PROTON ELASTIC AND INELASTIC SCATTERING AT INTERMEDIATE ENERGIES FROM ISOTOPES OF OXYGEN AND ^{9}Be AS PART OF A UNIFIED STUDY OF THESE NUCLEI

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Combined studies of selected nuclei, and selected nuclear excitations with both electron scattering and proton scattering in the same region of momentum transfer can provide a far richer insight into nuclear structure and nuclear reaction mechanisms than either study done separately. There has been extensive electron scattering work done on the oxygen isotopes by the M.I.T. group at the Bates Accelerator Laboratory and we report here the progress that has been made in analyzing the recent proton scattering data from the oxygen isotopes taken at the IUCF during the runs of May 10 and June 12, 1978.

During these runs 135 MeV protons were scattered from a variety of isotopically mixed beryllium oxide foils. Spectra were measured over a range of scattering angles between 12° and 88° by use of the high resolution proton spectrograph. A small portion of a typical spectrum taken during these runs is shown in Figure 1 (note logarithmic scale). The high resolution of the IUCF proton spectrograph allows a clean recoil separation of the enriched oxygen isotope elastic peaks (^{16}O-14%, ^{17}O-19%, ^{18}O-67%) as well as separation of many excited states of ^{17}O and ^{18}O occuring higher in excitation energy. Also, in the Figure 1 spectrum are peaks due to the trace impurities ^{12}C and ^{24}Mg present in the target at the level of a few parts in 10^4.

The reduction of the acquired data into cross sections has almost been completed for all levels below 6.5 MeV by the M.I.T. group. B. Norum has modified his (e,e') line shape analysis program for use with these proton data by eliminating the radiative features and including a multicomponent peak shape to account for the proton resolution function. The proton peak shape requires an exponential leading edge, an asymmetric gaussian-like central component, an exponential trailing edge, and a background component. This general structure was determined by examination of isolated peaks. The solid curves shown in Figure 1 are typical of the quality of the fits obtainable with this analysis code. The line shape analysis approach enables the precise extraction of peak areas and the proper determination of the background levels.

The analysis of the elastic proton scattering data[1] from the oxygen isotopes is essentially complete and is

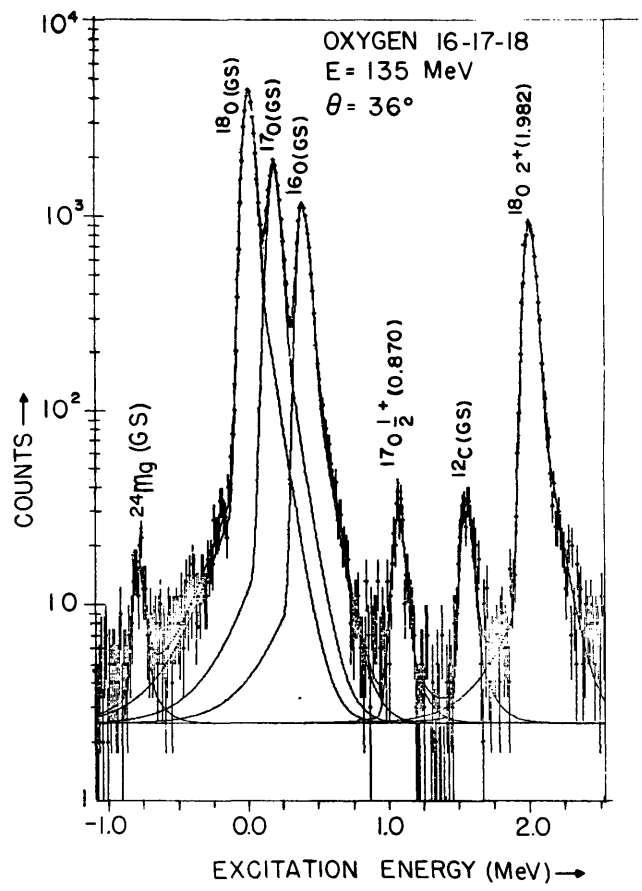

Figure 1. Section of typical proton spectrum taken during the oxygen experiment. Solid lines indicate the results of the MIT line shape fitting code.

presented in Figure 2 in the form of two ratios: the ratio of the ^{17}O cross section to the ^{16}O cross section; and the ratio of ^{18}O cross section to the ^{16}O cross section. From this ratio plot it is evident that the ^{17}O ratio is everywhere slightly larger than 1 and the ^{18}O ratio is everywhere less than 1.

The electron scattering results[2] for the monopole part of ^{17}O and ^{18}O are displayed in Figure 3 in the form of ratios with respect to the ^{16}O cross section. Except for the region around $\sim 1.5\ fm^{-1}$ where very rapid variations in cross section are caused by a diffractive minimum, the general observation that the ^{17}O ratio is close to 1 and the ^{18}O ratio is less than 1 is strikingly similar to the proton results. This similarity in behavior is a good indication that we may well be successful in understanding the proton data in terms of a simple approximation in which the influence of the valence neutrons and their polarization of the core is treated as a perturbation using a DWIA treatment based on the ^{16}O core as the distorting optical potential. Combining these data in this way may provide us with a powerful means of making the proton a good probe of these valence neutrons.

We began the analysis of inelastic levels by studying the 1d 5/2 - 2s 1/2 single-particle transition in ^{17}O for which our electron scattering data for this level is presented in Figure 4 and is compared to a DWIA calculation by Picklesimer and Walker in which a single neutron is assumed to be solely responsible for the transition. The total calculation describes the data rather well for $\theta < 65^o$, while for angles greater than this where the exchange contribution is dominent the data follow much more closely the direct contribution by itself. The good agreement with the data for forward angles lends support to the single particle nature of this transition. This is consistent with the measure we have from electron scattering of the radial dependence of the transition charge density, i.e. a neutron with ~ 0.5 proton charge). The electron scattering results for the transition current and magnetization densities seriously disagree with the single particle predictions and perhaps an understanding of this discrepancy can shed light on the difficulties in the exchange term calculation for the proton data.

Due to the efforts of J. Kelly, most of the cross sections for the oxygen excited states from the proton data are now available. The cross sections from odd parity levels of ^{17}O arising from the coupling of the d 5/2 neutron to the 3^- oscillation of the ^{16}O core show a surprising uniformity of shape and great similarity to the cross section for the 3^- state in ^{16}O by itself (see Figure 5). This observation is also seen in the electron scattering results and lends some credence to the spectator model for these levels.

For the future this experiment is now entering a phase where very intensive theoretical work is required. The wealth of exciting data now available on the oxygen isotopes from both proton and electron scattering has already stimulated a number of calculations at Indiana, M.I.T. and elsewhere. Experimentally we would like to extend the measurements to larger scattering angles and take additional spectra at higher excitation energy (10-20 MeV).

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1) B. Norum, et al., Asilomar Conference, November 1978.

2) H. Miska, et al., to be published in Physics Letters B.

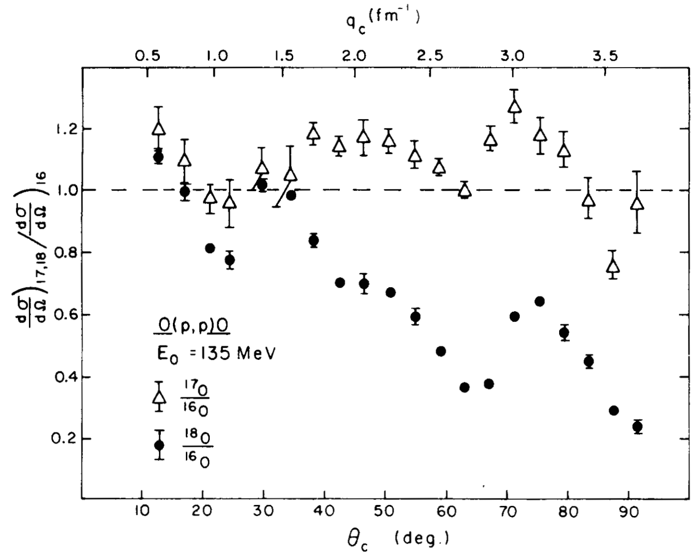

Figure 2. Ratio of elastic proton scattering cross sections for ^{17}O and ^{18}O with respect to ^{16}O. Incident proton energy = 135 MeV.

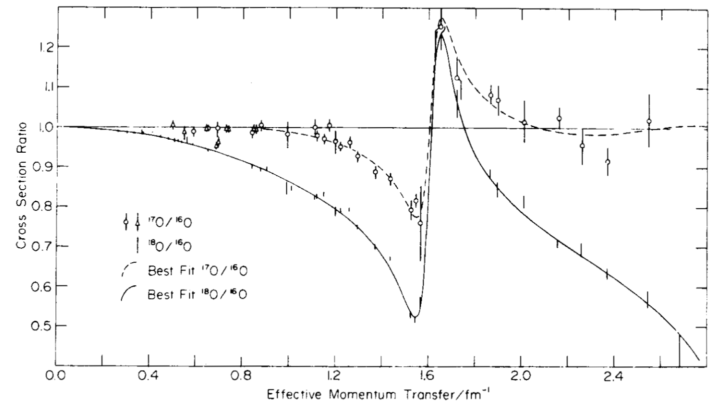

Figure 3. Ratio of elastic electron scattering cross sections for ^{17}O and ^{18}O with respect to ^{16}O.

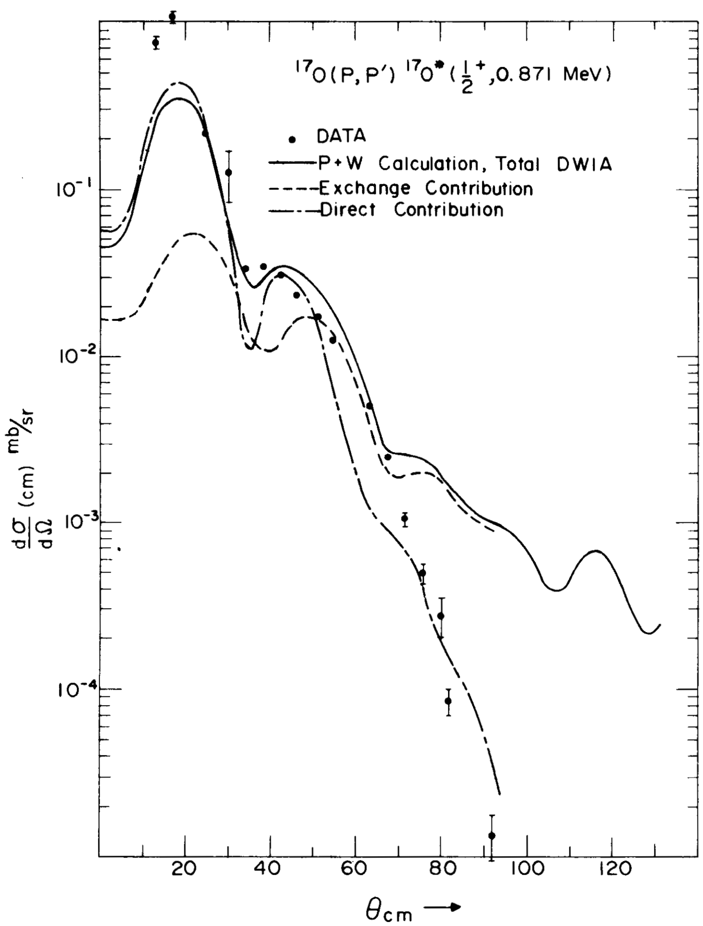

Figure 4. Inelastic proton scattering results for the 12/+(0.871 MeV) level of ^{17}O. The curves are the result of a calculation by Picklesimer and Walker.

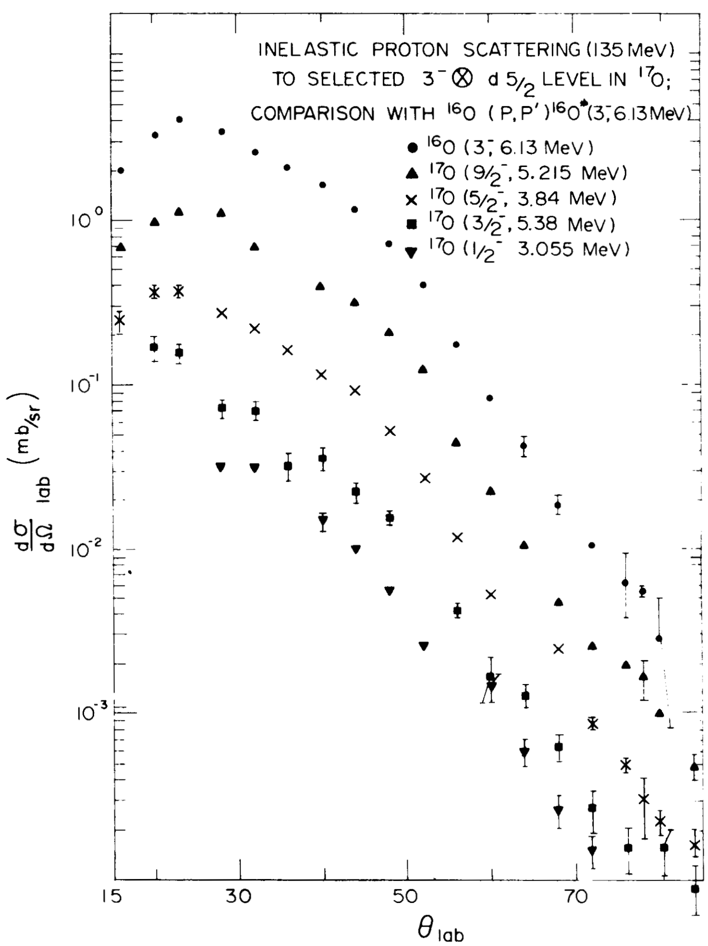

Figure 5. Inelastic proton scattering results for selected odd parity levels in ^{17}O in comparison with the results for the 3^- (6.13 MeV) level in ^{16}O.

Figure 6. Dialogue between theorists and experimentalists during data taking run for this experiment.