. C37 (1988) 1633
88DR02 DROZDZ ET AL, PHYS. LETT. B206 (1988) 567
88DU04 DUBOVOY AND CHITANAVA, YAD. FIZ. 47 (1988) 75
88DU09 DUFOUR ET AL, PHYS. LETT. B206 (1988) 195
88DU1B DUFOUR, PARKER AND HEINZE, ASTROPHYS. J. 327 (1988) 859
88DU1G DUFOUR, GARNETT AND SHIELDS, ASTROPHYS. J. 332 (1988) 752
88ER04 ERNST AND DHUGA, PHYS. REV. C37 (1988) 2651
88FA1B FAESSLER, NUCL. PHYS. A479 (1988) 3C
88FE1A FERRANDO ET AL, PHYS. REV. C37 (1988) 1490
88FEZX FELDMAN ET AL, BULL. AM. PHYS. SOC. 33 (1988) 1570
88FI01 FIASE ET AL, J. PHYS. G14 (1988) 27
88FO1E FORREST AND MURPHY, SOL. PHYS. 118 (1988) 123
88FR02 FRIEDMAN ET AL, PHYS. LETT. B200 (1988) 251
88FR06 FRANCO AND TEKOU, PHYS. REV. C37 (1988) 1097
88FR14 FRICKE, BRANDAN AND MCVOY, PHYS. REV. C38 (1988) 682
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88MU20 MUTO, PHYS. LETT. B213 (1988) 115
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88PE1H PENG, AIP CONF. PROC. 176 (1988) 39
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88PO1G POYARKOV, PROC. 38TH MTG. NUCL. SPECTROSCOPY STRUC. AT. NUCL., BAKU, USSR, NAUKA (1988) 457
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88RO1L ROLFS, BULL. AM. PHYS. SOC. 33 (1988) 1712
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88RO1R ROTTER, FORTSCHR. PHYSIK 36 (1988) 781
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88SH1H SHEN ET AL, CHIN. PHYS. 8 (1988) 163
88SI01 SILK ET AL, PHYS. REV. C37 (1988) 158
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88WU1A WU, CHIN. PHYS. 8 (1988) 213
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89AD1B ADAMOVICH ET AL, PHYS. REV. C40 (1989) 66
89AL1D ALEKSANDROV ET AL, TASHKENT (1989) 377
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89BA63	BATUSOV ET AL, SOV. J. NUCL. PHYS. 49 (1989) 777
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89BR14	BRANCUS ET AL, Z. PHYS. A333 (1989) 71
89BU15	BULGAC, PHYS. REV. C40 (1989) 1073
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89CA14	CARLIN FILHO ET AL, PHYS. REV. C40 (1989) 91
89CA15	CAVALLARO ET AL, PHYS. REV. C40 (1989) 98
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89DE02	DEYOUNG ET AL, PHYS. REV. C39 (1989) 128
89DE1P	DEMKOV AND KARPESHIN, TASHKENT (1989) 438
89DE22	DE BOER ET AL, J. PHYS. G15 (1989) L177
89DO04	DOBES, PHYS. LETT. B222 (1989) 315
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89FE07	FERNANDEZ, LOPEZ-ARIAS AND PRIETO, Z. PHYS. A334 (1989) 349
89FE1F	FELDMEIER, SCHONHOFEN AND CUBERO, NUCL. PHYS. A495 (1989) 337C
89FEZV	FELDMAN ET AL, BULL. AM. PHYS. SOC. 34 (1989) 1232
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89FI04	FINK ET AL, PHYS. LETT. B218 (1989) 277
89FI05	FIELDS ET AL, PHYS. LETT. B220 (1989) 356
89FO07	FONTE ET AL, NUCL. PHYS. A495 (1989) 43C
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91IS1D ISKRA, XXTH INT. SYMP. ON NUCL. PHYS., CASTLE GAUSSIG, WORLD SCIENTIFIC (1991) 51
91KA09 KAWAHIGASHI AND ICHIMURA, PROG. THEOR. PHYS. 85 (1991) 829
91KA12 KARADZHEV ET AL, SOV. J. NUCL. PHYS. 53 (1991) 204
91KA19 KANEKO, LEMERE AND TANG, PHYS. REV. C44 (1991) 1588
91KA22 KAKI, NUCL. PHYS. A531 (1991) 478
91KE02 KELLY ET AL, PHYS. REV. C43 (1991) 1272
91KH08 KHOA ET AL, PHYS. LETT. B260 (1991) 278
91KI08 KING ET AL, PHYS. REV. C44 (1991) 1077
91KN03 KNIEST ET AL, PHYS. REV. C44 (1991) 491
91KN04 KNOBLES AND UDAGAWA, NUCL. PHYS. A533 (1991) 189
91KO18 KOEPF AND RING, Z. PHYS. A339 (1991) 81
91KO1C KONG AND LIU, CHIN. PHYS. 11 (1991) 345
91KO1P KOEHLER AND O'BRIEN, AIP CONF. PROC. 238 (1991) 892
91KO23 KOEPF, SHARMA AND RING, NUCL. PHYS. A533 (1991) 95
91KO31 KOEHLER AND GRAFF, PHYS. REV. C44 (1991) 2788
91KO40 KOZYR, IZV. AKAD. NAUK SSSR 55 (1991) 144
91LA02 LAGU AND SINGH, NUCL. PHYS. A528 (1991) 525
91LE06 LEMAIRE ET AL, PHYS. REV. C43 (1991) 2711
91LE13 LEBEDEV AND TRYASUCHEV, J. PHYS. G17 (1991) 1197
91LE14 LEIDEMANN, ORLANDINI AND TRAINI, PHYS. REV. C44 (1991) 1705
91LI25 LICHTENHALER ET AL, PHYS. REV. C44 (1991) 1152
91LI28 LIU ET AL, NUCL. PHYS. A534 (1991) 25
91LI29 LIU ET AL, NUCL. PHYS. A534 (1991) 48
91LI41 LI, ZHAO AND FANG, CHIN. J. NUCL. PHYS. 13 (1991) 223
91MA29 MAJUMDAR, SAMANTA AND SAMADDAR, J. PHYS. G17 (1991) 1387
91MA33 MAVROMATIS, ELLIS AND MUTHER, NUCL. PHYS. A530 (1991) 251
91MA39 MACGREGOR ET AL, NUCL. PHYS. A533 (1991) 269
91MC08 MCGLONE AND JOHNSON, NUCL. INSTRUM. METHODS PHYS. RES. B61 (1991) 201
91MO1B MOTAROU ET AL, PHYS. REV. C44 (1991) 365
91MU04 MUTHER AND SKOURAS, J. PHYS. G17 (1991) L27
91NA05 NAVILIAT-CUNCIC ET AL, J. PHYS. G17 (1991) 919
91NI02 NIEVES ET AL, PHYS. REV. C43 (1991) 1937
91OM03 OMAR, SAAD AND DARWISH, APPL. RADIAT. ISOT. 42 (1991) 823
91OR01 ORR ET AL, PHYS. LETT. B258 (1991) 29
91OR02 ORYU ET AL, NUCL. PHYS. A534 (1991) 221
91OW01 OWENS, MATTHEWS AND ADAMS, J. PHYS. G17 (1991) 261
91PA06 PACATI AND RADICI, PHYS. LETT. B257 (1991) 263
91PA1C PAVLENKO, ASTRON. ZH. 68 (1991) 431
91PH01 PHAM, NUOVO CIM. A104 (1991) 1455
91PI07 PILE ET AL, PHYS. REV. LETT. 66 (1991) 2585
91RA14 RASHDAN, FAESSLER AND WADIA, J. PHYS. G17 (1991) 1401
91RA1C RAITERI ET AL, ASTROPHYS. J. 371 (1991) 665
91RE02 REEDER ET AL, PHYS. REV. C44 (1991) 1435
91RU1B RUAN, CHIN. J. NUCL. PHYS. 13 (1991) 377
91SA1F SAGE, MAUERSBERGER AND HENKEL, ASTRON. ASTROPHYS. 249 (1991) 31

91SA20 SAMANTA AND MUKHERJEE, PHYS. REV. C44 (1991) 2233
91SC26 SCHMID, MUTHER AND MACHLEIDT, NUCL. PHYS. A530 (1991) 14
91SE12 SEMENOV ET AL, SOV. J. NUCL. PHYS. 54 (1991) 429
91SH08 SHEN, FENG AND ZHUO, PHYS. REV. C43 (1991) 2773
91SH1F SHELINE, SOOD AND RAGNARSSON, INT. J. MOD. PHYS. A6 (1991) 5057
91SK02 SKOURAS AND MUTHER, NUCL. PHYS. A534 (1991) 128
91TA11 TAZAWA AND ABE, PROG. THEOR. PHYS. 85 (1991) 567
91TE03 TERUYA, DE TOLEDO PIZA AND DIAS, PHYS. REV. C44 (1991) 537
91TH04 THIEL, PARK AND SCHEID, J. PHYS. G17 (1991) 1237
91TO03 TOKI ET AL, NUCL. PHYS. A524 (1991) 633
91UM01 UMAR ET AL, PHYS. REV. C44 (1991) 2512
91VA1F VARIAMOV ET AL, BULL. ACAD. SCI. 55 (1991) 137
91VO02 VOEGLER ET AL, PHYS. REV. C43 (1991) 2172
91YA08 YAMAGUCHI, PHYS. REV. C44 (1991) 1171
91ZH05 ZHU, MANG AND RING, PHYS. LETT. B254 (1991) 325
91ZH06 ZHANG AND ONLEY, NUCL. PHYS. A526 (1991) 245
91ZH16 ZHANG AND ONLEY, PHYS. REV. C44 (1991) 1915
91ZH17 ZHANG AND ONLEY, PHYS. REV. C44 (1991) 2230
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92BA31 BAUER ET AL, PHYS. REV. C46 (1992) R20
92BA50 BAYE AND TIMOFEYUK, PHYS. LETT. B293 (1992) 13
92BE03 BEREZHNOY, MIKHAILYUK AND PILIPENKO, J. PHYS. G18 (1992) 85
92BE21 BERHEIDE ET AL, Z. PHYS. A343 (1992) 483
92BO04 BORROMEO ET AL, NUCL. PHYS. A539 (1992) 189
92BO07 BOFFI ET AL, NUCL. PHYS. A539 (1992) 597
92BR05 BRUNE AND KAVANAGH, PHYS. REV. C45 (1992) 1382
92CA04 CARRASCO AND OSET, NUCL. PHYS. A536 (1992) 445
92CH1E CHEN AND MA, HIGH ENERGY PHYS. NUCL. PHYS. 16 (1992) 123
92CL04 CLARKE, J. PHYS. G18 (1992) 917
92CR05 CRESPO, JOHNSON AND TOSTEVIN, PHYS. REV. C46 (1992) 279
92DA19 D'ARRIGO ET AL, NUCL. PHYS. A549 (1992) 375
92DE06 DE BLASIO ET AL, PHYS. REV. LETT. 68 (1992) 1663
92EN02 ENDISCH ET AL, NUCL. INSTRUM. METHODS PHYS. RES. B62 (1992) 513
92FA04 FALLAVIER ET AL, NUCL. INSTRUM. METHODS PHYS. RES. B64 (1992) 83
92FR05 FRITSCH ET AL, PHYS. REV. LETT 68 (1992) 1667
92GO07 GOKALP AND YILMAZ, NUOVO CIM. 105 (1992) 695
92IG01 IGASHIRA, KITAZAWA AND TAKAURA, NUCL. PHYS. A536 (1992) 285
92JA04 JAIN, PHYS. REV. C45 (1992) 2387
92JA13 JAQUA ET AL, PHYS. REV. C46 (1992) 2333
92KA1K KANEKO AND TANG, PHYS. LETT. B296 (1992) 285
92KA21 KANEKO, LEMERE AND TANG, PHYS. REV. C46 (1992) 298
92KW01 KWASNIEWICZ AND JARCZYK, NUCL. PHYS. A541 (1992) 193
92LA01 LAYMON, BROWN AND BALAMUTH, PHYS. REV. C45 (1992) R576
92LA08 LANE, NUCL. INSTRUM. METHODS PHYS. RES. B64 (1992) 448
92LI1D LI AND ZHOU, HIGH ENERGY PHYS. NUCL. PHYS. 16 (1992) 229
92LU01 LUDWIG ET AL, PHYS. LETT. B274 (1992) 275
92MA09 MACK ET AL, PHYS. REV. C45 (1992) 1767
92MA45 MARCOS, VAN GIAI AND SAVUSHKIN, NUCL. PHYS. A549 (1992) 143
92MI01 MILLENER, HAYES AND STROTTMAN, PHYS. REV. C45 (1992) 473
92MI1H MINAMISONO ET AL, HYPERFINE INTERACT. 73 (1992) 347
92NA04 NAQVI AND DRAAYER, NUCL. PHYS. A536 (1992) 297
92OL02 OLKHOVSKY AND DOROSHKO, EUROPHYS. LETT. 18 (1992) 483
92PH01 PHAM ET AL, PHYS. REV. C46 (1992) 621
92PY1A PYYKKÖ, Z. NATURFORSCH. A47 (1992) 189

92QI02 QI ET AL, CHIN. J. NUCL. PHYS. 14 (1992) 15
92RY02 RYCKEBUSCH ET AL, PHYS. LETT. B291 (1992) 213
92SA1F SARANGI AND SATPATHY, PRAMANA 39 (1992) 279
92SH11 SHOPPA AND KOONIN, PHYS. REV. C46 (1992) 382
92SI01 SIMS ET AL, PHYS. REV. C45 (1992) 479
92SU02 SUZUKI, SAGAWA AND ARIMA, NUCL. PHYS. A536 (1992) 141
92TO04 TOWNER, NUCL. PHYS. A542 (1992) 631
92WA1L WARBURTON, BROWN AND TOWNER, PRIVATE COMMUNICATION
92WA22 WARBURTON AND BROWN, PHYS. REV. C46 (1992) 923
92WA25 WARBURTON, BROWN AND MILLENER, PHYS. LETT. B293 (1992) 7
92WI13 WILKERSON ET AL, NUCL. PHYS. A549 (1992) 223
92ZH07 ZHENG, SPRUNG AND ZAMICK, NUCL. PHYS. A540 (1992) 57
92ZU01 ZUBANOV ET AL, PHYS. REV. C45 (1992) 174
92ZU1B ZUBANOV ET AL, PHYS. REV. C 46 (1992) 1147
93CH1A CHOU, WARBURTON AND BROWN, PHYS. REV. C47 (1993) 163