Electron scattering from excited states of ^{18}O above 10 MeV

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The giant resonance region of ^{18}O has been investigated by means of inelastic electron scattering at three values of the momentum transfer. The main features of the giant dipole resonance correlate well with photonuclear reaction data. In addition, considerable contribution from quadrupole excitations is apparent in the excitation energy range from 10 to 23 MeV, with some additional strength from 30 to 45 MeV.

[NUCLEAR REACTIONS ^{18}O(e,e'), $E=80.0$–165.7 MeV, $\theta=67.0$–$132.0°$—enriched gas target. Measured $\sigma(E',\theta)$. Deduced differential form factors.]

The two neutrons outside of the doubly closed 1p-shell ^{16}O core structure of ^{18}O make this nucleus of particular interest for giant resonance studies. Theoretical studies of the effect of the dynamic excitation of the core coupled to $(sd)^n$ configurations predict a strong core polarization leading to pronounced structure for the $E1$, $E2$, $E4$, $E0$, and $M2$ excitations of ^{18}O in the 15–45 MeV range of excitation energy.[1] All the major photonuclear cross sections have been thoroughly studied recently and are discussed in the paper by Woodworth *et al.*[2] The giant dipole resonance (1^- states) show considerable structure from the (γn) threshold up to about 26 MeV, apparently dominated by the $T_<$ $(T=1)$ isospin component. The $T_>$ $(T=2)$ isospin component extends from approximately 20 to above 40 MeV with a broad maximum at 27 MeV and weak additional broad resonances at 30 and 36 MeV. The two resonances at 17.3 and 19.4 MeV were also assigned to the $T=2$ isospin component.

The radiative pion capture reaction ^{18}O(π^-,γ) has also been recently studied by Strassner *et al.*[3] As discussed by the authors of Ref. 3, this reaction is selective in exciting analogs of $M1$ and $M2$ transitions and to a lesser extent $E1$ transitions ($J^\pi=1^-,2^-$; $T=1$, 2 states of ^{18}N).

Obviously a complete inelastic electron scattering study would greatly contribute to the understanding of the structure of ^{18}O states in the giant

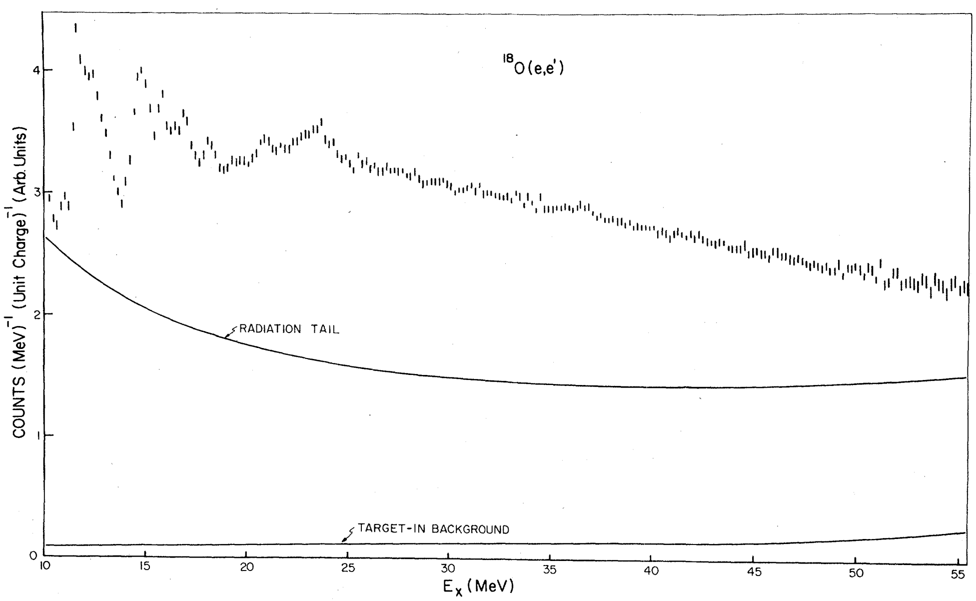

FIG. 1. Inelastic electron scattering spectrum at 165.7 MeV, 67°, showing the contributions due to the elastic peak radiation tail and background due to the target. The target-in background shown was obtained by fitting a smooth curve through the data obtained with an empty target and scaling that curve by a factor 1.12 that takes into account multiple scattering events in the target gas.

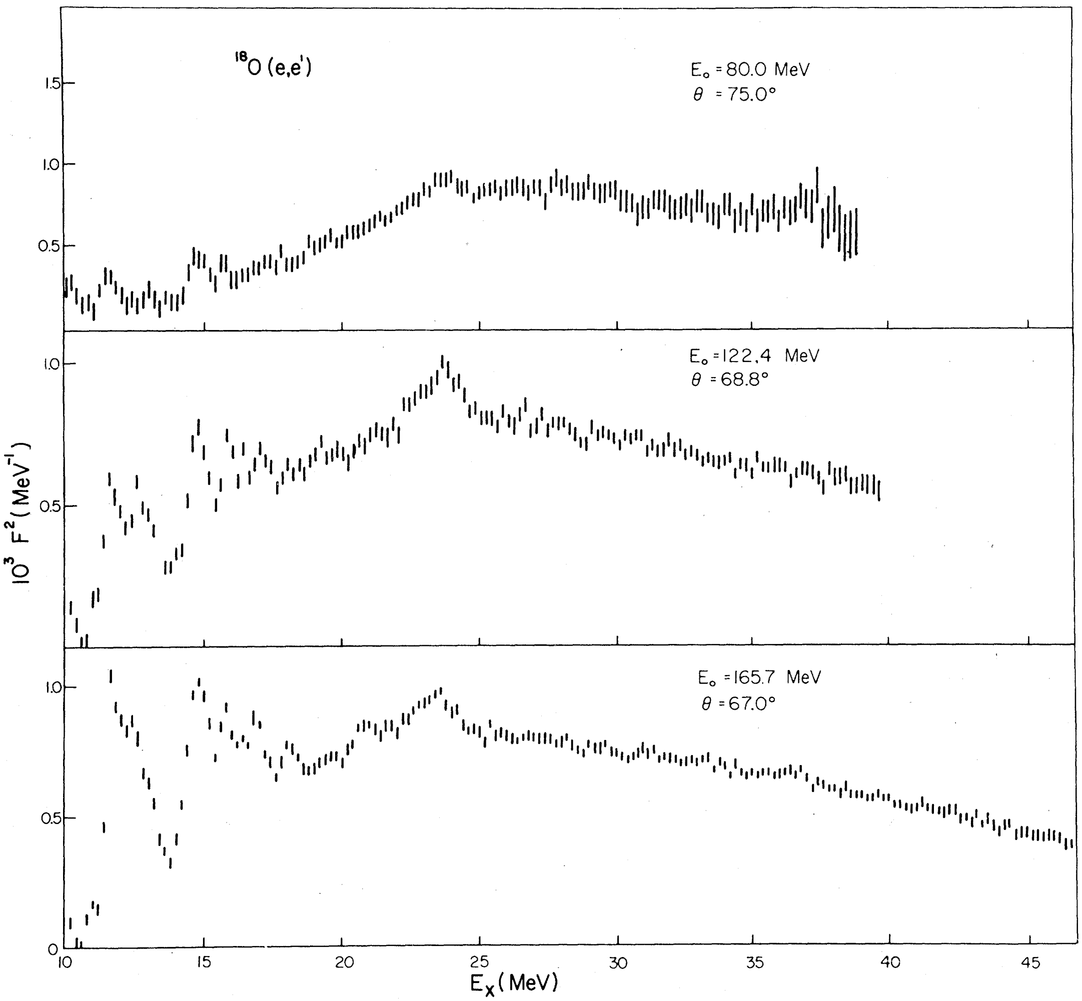

FIG. 2. Differential form factors at forward angles (energy bin width = 200 keV). The three spectra correspond to q(23 MeV) = 0.43, 0.63, and 0.86 fm^{-1}, top to bottom, respectively.

resonances region. In an early experiment by Vanpraet[4] at 180° with 69 MeV incident electrons, about eleven transitions were observed from 10.9 to 26.9 MeV excitation. The location and strength of these states is in poor agreement with the states observed in the photonuclear and pion capture work of Refs. 2 and 3.

In this work inelastic electron scattering spectra were obtained for the following values of incident energy and scattering angle: 80.0 MeV (75.0°), 122.4 MeV (68.8°), 80.0 MeV (132.0°), and 165.7 MeV (67.0°). The corresponding values of the momentum transfer (at 23 MeV excitation) were q = 0.43, 0.63, 0.64, and 0.86 fm^{-1}, respectively. All the measurements were carried out using the electron scattering facility[5] and experimental procedures already described.[6] The target consisted of 91.7% ^{18}O (4.3% ^{16}O, 4% ^{17}O) gas contained at high pressure (~10 atm) in a cylindrical cell.[5] The backgrounds due to the radiation tail and the target container were first subtracted from the data (see Fig. 1 for an example), radiative corrections were then applied, and the differential form factors calculated following the procedures described in Ref. 6. The normalizing elastic scattering form factor was taken from the work of Ref. 7.

The differential form factors obtained for the forward-angle runs are displayed in Fig. 2. The data are dominated by longitudinal excitations. The following features of the form factors are apparent:

(a) As with the case of the photonuclear cross sections of Ref. 2, the main feature of the dipole resonance is located at 23.6 MeV, with the "pygmy" resonance made up of several reson-

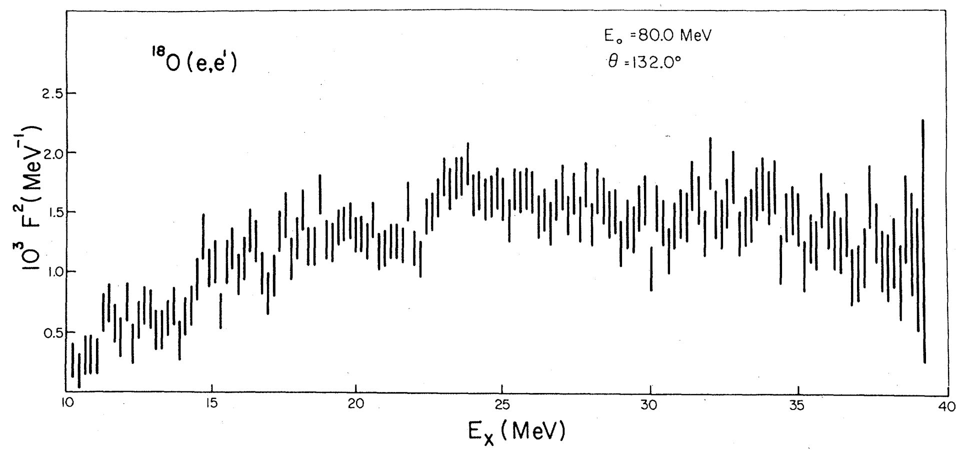

FIG. 3. Differential form factor at 132° corresponding to a momentum transfer q (23 MeV) = 0.64 fm^{-1}.

ances, the most prominent one located at 14.7 MeV. The relative importance of the 23.6 MeV resonance increases with momentum transfer when compared to the form factor above 25 MeV. This is in agreement with the isospin assignment of Ref. 2, as discussed for the ^{15}N case in Ref. 6.

(b) The differential form factor has prominent and distinct peaks in the excitation energy region from 10 to ~24 MeV which increase in magnitude as the momentum transfer increases. From 40- and 60-keV bin width sorts of the data of Figs. 2 and 3, the excitation energies and most probable spin-parity assignments for the peaks in our data are 11.6 MeV ($2^+,4^+$), 12.1 MeV (2^+), 12.5 MeV ($2^+,4^+$), 14.8 MeV (2^+), 15.8 MeV (2^+), 18.0 MeV (2^+), and 20.8 MeV (2^+). Some of these peaks are also apparent in the data at 132° (Fig. 3). In particular, for the energy region considered (below 24 MeV) there is evidence for sizable transverse contributions at 14.8, 15.7, 16.2, 17.6, 18.5, and 21.8 MeV.

(c) In the region above the dominant 23.6 MeV excitation the form factor decreases slowly and shows considerable, but weak structure up to at least 45 MeV excitation. This is in evidence in the data at 165.7 MeV, 67.0°, which were obtained during a long run with a stable incident beam. Several weak and broad bumps can be seen in the data, with relative maxima at 31.2, 34.0, and 36.8 MeV. This is qualitatively in agreement with the $E2$ ($T=2$) strength distribution predicted by Knüpfer and Huber.[8] The data of Fig. 3 show also that there is a considerable transverse component in the form factor from 23 to 40 MeV.

In conclusion, the data presented here show that the inelastic electron scattering spectrum of ^{18}O is rich in features worthy of further study. The present measurements were hampered by (a) the low energy resolution (typically the width of the elastic peak was ~250 keV full width at half maximum) for the study of isolated resonances, and the unavailability of beams with energies than 170 MeV, and (b) the limitation to spectrometer angles of less than 135°, which precluded a definite determination of the transverse contribution to the form factors and thus a comparison of the electron scattering data to the radiative capture experiment of Ref. 3.

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